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A Review of Mindfulness-Based Apps for Children

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Abstract

Objectives The use of mobile applications (apps) for the practice of mindfulness is becoming more and more popular. However, little is known about the mindfulness-based apps that are available for children. The present study aimed to overcome this gap. We identified and characterized mindfulness apps for children and provided an expert-based evaluation on apps engagement, functionality, aesthetics, information, and overall quality with the Mobile App Rating Scale (MARS).

Methods Using the search term "mindfulness," a human and a machine rater identified all apps in the Google Play and Apple Store. Three selection criteria were applied: the apps should be in English, related to mindfulness, and suitable for children (as defined in the store's descriptive text). An expert multidisciplinary team of six trained judges used the MARS to evaluate the selected apps, whose main features were also extracted.

Results Among the 1933 identified apps, 57 met selection criteria. The 36 free apps achieved an average score of 3.41 (out of 5) in MARS overall quality, with *Mindfulness with Petit BamBou* achieving the highest score (4.33). Most apps included audio-based meditation exercises, some of them combined with videos. Exercises were typically presented as isolated practices rather embedded in sequenced programs.

Conclusions Despite the general "acceptable" level of quality, most apps failed to achieve a score of good (≥ 4.0) in all MARS dimensions. Overall, it seems that there is room for improvement in what concerns the mindfulness-based apps freely available for children. Moreover, empirical evidence on their effectiveness is clearly warranted.

Keywords Mindfulness · Mindfulness-based mobile apps · Mobile health (mHealth) · Children · Mobile App Rating Scale

Mindfulness is defined by Kabat-Zinn (2003) as "the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment" (p. 145). In the last decades, the training of this skill has become a widely spread form of health promotion in many fields (Bishop et al. 2004), such as clinical (Biegel et al. 2009), educational (Carsley et al. 2017), and organizational (Rupprecht et al. 2019). There is now a large body of research showing that mindfulness skills can be enhanced formally through systematic interventions, typically implemented under the guidance of qualified instructors (Meiklejohn et al. 2012). A major component of these interventions consists in the implementation of attentional exercises aimed to promote people's awareness to the present moment, here broadly subsumed under the term "meditation" (Greenberg and Harris 2012). Meditation exercises can occur with or without external guidance (e.g., voice) and they are aimed to direct individuals' attention to their own feelings, thoughts, sensations, or external stimulus, like sounds (Greenberg and Harris 2012). Meditation-based exercises can take different forms, such as breathing, where individuals are asked to notice and concentrate on the sensations involved in breath (Bishop et al. 2004), and body scan, through which they are encouraged to focus on each and every part of the body in a sequential way, from toes to head (Zelazo and Lyons 2012).

The interest in mindfulness strategies as part of psychological interventions has grown over the past 30 years, with many studies showing an association of mindfulness practice with increased general wellbeing (for a review, see Creswell 2017). Mainly in adults, mindfulness has been integrated as a fundamental part of several psychological therapies for treating depression (Segal et al. 2002) or managing personality disorders (Linehan 1993). It is also integrated in programs aimed at

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reducing stress, such as the well-known Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn 1982; Lindsay et al. 2018). MBSR is one of the most widely used programs in clinical settings (Grossman et al. 2004). It instructs people to focus their attention on the present moment through the implementation of attentional strategies (in group or individually), such as breathing and body scans (Zelazo and Lyons 2012). Even in the absence of psychological disorders—for example, when people are simply under pressure—the ability to maintain a mindful perspective has been found to be helpful, by supporting flexible and adaptive behaviors (Thompson and Gauntlett-Gilbert 2008). Therefore, even the informal integration of mindfulness exercises into the everyday activities of healthy adults seems to bring benefits at several levels of their lives (Meiklejohn et al. 2012).

Although research showing health benefits of mindfulness is considerably more consistent in adult than in child populations, these latter also seem to benefit from this type of training (Thompson and Gauntlett-Gilbert 2008). Mindfulness interventions in young people with typical development have been found to produce positive effects on emotional regulation, stress reduction, anxiety, self-esteem, and sleep (Biegel et al. 2009; Bootzin and Stevens 2005; Mendelson et al. 2010; Napoli et al. 2005; Wall 2005). The training of mindfulness-related skills seems to be particularly valuable for young people exposed to stress and adversity (Bootzin and Stevens 2005; Mendelson et al. 2013). Recent studies also reported positive effects of mindfulness in children with autism spectrum disorder and their parents (Lunsky et al. 2017; Ridderinkhof et al. 2018), and in children with developmental delays and their parents (Neece et al. 2018). In addition to health benefits, mindfulness practices also seem to bring benefits to academic achievement. In a study with children in Grades 5–8, Caballero et al. (2019) found that higher levels of mindfulness were associated with better academic achievement, as well as with higher attendance rates and fewer suspension episodes. Likewise, in a comprehensive meta-analysis of mindfulness-based interventions conducted with 4- to 18-year-olds, Klingbeil et al. (2017) found significant improvements on cognitive performance and indicators of academic achievement.

In the above-mentioned studies, mindfulness training typically occurs in small-group sessions implemented over time, where different exercises are carried out under the guidance of a qualified instructor in face-to-face settings (Zelazo and Lyons 2012). However, the popularity of mindfulness fueled by the media allied to the ubiquity of smartphones has led to the exponential growth of mobile applications (hereafter, apps) aimed to offer mindfulness practices to the general population (O' Reilly et al. 2016; Tunney et al. 2017). For example, in 2014, one of the first reviews on mindfulness-based apps found around 600 apps for iPhone (Mani et al. 2015). The widespread availability of these apps to the public prompted researchers to examine the effects of promoting mindfulness by means of digital devices.

