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A randomized controlled trial for evaluating the effects of an online mindfulness-based intervention for parents of children with attention-deficit/hyperactivity disorder: a study protocol

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Abstract

Background Childhood attention-deficit/hyperactivity disorder (ADHD) has been associated with poor family functioning and higher risks of conflicts in parent-child relationships. Mindfulness-based intervention (MBI) has been evaluated for its benefits in improving family functioning and has been increasingly applied within the context of a family environment. Furthermore, online MBIs have been developed and combined with multiple technologies used by practitioners and researchers due to their lower cost, ability to overcome geographic restrictions, and capacity to mitigate the impacts of unpredictable events such as the COVID-19 pandemic. Given the limitations of current online MBI research such as the absence of control groups, small sample sizes, and a low completion rate, this study aims to evaluate the effects of an online family MBI on the outcomes of children with ADHD and their parents.

Methods This study is a two-arm randomized controlled trial (RCT) study, comparing online family MBI (arm 1) and an online psychoeducation program (arm 2) designed for parents and their ADHD children. The outcome measures of child ADHD symptoms, child executive functioning, parent mental health, sleep quality, and family expressed emotions will be assessed before the interventions (T0), immediately after the interventions at 4 weeks (T1), and at three-month after interventions (T2). Intent-to-treat principle will be used to conduct quantitative data analysis. Chi-squared difference tests and *t*-tests will be performed to compare the differences between groups, and a linear mixed model will be conducted to examine the time effects and time × group effects. Mediation analysis will be conducted to see the mediating roles of parental stress and expressed emotions of parents.

Discussion This study transfers the promising effect of online MBI to clinical populations, particularly for parents of children with chronic conditions, and the children themselves. By examining expressed emotions within the family

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context, the findings might shed light on the mechanism of the online MBI in affecting the mental health outcomes of parents and the ADHD symptoms and executive functioning of their children.

Trial registration This study has been registered with ClinicalTrials.gov (NCT06298136||https://www.clinicaltrials.gov/). The registration date was 7th March, 2024.

Keywords Mindfulness-based intervention, Online, Attention deficit/Hyperactivity disorder, Parents, Randomized controlled trial

Background

Attention Deficit/Hyperactivity Disorder (ADHD) is a developmental disorder that is frequently diagnosed and characterized by symptoms such as inattention, hyperactivity, and impulsivity. These symptoms often lead to difficulties in social and academic performance, as well as deficits in executive functions (EFs), which include cognitive flexibility, self-regulation, and problem-solving abilities [1]. According to the 5th edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) [2], the prevalence of ADHD can be up to 5%. A previous study conducted by Leung et al. [3] estimated that 3.9% of Chinese adolescents were diagnosed with symptoms of ADHD, and a national survey in the United States further stated that 9.4% of children aged 2–17 years old had been diagnosed as having ADHD [4]. When exhibiting hyperactive and impulsive behaviors, ADHD children might engage in physical and relational aggression, have difficulties in social functioning and school performance, and even cause physical accidents, and thus, encounter rejection from peers [5, 6].

Childhood ADHD has been associated with poor family functioning and an increased likelihood of conflict in parent-child relationships [7]. Challenging child behaviors and harsh parenting can be exacerbated in a dyadic process. When children show their comorbid oppositional and conduct problems in the family context, parents are more prone to respond with rejection, heightened hostility, and negative emotionality, which further deteriorates children's ADHD symptoms [8]. According to previous studies [9, 10], parents of children exhibiting ADHD symptoms have been shown to experience higher levels of psychological distress and marital conflicts, along with lower levels of parenting satisfaction, social support, and quality of life. In order to address the negative interactions within the parent-child relationship, interventions should not only target the ADHD symptoms in children but also aim to enhance parents' understanding of these symptoms. It is crucial to recognize that many parents themselves may exhibit symptoms of ADHD, underscoring the importance of parents acknowledging their own inattentiveness, hyperactivity and impulsivity which can contribute to inappropriate parenting styles such as overreactive parenting. The interaction between children with ADHD and their parents can potentially exacerbate the symptoms [11]. Therefore, interventions that adopt a family-centered perspective can play a significant role in enhancing parents' knowledge and capabilities in effectively interacting with their ADHD children, ultimately leading to improved family functioning and dynamics [12].