In a qualitative focus group study with children aged 10–12 years, Tunney et al. (2017) compared the effects of technology-delivered vs. face-to-face mindfulness training. Authors found an overlap between the two modes of delivery, with the same themes arising among children involved in the two experiences (viz., relaxation, engagement, awareness, thinking, practice, and directing attention). This was an important finding as it suggested that implementing mindfulness training via technology produced a similar experience as implementing it via human contact. However, interesting differences between these two modes of delivery emerged. Specifically, face-to-face contexts tended be classified as soothing and also boring and tiring, with some children finding activities confusing and pointless. The practice of mindfulness through technology was found to be an asset that could enrich children's experience. The use of technology in educational contexts is not new, given youngsters interest in digital devices to entertain themselves with high levels of motivation. Using apps for skill development seems to have the potential to inspire original, enjoyable, and interactive learning experiences, mainly in young people (Huang and Kao 2015; Mkpojiogu et al. 2018). Their openness to technology can be a catalyst in instigating and maintaining the practice of mindfulness (Donovan et al. 2016; O' Reilly et al. 2016; Tunney et al. 2017).

Technology-based mindfulness training also seems to help children and adolescents to better grasp more abstract concepts associated with the enactment of mindfulness strategies, for example, through the possibility of combining audio with visual information (Thompson and Gauntlett-Gilbert 2008). There are also practical advantages of implementing mindfulness practices by means of technology (Creswell 2017). Compared with face-to-face settings, the use of apps is cheaper and requires less resources (e.g., no need of an instructor). Moreover, the portability offered by mobile devices, allows individuals to practice mindfulness in any place, at any moment (Bakosh et al. 2018; Creswell 2017).

Despite the assumed advantages of apps-delivered interventions, few studies compare the effectiveness of digital vs. face-to-face implementations in children and little is known about the degree to which they can be self-reliant users of mindfulness apps. Children may become proficient technology users at a very young age, but they also experience difficulties in using apps, such as uncontrolled swiping, incorrect tapping, or accidental app exiting (Chiong and Shuler 2010). Therefore, the role of parents or other caregivers in mediating technology usage is particularly important (Nikken and Schols 2015). Still, the extent to which the proper use of mindfulness apps requires external help is a topic barely researched.

Due to the always-present digital world, nowadays children grow up immersed in technological practices (Kucirkova

2018). Either in educational or in entertainment fields, mobile apps seem to be favored by young people as they offer highly interactive and stress-free experiences (Mkpojiogu et al. 2018). As discussed above, the combination of technology and mindfulness seems thus promising for developing mindful youngsters. However, despite the availability of these apps and the widespread assumption on their benefits, there is currently no evidence regarding the quality of those apps, as well as on their main characteristics. Such information is a crucial aspect to ensure its usability (Mkpojiogu et al. 2018). Nevertheless, to the best of our knowledge, there is no published review on the mindfulness apps available for children. Mani et al. (2015) published a review of mindfulness-based apps, but their search was limited to the iOS system and it was not specifically targeted for children. The present study aims to expand these findings in two ways. First, we did not restrict our search to an operating system and examined all mindfulness-based apps that were available in both iOS and Android systems. Second, we focused our analysis on apps suitable for children and included data on their quality and main features. The structure of mindfulness training may follow similar guiding principles for adults and children. Nonetheless, there are undeniable cognitive, perceptual, and emotional differences between these two age groups that must be accommodated when developing such apps (Thompson and Gauntlett-Gilbert 2008). For example, mindfulness interventions for children should have simple instructions and short activities, rely on metaphors and images, use movement-based activities, and balance silent, inquiry-based, and interactive activities (Zelazo and Lyons 2012). Designing apps for children also requires distinct usability approaches. For instance, children's apps should avoid redundant navigation, scrolling, and advertisement, and should rely on simple actions, include animations and sounds, display age-targeted and interactive designs, and be capable of entertaining (Mkpojiogu et al. 2018; Sherwin and Nielsen 2019). All in all, it seems important to narrow past reviews and gather detailed and systematic data mindfulness apps for children, concerning their main features and quality assessed from an expert viewpoint. This information may be useful for users and also for researchers, as it may stimulate the implementation of scientific studies testing the validity of these apps.

Method

Systematic Search (Apps Selection)

The identification of mindfulness-based apps was done by a human and a machine rater. The human rater was the first author. The machine rater was composed by two web-scrappers, which were implemented using the tools app-store-scraper (https://www.npmjs.com/package/app-store-scraper) and google-play-scraper (https://www.npmjs.com/package/google-play-scraper). Both human and machine raters identified mindfulness-based apps in the Google Play (Android) and Apple Store (iOS) between January and February 2019 using the search term "mindfulness."

The manual search revealed 1621 apps and the machine-based search revealed 1683 apps, with an agreement of 83% (i.e., 1371 apps). We therefore examined which apps were found by the human rater but not by the script, and vice-versa. This analysis resulted in a total of 1933 apps (1613 for iOS, 170 for Android, and 150 for both). The first author read the description of these apps and applied two inclusion criteria (the app should be in English and the store description should explicitly mention its suitability for children); and one exclusion criteria (no relation to mindfulness). The application of these criteria resulted in 56 apps. A second human rater applied the same three criteria independently. There was a disagreement of 1% (22 apps), which was solved by the last author. Among these 22 apps, 21 did not fulfill one of the selection criteria. There was however one app that matched these criteria but was not identified by the first author. This app was then added, resulting in a total of 57 mindfulness-based apps for children. The description page of these apps was screened by the first author, who manually extracted information concerning apps' operating system, developer, cost, release date, number of installations, and user ratings. This information was then cross-checked with that provided by the script. To gather scientific evidence on apps' effectiveness, the first and last authors independently retrieved English-language peer-reviewed papers until February 2020 from PubMed, Web of Science Core Collection, and all databases available through EBSCO (e.g., APA PsycArticles, APA PsycInfo, APA PsycTherapy, Psychology and Behavioral Sciences Collection) using the following search terms: each app's name AND "apps" OR "applications" OR "mobile application." Only empirical studies reporting the effects of the app on at least one health-related or psycho-social outcome were considered.

Quality Assessment

We used the Mobile App Rating Scale (MARS) developed by Stoyanov et al. (2015), who provided evidence that this is a simple, objective, and reliable tool to measure the quality of health mobile apps targeting users of any age (children, adolescents, adults). Specifically, MARS is a multidimensional instrument for researchers, health-related professionals, and developers to rate the degree to which apps meet quality criteria. Indeed, MARS is currently among the most widely tools to evaluate the apps quality in varying fields and populations, such as apps for mindfulness training (Mani et al. 2015) and management of pain (Salazar et al. 2018) and weight (Bardus et al. 2016) in adults, as well as apps to

improve diet and physical activity in children and adolescents (Schoeppe et al. 2017). Sound validity evidence of German (Messner et al. 2020), Spanish (Martin Payo et al. 2019), and Italian (Domnich et al. 2016) versions of MARS has also been reported. Additionally, MARS is used as one of the sources of information to develop assistance guidelines for navigating within the health-related app marketplaces (e.g., PsyberGuide, www.psyberguide.org).

The original MARS version was independently translated into Portuguese by two Portuguese native speakers fluent in English. After discussion, a single version was obtained and used in the present study. MARS comprises 19 items organized into four dimensions: *engagement*, which measures how much the app is fun, interesting, customizable, interactive, and well targeted to audience; *functionality*, which measures the performance, ease of use, navigation, flow logic, and gestural design of the app; *aesthetics*, which measures graphic design, overall visual appeal, color scheme, and stylistic consistency; and *information*, which measures the accuracy of the app description in the store, goals statement, and the quality and quantity of verbal and visual information, as well as the credibility and existence of supporting evidence (these two later points—credibility and evidence—were not included in our study because these features were already taken into account in the systematic search described above).

Each item of MARS is rated in a 5-point scale (1—Inadequate, 2—Poor, 3—Acceptable, 4—Good, 5—Excellent), which includes item-specific descriptors for the five response categories, aimed to clarify the meaning of each response with concrete indicators. For example, one item of the engagement dimension is "Customization: Does it provide/retain all necessary settings/preferences for apps features (e.g., sound, content, notifications, etc.)?" The responses range from "1. Does not allow any customization or requires setting to be input every time" to "5. Allows complete tailoring to the individual's characteristics/preferences, retains all settings." Items responses are then averaged to achieve the final score for each of the four dimensions assessed. Additionally, there is an overall quality score, which results from the mean of the four dimensions. The use of mean scores instead of total scores is justified as some items can be rated as Not Applicable (viz., items 14–17). The mean scores are also used to provide quality ratings similar to the familiar star-rating format typically available for app users (Stoyanov et al. 2015).

Following the procedure recommended by Stoyanov et al. (2015), we asked an expert multidisciplinary team of six judges to rate the selected apps using MARS. This team included one clinical psychology doing a PhD in technology use in school contexts, three research assistants doing a master's in educational psychology, one research assistant working on apps development and doing a master's in informatics engineering, and one UX designer doing a PhD in digital media. These judges received appropriate training in a two-part workshop. The first part included a session focused on the concept of mindfulness, including good practices to develop mindfulness interventions for children (Zelazo and Lyons 2012) and fundamental features underlying children's use of technology (Mkpojiogu et al. 2018; Sherwin and Nielsen 2019). This allowed judges to achieve a global comprehension about the theme of the apps under evaluation and the target group. The second part of workshop started with the presentation of the rating system followed by a discussion about the meaning of all MARS items. This discussion was based on a mindfulness app that did not fulfill the inclusion criteria. During the workshop, judges were asked to rate the app individually. Then, each MARS item was discussed collectively to achieve a shared understanding among all judges. After the workshop, the six judges were asked to evaluate the quality of the selected mindfulness-based apps, which were identified through direct links to download them. They were told to use each app for at least 15 min with the goal of collecting enough information to provide confident responses to MARS items. Judges were told to respond to these items independently after using the app, even though they could go back to the app while answering the items to assure accurate responses. For apps available both in iOS and in Android, raters were asked to use the iOS version.

The rating system demonstrated a good level of interrater reliability among the six judges, measured throughout the two-way mixed intraclass correlation coefficient: for engagement, ICC = 0.85, 95% CI 0.76–0.91; for functionality, ICC = 0.77, 95% CI 0.64–0.87; for aesthetics, ICC = 0.86, 95% CI 0.77–0.92; for information, ICC = 0.76, 95% CI 0.62–0.86, and for overall quality, ICC = 0.85, 95% CI 0.76–0.91. Based on these results, for each app, we calculated the average across judges for the four MARS dimensions and overall quality.

In addition to this quality assessment, we also extracted the main features of each selected app: (a) the need to be registered for using the app; (b) how the information about exercises was presented (audio files and/or video demonstrations); (c) inclusion of reminders, for example, to notify users to do the activities; (d) sharing options within social networks; (e) possibility to buy additional app features; (f) type of activities offered to users, namely, active (e.g., enact an exercise) or passive (e.g., theoretical presentation of contents); and (g) availability of sequenced programs combining a set of activities.

Results

Table 1 provides an overview of these apps in terms of operating system, developer, cost, release date, number of installations, user ratings, and evidence of effectiveness. This information is summarized below.