Mindfulness-based intervention in the family context

Pharmacotherapy and behavioral interventions have traditionally been the primary treatments for symptoms of childhood ADHD. However, it is important to be aware of the potential side effects of pharmacotherapy, which can include increased negative emotions, sleep disturbances, and decreased appetite [13]. Additionally, parents who are dealing with their child's ADHD symptoms may find it challenging to adhere to the protocols of behavioral interventions. Furthermore, the long-term effectiveness of these interventions is questionable due to the difficulties parents and their children with ADHD may face in maintaining consistent self-training practices [14, 15].

Mindfulness-based intervention (MBI) has been applied in several conditions and situations, especially for enhancing the mental health status of individuals with chronic medical conditions. Mindfulness involves training oneself to regulate attention in order to maintain a non-judgmental awareness of the present moment while adopting an attitude of "curiosity, openness to experience, and acceptance" [16]. This approach can be helpful in developing more effective coping strategies. MBIs encompass a variety of mindfulness exercises, such as mindful breathing, mindful eating, mindful stretching, body scans, and mindful sitting. These practices are designed to help individuals cultivate awareness of bringing attention back to a chosen anchor such as a breath or a part of body [11], and strengthen their coping mechanisms for everyday life challenges.

MBIs have been evaluated for their potential effects on various aspects of both child and parent status. Mindfulness practices are considered beneficial for promoting children's cognitive development. Takacs et al. conducted a meta-analysis of 90 behavioral interventions, demonstrating a significant moderate effect of mindfulness practices on children's executive functioning [17]. In another

meta-analysis of 13 studies focusing on children and adolescents [18], 5 studies confirmed significant effects of MBIs on children's attention or executive functioning.

The outcomes for parents have also been examined. A systematic review of 10 studies involving parents and their children with ADHD found that MBP for parents resulted in small-to-large within-group effects on parenting stress post-treatment [19]. It was also found to be superior to other active controls in reducing parenting stress. Another review also reported a small positive effect of child-parent parallel MBIs on parental mental health [20]. In a systematic review by Ruskin et al. [21], six studies focused on detailed aspects of parent mental health of depression or anxiety, with four studies reporting significant improvements through mindfulness or acceptance interventions. In a self-help MBI towards health parents, their mindfulness and well-being status were significantly higher compared to those in the waitlist control group [22]. Additionally, MBIs were found to be acceptable and feasible for enhancing sleep quality among adults, helping them fall asleep faster and stay asleep [23]. Burgess et al. assessed the effectiveness of an online mindfulness practice in a qualitative study [24]. Beyond its acceptability and usability, improved sleep quality was reported by 11 out of 12 parents of children aged 2–5 years in low-risk families.

Moreover, previous reviews have explored the advantages of MBIs in enhancing family dynamics, revealing an increasing interest in their application within family settings. Burgdorf et al. reported that MBI could potentially alleviate parental distress, with effects ranging from small to moderate in terms of sustainability [25]. Xie et al. observed small positive effects of MBI in improving family functioning and mental health status of both parents and children [20]. For children with ADHD and their parents, a randomized controlled trial (RCT) reported small but non-significant post-intervention effects of an 8-week family MBI in children's ADHD symptoms and mindful parenting compared with the control group of care-as-usual treatment [26]. Similar results were reported by Lo et al. that the family MBI showed a significant improvement in children's ADHD symptoms and a reduction of parental distress compared with the waitlist-controlled group [27]. When compared to multiple forms of treatments such as the traditional cognitive behavioral therapy [28] and pharmacology [29], MBIs were also reported to be an effective alternative or addition in the treatment of childhood ADHD. Especially, MBIs might be more acceptable to families than medication [29]. Above all, the effects of MBI have highlighted its potential benefits from family perspectives, which might be a supplementary approach based on pharmacotherapy to improve the quality of lives of both children with ADHD symptoms and their parents. However, face-to-face MBI for families are challenging in implementation due to high demands in recruitment and logistic arrangement and many families may not be available to identify one within their care system. Alternative delivery mode should be considered for enhancing mental health care accessibility.