Table 1 Characteristics of the 57 mindfulness-related apps suitable for children

App name[a]	Developer	Cost	Release date		Number of installations		User ratings (max. 5)		Evidence based?
			iOS	Android	iOS	Android	iOS	Android	
Align Mindfulness	Abundat, LLC	Free	30/11/17	27/11/18	Unknown	10+	5.0	3.0	No
BreazeApp	newpixel	Free	12/04/17	Not available	Unknown	Not available	Unknown	Not available	No
Breethe - Guided Meditation and Mindfulness	OMG. I Can Meditate! Inc.	Free	Unknown	25/01/16	Unknown	50,000+	4.5	4.4	No
buddhify - mindfulness meditation on the go	Mindfulness Everywhere	4.19 (Android); 5.49 (iOS)	01/01/14	25/11/14	5	1000+	4.7	4.4	No
Bunny Mindfulness: meditation for kids of all ages	Rob Sturgeon	1.09	04/05/17	03/08/17	Unknown	Unknown	Unknown	Unknown	No
Calm mom, calm dad, calm child - calming collection	Oceanhouse Media	8.99	09/03/17	Not available	Unknown	Not available	Unknown	Not available	No
Chakra chime	Goodman Gear	Free	13/09/10	Not available	Unknown	Not available	3.5	Not available	No
Children's bedtime meditation	Diviniti Publishing Ltd	Free	Unknown	Unknown	Unknown	Unknown	4.1	Unknown	No
Chill Outz	Mind-Out LLC	5.49	30/09/14	Not available	Unknown	Not available	Unknown	Not available	No
Chill Panda	Onteca	Free	14/12/16	Unknown	Unknown	Unknown	Unknown	Unknown	No
Chill Skills	Lisa Hemmings	Free	24/07/18	Unknown	Unknown	Unknown	Unknown	Unknown	No
Cosmic Kids Yoga	Cosmic Kids	Free	28/07/18	Unknown	Unknown	1000+	4.5	4.8	No
DreamyKid - meditation app just for kids	Taylan Wenzel	Free	09/07/05	Not available	Unknown	Not available	3.4	Not available	No
Everywhere: mindful meditation[b]	Mindfulness Everywhere	Free	23/02/18	Unknown	Unknown	Unknown	Unknown	Unknown	No
Feeling Mindful	Morphonix LLC	3.49	16/11/15	16/11/15	Unknown	Unknown	Unknown	Unknown	No
Feeling Mindful Lite	Morphonix LLC	Free	16/11/15	23/12/15	Unknown	100+	Unknown	2.3	No
GoNoodle - Kid Movement & Mindfulness Videos!	GoNoodle, Inc.	Free	29/10/15	30/05/18	4	1,000,000+	4.1	4.3	No
Happy children	iMAX Games	3.49	05/05/17	Unknown	Unknown	Unknown	Unknown	Unknown	No
Happy little hearts meditation	Oceanhouse Media	7.49 (Android); 7.99 (iOS)	31/01/19	Unknown	Unknown	Unknown	Unknown	Unknown	No
Headspace: Meditation and Mindfulness	Headspace, Inc.	Free	02/02/12	06/01/12	2682	10,000,000+	5.0	4.5	Yes
Inner Explorer: Daily Mindfulness Practice	Inner Explorer, Inc.	Free	10/07/05	12/02/17	Unknown	1000+	4.3	4.5	No
LoveBcalm	LoveBcalm Inc.	3.49	01/08/18	01/08/18	Unknown	Unknown	Unknown	Unknown	No
MaddieDreams	Lisa Orchard	2.29	Unknown	Not available	Unknown	Not available	Unknown	Not available	No
MEDITATION FOR KIDS	Supportive Apps	Free	Not available	14/04/18	Not available	1000+	Not available	4.5	No
Meditation for kids	Sada Yogini (Google); Christine Creighton (Apple)	Free	21/10/18	06/01/19	Unknown	500+	4.9	4.2	No
Meditation Kids	Maria Rosa Valdes	Free	01/09/16	Unknown	Unknown	Unknown	5.0	Unknown	No
Meditation studio	Meditation studio	Free	16/12/15	23/11/16	Unknown	10,000+	5.0	4.6	No
Mental Stillness	Healthed	Free	25/05/17	Not available	Unknown	Not available	5.0	Not available	No
Mind Yeti	Committee for Children	Free	18/05/17	Not available	Unknown	Not available	3.0	Not available	No
Mindful Gnats	Handaxe Limited	Free	12/05/15	21/05/15	Unknown	10,000+	Unknown	4.6	No
Mindful Minutes - Relaxing Meditations for Kids	Oops yay	2.29	20/09/16	Not available	Unknown	Not available	Unknown	Not available	No
Mindful Powers	Smashing Ideas LLC	Free	12/10/17	Not available	Unknown	Not available	4.0	Not available	No
Mindful Powers edu	Smashing Ideas LLC	5.49	11/12/17	Not available	Unknown	Not available	4.0	Not available	No
Mindfulness for Children	Jannik Holgersen	6.49 (Android); 5.49 (iOS	Unknown	Unknown	Unknown	1000+	4.3	4.3	No
Mindfulness for Children free	Jannik Holgersen	Free	Unknown	03/12/14	Unknown	10,000+	3.7	3.0	No
Mindfulness Meditation for Children & Teenagers	James Holmes	5.49	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	No
Mindfulness with Petit BamBou	FeelVeryBien	Free	14/12/14	02/06/15	10+	1,000,000+	5.0	4.7	No
Mood Monster's yoga workshop	Karrin Burns	Free	03/06/18	Not available	Unknown	Not available	4.6	Not available	No
NutSpace - child development	NutSpace	Free	22/11/17	Unknown	Unknown	Unknown	Unknown	Unknown	No
One-Moment meditation	The One Moment Company LLC	Free	14/05/14	Unknown	Unknown	Unknown	5.0	Unknown	No
Rainbow country - meditation	Bo Kalvslund	1.09	05/08/18	Not available	Unknown	Not available	Unknown	Not available	No
Samten	Samten Limited	Free	02/02/18	01/02/18	Unknown	500+	Unknown	4.1	No
SB EN Lite (SoulBuddy)	Sophie Loof Martensson	Free	14/06/13	Not available	Unknown	Not available	Unknown	Not available	No

Table 1 (continued)

App name[a]	Developer	Cost	Release date		Number of installations		User ratings (max. 5)		Evidence based?
			iOS	Android	iOS	Android	iOS	Android	
Serenity: Guided Meditation	Olson Meditation and mindfulness apps Ltd	Free	01/09/18	30/08/18	Unknown	10,000+	4.5	4.7	No
Sitting Still	MindApps	1.79 (Android); 1.09 (iOS)	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	No
Smiling Mind	Smiling Mind	Free	01/10/12	06/10/14	Unknown	500,000+	4.0	3.9	Yes
SoulBuddy EN	Sophie Loof Martensson	2.29	08/02/13	Not available	Unknown	Not available	Unknown	Not available	No
Stop, Breath & Think Kids	Stop, Breathe & Think, PBC	Free	04/05/17	29/09/14	Unknown	1,000,000+	4.0	4.3	No
Super powers for super kids	ZenZone Interactive Limited	2.79 (Android); 2.29 (iOS)	09/07/14	Unknown	Unknown	Unknown	Unknown	Unknown	No
Take 10 Mindful Minutes	Frances Kelly	Free	30/05/14	25/05/14	Unknown	10,000+	Unknown	4.2	No
Take 5 Mindful Minutes	Frances Kelly	Free	06/11/14	27/05/14	Unknown	5000+	Unknown	4.1	No
Take a breather	Janine Fletcher	6.99	22/01/16	Not available	Unknown	Not available	Unknown	Not available	No
Time for time, a mindfulness meditation tool for young people[b]	DabApps	Free	13/10/15	Not available	Unknown	Not available	Unknown	Not available	No
Time in kid	Moving Graphics	2.29	06/10/17	Not available	Unknown	Not available	Unknown	Not available	No
Unplug: guided meditation	Unplug Meditation LLC	Free	01/02/17	Unknown	Unknown	Unknown	5.0	Unknown	No
Wellbeyond meditation for kids	Wellbeyond Inc.	Free	31/05/16	Not available	Unknown	Not available	4.5	Not available	No
Welzen: guided meditation	Welzen LLC	Free	26/01/16	27/05/16	Unknown	10,000+	4.5	4.3	No

[a] The apps are in alphabetical order and the names are presented as they were in the Google Play and Apple Store (uppercases included). The version of the apps used in this study may not be available in the Google Play and Apple Store at the current time, as they may be replaced or deleted. [b] Apps that were excluded from the app quality analysis due to technical issues that prevented us to log in

First, 37 apps were available in both Android and iOS and 19 apps were only available in iOS, whereas only one app was available in Android uniquely (*MEDITATION FOR KIDS*). Second, 19 apps were paid, with the cost ranging from 1.09€ to 7.99€. Third, the oldest apps were released in 2005 (*DreamyKid – meditation app just for kids* and *Inner Explorer: Daily Mindfulness Practice*), with the majority having been released after 2013. Fourth, though the number of installations was largely unknown (or not available), the most frequently installed app, with more than 10 millions of downloads, was *Headspace: Meditation and Mindfulness*, followed by *GoNoodle – Kid Movement & Mindfulness Videos!*; *Mindfulness with Petit BamBou*; and *Stop, Breath & Think Kids*, with more than 1,000,000 downloads. Fifth, there was no information on user ratings for almost half of the apps, but for those available, the best-rated apps were, for iOS and all with 5 stars, *Align Mindfulness*, *Headspace: Meditation and Mindfulness*, *Mental Stillness*, *Meditation kids*, *Meditation studio*, *Mindfulness with Petit BamBou*, *One-Moment meditation*, and *Unplug: guided meditation*, and for Android and all with more than 4.5 stars, *Cosmic Kids Yoga* (4.8 stars), *Mindfulness with Petit BamBou* (4.7 stars), *Serenity: Guided Meditation* (4.7 stars), *Mindfulness Gnats* (4.6 stars), and *Meditation studio* (4.6 stars), whereas the poorest rated apps were *Mind Yeti* for iOS (3 stars) and *Feeling Mindful Lite* for Android (2.3 stars). The number of downloads and user ratings should however be read careful, as it may not equate to app usage or quality (BinDhim et al. 2015). Downloads and ratings could have been made by publishers with promotion goals as well as by consumers, including not only target users (i.e., children) but also their caregivers, who are mediators of children's app use (Nikken and Schols 2015).

Finally, our search revealed that only two apps were found to have published evidence on their effectiveness, though in adult populations. We found 21 studies (11 randomized controlled trials) testing the effects of *Headspace: Meditation and Mindfulness*, including one study that compared this app with *Smiling Mind*. Because to describe these studies goes beyond the scope of this paper, we provide a full list of these studies in Supplementary Table 1. Some of them are briefly mentioned in what follows to illustrate mindfulness apps' effects. There is evidence on the benefits of *Headspace: Meditation and Mindfulness* in the general population (Bennike et al. 2017), university students (Flett et al. 2020), clinical patients (Kubo et al. 2018), and medical staff (Yang et al. 2018), in a wide range of health-related and psycho-social outcomes, such as wellbeing (Bostock

et al. 2019), anger and aggression (DeSteno et al. 2017), stress (Economides et al. 2018), or depression (Fish and Saul 2019). *Smiling Mind* had positive effects on the improvement of depressive symptoms, college adjustment, and resilience on university students (Flett et al. 2018).

Because we were not authorized by the University to buy paid apps, only the 38 free mindfulness-based apps were selected for further qualitative analysis. Two additional apps were excluded due to technical issues that prevented us to log in. Thus, the final number of rated apps was 36 (links for download are provided on Supplementary Table 2). As per the descriptive text in the store, all of these apps were deemed suitable for children, but only 17 were specifically designed for this population.

The final scores for each app by MARS dimension and overall quality (1—Inadequate, 2—Poor, 3—Acceptable, 4—Good, 5—Excellent) are presented in Table 2. In this table, we also identified the three best apps and the three worst apps in each dimension. The 36 mindfulness apps reviewed had a mean overall quality of 3.41, suggesting an "acceptable" level of quality. The *Mindfulness with Petit BamBou* app had the highest overall quality score (4.33), followed by *Headspace: Meditation and Mindfulness* (4.26), *Breethe - Guided Meditation and Mindfulness* (4.20), and *Stop, Breath & Think Kids* (4.20). The lowest overall quality app was *Align Mindfulness* (2.27), followed by *MEDITATION FOR KIDS* (2.67), and *DreamyKid – mediation app just for kids* (2.73).

An analysis of the 36 apps by MARS dimension showed that the higher average score was obtained for the functionality dimension (average of 3.94), with 97% of the apps being rated as having an "acceptable" level of quality (i.e., 3 or above). The second and third best-rated dimensions concerned information (average of 3.39), with 78% of the apps being considered to have an "acceptable" level, and aesthetics (average of 3.30), with 67% of the apps being considered to have an "acceptable" level. Finally, the poorest rated dimension was engagement (average of 3.01), with 50% of the apps rated has "inadequate" or "poor."

Table 3 details the main features of the 36 apps. Results showed that one-third of the apps required users to be registered and provide personal data. Almost all apps presented the exercises with the support of audio files (e.g., meditation guidance), whereas less than half included demonstration videos (e.g., *Cosmic Kids Yoga* asked children to mimic the visual input). Only 11 apps used video presentations coupled with audio information. One app (*Align Mindfulness*) provided neither audio nor video information, but only pop-up questions for users to reply through texting. Only 16 apps could be programmed to notify users about their mindfulness training through reminders. Nine apps included an option to share the experience in a social network. About one-half of the 36 free apps offered limited free content and included in-app purchase options to add new contents (e.g., meditations, full programs).

All apps requested users to play an activate role when performing a particular exercise. Excepting the *Align Mindfulness* app above mentioned, all of these exercises consisted of meditation combined with breathing and body scan aimed to promote users' awareness of the present moment. These meditations were mainly guided through voice, combined or not with visual input. For example, the *Mindfulness with Petit BamBou* app included the "calming breath of 3 min" where a soothing voice directed the child to breath slowly and gently and to focus on the good sensations of the body. Some apps presented these guided meditations through videos (e.g., animations, mascots, or real people) in order to demonstrate how to perform technique, for example, how to breath correctly. The *Align Mindfulness* app, instead of meditation, presented thought-provoking reflection prompts, where users could type up a response or take a moment to reflect on it (e.g., what has been the best part of the day?). This app was rated as having poor scores in all dimensions of MARS. Five of the apps additionally included passive activities, where users were provided with theoretical information related to mindfulness. In three of these apps (*Chill Panda*; *Feeling Mindful Lite*; and *Stop, Breath and Think Kids*), this educational component aimed to teach children about emotions and how to identify feelings. For example, the *Feeling Mindful Lite* app explained in a simplified way through animations the role of amygdala on emotions and the role of brainstem on breathing.

Only eight apps provided program-based training, which combined several exercises to be implemented throughout time in a sequential way. For example, *Headspace: Meditation and Mindfulness* provided free access to a 10-day program with 10 guided meditation sessions of approximately 10 min each (Take 10 program). The *Inner Explorer: Daily Mindfulness Practice* program offered 5 to 10 min of audio-guided daily practices appropriate for four different age groups (from pre-kindergarten to Grade 12). *Mindfulness with Petit BamBou* included a set of guided meditations to be followed according to specific order and organized by themes. Among these themes, only the "Discovery program," with eight sessions to be implemented in sequence, was available for free. *Mindful Powers* guided kids through a series of 10 progressive and interactive voice-guided sessions. *Samten* offered the "30-day challenge," which is a step by step program. *Serenity: Guided Meditation* presented a variety of mindfulness techniques organized into different levels of complexity. *Smiling Mind* provided programs for different ages and contexts (e.g., classroom and workplace). *Welzen: guided meditation* offered progressive mindfulness meditation practice with specific goals (e.g., sleep better).

Table 2 Evaluation of the 36 mindfulness-based apps for children (max. 5 points) with indication of the three best (+) and three worst (-) apps per MARS dimension

App name	Engagement		Functionality		Aesthetics		Information		Overall quality	
Align Mindfulness	2.03	-	2.38	-	2.28	-	2.39	-	2.27	-
BreazeApp	2.37		4.33		2.22	-	2.76	-	2.92	
Breethe - Guided Meditation and Mindfulness	3.73		4.38		4.50	+	4.18	+	4.20	+
Chakra chime	2.50		3.42	-	2.44		2.64	-	2.75	
Children's bedtime meditation	2.87		3.88		3.22		3.38		3.34	
Chill Panda	3.47		3.71		2.72		3.29		3.30	
Chill Skills	2.57		3.71		2.83		3.40		3.13	
Cosmic Kids Yoga	3.47		4.08		3.72		3.24		3.63	
DreamyKid - meditation app just for kids	2.33		3.33	-	2.33		2.92		2.73	-
Feeling Mindful Lite	2.70		4.13		2.83		3.51		3.29	
GoNoodle - Kid Movement & Mindfulness Videos!	3.27		3.96		3.67		3.53		3.61	
Headspace: Meditation and Mindfulness	3.97	+	4.50	+	4.56	+	4.00		4.26	+
Inner Explorer: Daily Mindfulness Practice	3.13		3.67		2.78		3.54		3.28	
MEDITATION FOR KIDS	1.73	-	3.46		2.39		3.12		2.67	-
Meditation for kids	3.07		3.92		3.22		3.08		3.32	
Meditation Kids	2.43		4.17		3.00		3.29		3.22	
Meditation studio	3.27		4.04		4.50	+	3.64		3.86	
Mental Stillness	2.57		4.13		3.56		3.13		3.34	
Mind Yeti	3.33		4.04		3.89		3.70		3.74	
Mindful Gnats	2.97		3.88		3.11		3.49		3.36	
Mindful Powers	3.80		3.88		3.89		3.70		3.82	
Mindfulness for Children free	2.53		3.92		2.17	-	3.41		3.01	
Mindfulness with Petit BamBou	3.93	+	4.50	+	4.44		4.43	+	4.33	+
Mood Monster's yoga workshop	2.97		4.50	+	3.06		2.79		3.33	
NutSpace - child development	3.40		3.79		3.39		3.67		3.56	
One-Moment meditation	2.90		4.13		3.00		3.42		3.36	
Samten	3.10		3.42		3.67		3.33		3.38	
SB EN Lite (SoulBuddy)	2.40		4.04		3.06		2.94		3.11	
Serenity: Guided Meditation	3.80		4.46		4.06		4.12	+	4.11	
Smiling Mind	3.70		3.75		3.56		3.34		3.59	
Stop, Breath & Think Kids	3.97	+	4.38		4.44		4.03		4.20	+
Take 10 Mindful Minutes	2.23		4.13		2.50		2.96		2.95	
Take 5 Mindful Minutes	2.20	-	4.13		2.56		2.92		2.95	
Unplug: guided meditation	3.57		3.75		3.61		3.99		3.73	
Wellbeyond meditation for kids	2.63		4.13		3.61		3.21		3.39	
Welzen: guided meditation	3.33		4.00		3.94		3.61		3.72	
M (*SD*)	3.01 (0.60)		3.94 (0.41)		3.30 (0.72)		3.39 (0.46)		3.41 (0.48)	

Discussion

The ubiquity of technology in children's life makes mobile apps a convenient way to implement interventions, such as mindfulness, to support their health and favor school achievement. There is now an increasing number of studies showing the validity of technology-delivered mindfulness interventions in adults (e.g., Flett et al. 2018), and preliminary evidence on their added value over face-to-face settings in children (Tunney et al. 2017). However, despite the large amount of mindfulness apps currently available to the public, little is known about the quality and characteristics of the apps available to users, particularly children. This study aimed to overcome this gap in two ways. First, we examined how many mindfulness-based apps were available for children in both iOS and Android systems and identified their main features. Second, an expert multidisciplinary team

Table 3 Summary of the main features of the 36 mindfulness-based apps for children

App name	Register	Audio	Video	Remind	Share	Purchases	Activities	Program
Align Mindfulness				✓			A	
BreazeApp		✓		✓			A	
Breethe - Guided Meditation and Mindfulness		✓	✓			✓	A	
Chakra chime		✓		✓			A	
Children's bedtime meditation*		✓			✓	✓	A	
Chill panda*		✓	✓				A+P	
Chill Skills	✓	✓	✓		✓	✓	A	
Cosmic Kids Yoga*	✓		✓		✓	✓	A+P	
DreamyKid - meditation app just for kids*		✓				✓	A	
Feeling Mindful Lite*			✓				A+P	
GoNoodle - Kid Movement & Mindfulness Videos!*			✓			✓	A	
Headspace: Meditation and Mindfulness	✓	✓	✓	✓	✓	✓	A	✓
Inner Explorer: Daily Mindfulness Practice	✓	✓		✓	✓		A	✓
MEDITATION FOR KIDS*		✓				✓	A	
Meditation for kids*		✓	✓		✓	✓	A	
Meditation Kids*		✓				✓	A	
Meditation studio		✓		✓		✓	A	
Mental Stillness		✓	✓				A	
Mind Yeti*	✓	✓					A	
Mindful Gnats*		✓	✓				A	
Mindful Powers*		✓		✓		✓	A	✓
Mindfulness for Children free*		✓		✓	✓	✓	A	
Mindfulness with Petit BamBou	✓	✓	✓	✓	✓	✓	A	✓
Mood Monster's yoga workshop*			✓				A	
NutSpace - child development*	✓		✓	✓			A+P	
One-Moment meditation		✓		✓			A	
Samten	✓	✓	✓	✓			A	✓
SB EN Lite (SoulBuddy)		✓				✓	A	
Serenity: Guided Meditation		✓		✓		✓	A	✓
Smiling Mind	✓	✓	✓	✓			A	✓
Stop, Breath & Think Kids*	✓	✓	✓	✓			A+P	
Take 10 Mindful Minutes		✓					A	
Take 5 Mindful Minutes		✓					A	
Unplug: guided meditation	✓	✓			✓	✓	A	
Wellbeyond meditation for kids*		✓				✓	A	
Welzen: guided meditation	✓	✓		✓		✓	A	✓

A = child has active role (e.g., breath). P = child has passive role (e.g., listen to a lecture).*Specifically designed for children

evaluated the quality of the apps in terms of engagement, functionality, aesthetics, information, and overall quality.

Through a combined human-machine procedure, we conducted a systematic search on Google Play (Android) and Apple Store (iOS) that resulted in the identification of almost 2000 mindfulness-based apps. However, less than 3% of those apps were deemed suitable for children. This finding suggests that the development of mindfulness-based technology is mainly oriented to the adult population, similarly to the scientific literature on the topic. Contrasting with the large evidence supporting the efficacy of mindfulness interventions in adulthood (for a review, see Keng et al. 2011), researchers interest on its effects on youngsters is recent, albeit growing (Carsley et al. 2017; Dunning et al. 2018; Zoogman et al. 2014). The market offering mindfulness apps seems to clearly mimic the landscape of the scientific literature currently available.

Among the 57 apps identified, we reviewed the 36 free apps. Together, these mindfulness apps were rated by the expert team as having an "acceptable" level of quality. An analysis by MARS dimension revealed that they had a good level of functionality and acceptable levels of information, aesthetics, and engagement, being this last dimension the one with the lowest score. The same pattern of MARS results was found for mindfulness-based apps restricted to the iOS system and not specifically targeted for children (Mani et al. 2015). Moreover, among the 36 apps reviewed, five obtained a rating of "good" (4.0 or above) in terms of overall quality (viz., *Mindfulness with Petit BamBou*; *Headspace: Meditation and Mindfulness*; *Breethe - Guided Meditation and Mindfulness*; *Stop, Breath & Think Kids*; and *Serenity: Guided Meditation*). These five apps were also among those receiving the highest user ratings (all with more than 4.5 stars). For the expert team, the best-rated app with a score of 4.33 was *Mindfulness with Petit BamBou*. This is a customizable app that includes a catalog of guided meditations with more than 240 lessons, suitable for beginner or experienced practitioners. It provides a meditation program organized by themes, covering topics such as sleep and stress management. It includes a mindfulness program for 5–12-year-olds aimed to increase kids' knowledge about themselves and help them to achieve internal peace. The app presents good child-specific features in a clean and colorful design (Sherwin and Nielsen 2019). Usage and navigation are facilitated by simple menus, easy actions, and no back button. The ability to entertain is assured by interactive exercises and short animations explaining meditation principles in instructive and funny ways. This was one of the best user-rated apps (5 stars for iOS and 4.7 stars for Android), with more than one million downloads. Unfortunately, it is not evidence based yet.

Our review also showed that seven apps obtained an overall quality rating of "poor" (below 3.0; *Align Mindfulness*, *MEDITATION FOR KIDS*, *DreamyKid - meditation app just for kids*, *Chakra chime*, *BreazeApp*, *Take 5 Mindful Minutes*, and *Take 10 Mindful Minutes*). These findings suggest that there is room for improvement in what concerns the quality of mindfulness apps available for children. This seems to be particularly important regarding the capability of the apps to be entertaining, interactive, and visually appealing, which are key features of child-targeted apps (Sherwin and Nielsen 2019). Mkpojiogu et al. (2018) claimed that the usability of an app involves not only the way users may interact with it but also the design of the interface. For that reason, an attractive and clean interface is one of the most important components of the apps as it will allow users to create a first impression and, eventually, determine its sustained use over time. Several of the reviewed apps, especially the lowest scored ones, presented complex and sometimes confusing layouts, which could pose difficulties for child users to understand how the app works, resulting in quick saturation and easy drop out. Rather than presenting too much information and colors, a clean design is characterized to be simple, yet stylish and functional (Mkpojiogu et al. 2018). Though content and functionality aspects are undoubtedly relevant, the design and development of apps should take into account usability issues, as these are a main predictor of people's acceptance and intention to use technology (Tao et al. 2019). Designing apps to promote children's wellbeing seems necessary to ensure that the apps are aligned with their development, abilities, and interests (Yarosh and Schueller 2017). For a sustained use, children's apps should be fun, attractive, easy to use, learnable, and understandable (Sherwin and Nielsen 2019). As observed here via MARS results, though achieving good levels of functionality, the majority of the apps exhibited lower than desirable scores concerning degree of information, aesthetics, and engagement.

Concerning apps features, most of them included audio files to support mindfulness exercises. Typically, these consisted of guided meditations aimed to raise children's awareness of the present moment. Children listen to a soothing voice that guides the focus of their attention during different activities, such as the sensations experienced during breathing, and that helps them to return to the task when the mind wanders. As noted in the "Introduction" section, these kinds of meditation-based exercises are at the core of mindfulness interventions (Bishop et al. 2004; Greenberg and Harris 2012; Zelazo and Lyons 2012). The effectiveness of using audio-guided tracks to facilitate daily mindfulness practices has already been reported (Bakosh et al. 2018). Therefore, their inclusion in the large majority of mindfulness apps for children is a valuable point, particularly when combined with video demonstrations. Indeed, an advantage of using apps for the practice of mindfulness is precisely the possibility of adding visual content to the verbal information provided. This can be an asset for child users, allowing them to grasp the most abstract concepts associated with mindfulness (O' Reilly et al. 2016). A reduced number of apps additionally included activities to potentiate the acquisition of mindfulness-related concepts. In particular, three apps (*Chill Panda*; *Feeling Mindful Lite*; and *Stop, Breath and Think Kids*) added contents to increase children's knowledge about emotions and to help them to identify their own feelings. Though disregarded in the majority of the apps here reviewed, this focus on emotions seems particularly useful as mindfulness is closely related to emotional regulation (Hill and Updegraff 2012). Finally, a less than desirable result was that only eight apps provided users with the option of running a program-based mindfulness training. A similar finding was already reported by Mani et al. (2015). This is problematic because, though little is still known about the best dosage and duration of mindfulness practice, there is evidence supporting the need for consistent practice over time to achieve positive and long-lasting effects (Bishop et al. 2004; Greenberg and Harris 2012; Zelazo and Lyons 2012).

It is worth highlighting that only two apps were found to have published studies aimed to provide scientific evidence about apps effectiveness (*Headspace: Meditation and Mindfulness* and *Smiling Mind*). Regrettably, this evidence only concerns adult populations and cannot be generalized to child populations. Simply put, none of the 57 mindfulness apps identified here seems to have scientific evidence supporting their effectiveness in children. This finding joins to those from a systematic review of mental health apps, which concluded that there is insufficient research evidence showing effectiveness of these apps in preadolescents and adolescents (Grist et al. 2017). BinDhim et al. (2015) similarly concluded that few studies attempted to evaluate the efficacy of health-related apps, and that even consumers' use behaviors were being overlooked. These are rather concerning findings because, paid or not, these non-evidence-based apps are freely available to people, achieve massive downloads, and may eventually be used by children.

In addition to gather valid information concerning these apps' effectiveness, it seems also important to gain insight into the differential effects of those apps against face-to-face settings. As detailed before, the use of apps is particularly appealing for child users and it may overcome several barriers. However, it may also create new challenges that have not been properly explored (e.g., children's difficulties in using apps, role of parents). Actually, given the importance of using duly trained and qualitied instructors to delivering mindfulness interventions (Zelazo and Lyons 2012), how is such expertise replaced by an app? All in all, although the available literature on delivering mindfulness interventions to adults via mobile applications seems promising, we still have a very long way to go in order to develop high-quality, appealing, and evidence-based apps to promote mindfulness skills in children. Until then, careful consideration in using available apps is clearly warranted.

Limitations and Future Research

Some limitations should be kept in mind when interpreting current findings. Only free apps (and free contents) were evaluated with MARS. Though this limits the generalization of the results to paid apps, it does not diminish their practical relevance. Our analyses focused on the most accessible apps, more likely to be downloaded and used by potential users, who typically use cost as a key criterion to install an app (Harbach et al. 2014). Still, future research should aim to examine the features and quality of paid mindfulness apps and compared them with free ones. Concerning MARS, it should be noted that this tool was developed to evaluate health-related apps targeting any age group. It would be useful to develop a MARS version specifically aimed to assess the degree to which an app claimed to be for children is actually appropriate for them and account for their developmental needs. Second, our MARS evaluation was made by an expert multidisciplinary team, leaving the target users out of the process. Despite the undeniable interest of measuring children's perceived quality of mindfulness apps, there is currently no valid instrument to that purpose. MARS was developed to be used by trained experts (Stoyanov et al. 2015), and the subsequently developed user version (uMARS) was only tested with 16–25-year-olds and requires a Grade 8 reading level (Stoyanov et al. 2016). Thus, there is no evidence about its validity and reliability for children. In any case, MARS and uMARS cannot replace the employment of user-centered and experimental to develop apps, examine end users' experiences, test apps' effectiveness, and improve their quality (Mani et al. 2015). Further efficacy and usability studies are clearly needed in the field to determine the best evidence-based mobile apps in the market and prompt their use in the benefit of children's health.

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Authors' contribution AN and TL designed and executed the study, analyzed the data, and wrote the manuscript. SLC collaborated with the design of the study and assisted with writing and editing of the final manuscript. All authors approved the final version of the manuscript for submission.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval This article does not involve human participants.

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