Online or apps-based MBIs have been developed and combined with multiple technologies used by practitioners and researchers for their lower cost, overcoming geographic restrictions, and mitigating the impacts of unpredictable events such as the COVID-19 pandemic. Despite these advancements, online MBIs are still in their infancy and face several challenges. First, existing research often suffers from methodological limitations, such as the absence of control groups and small sample sizes, which hinder the ability to generalize and validate the effectiveness of online MBIs [19]. Second, engagement is the key factor for exerting the effects of MBI. Parents of children with ADHD already struggle to balance work and family responsibilities, and some also contend with attention difficulties [30], which can make daily mindfulness practice challenging. Particularly with online MBIs, completion rates reported by parents have been lower than 30%, and data specifically regarding parents of children with ADHD is not yet available [31].

Thus, the online-based MBI should be adjusted to be better adapted to the nature of the target population. Previous strategies, such as phone support from mentors and daily digital reminders, have shown limited success in boosting engagement. Given that the parents of children with ADHD might experience significant higher level of parental stress [9, 10], future online MBIs should explore integrating professional support with various technological approaches. Enhancing the availability of professional support, along with incorporating emergency management and building rapport through audio and video, could improve motivation and provide a sense of security, encouraging parents to complete the online MBI [32].

This research modified our online-based MBI to be more accessible and engaging for parents of children with ADHD symptoms [22]. Our program includes short online videos for psychoeducation and audio guidance for mindfulness exercises for both children and parents, each lasting between 3 and 15 min for daily practice. A previous RCT study with healthy parents indicated that such a self-help program could be beneficial in reducing anxiety and increasing mindfulness and overall well-being [22]. Additionally, we incorporated weekly live online meetings for parents with instructors into our online MBI, and our pilot study has reported significant positive outcomes of inattention and hyperactivity related to child ADHD symptoms [33].

The mechanism of online MBI in treating child ADHD within family context

Online family MBI has been considered to improve expressed emotions (EEs), which might be a crucial element to understand the mechanism of online MBI within the family context. EE is a concept commonly used within a family environment of criticism, hostility, and over-involvement, which can be associated with clinical outcomes of serious mental disorders [34]. EE has been found to buffer the negative mental health outcomes of both parents and their children with ADHD symptoms, and parenting interventions have also been investigated for their ability to reduce the EE experienced by parents of children with ADHD symptoms [35, 36]. In line with the findings from a previous RCT study, young adults experiencing their first episode of psychosis exhibited a significant decrease in perceived criticism and over-involvement after their caregivers participated in an MBI [37]. In the pilot study preceding this protocol, improvements were observed in parental stress and children's ADHD symptoms within the online MBI group [33]. The positive changes might be given insights by the framework of EE, which also contributed potential research directions for the mechanisms behind online family MBIs.

The role of EEs within the family context requires additional exploration due to its varied impact across different populations and cultural backgrounds. Results of a meta-analysis showed the predicting role of criticism from parents in the relapse of first episode psychosis [38]. Similar to the results reported by Musser et al. [39], they found that parental criticism had negative effects on the development of children with ADHD. However, findings from another study only demonstrated the associations between maternal criticism and oppositional behaviors but not ADHD severity, indicating that the lasting effects of EE warrant further investigation [40]. Besides, criticism and similar parental attitudes seem to be more acceptable in Asian families and other countries with a culture of collectivism [34, 41]. Ng et al. found that the scores of participants who scored above cut-off scores in EEs were elevated 6 times of one-year relapse of schizophrenia, suggesting the damaging effect of EE [42]. Currently, EE has been little studied in child ADHD in Asia, which requires more studies to examine the roles of EEs targeting both children with ADHD and their Asian families.

Research objectives

The primary aim of this study is to examine the effects of the online family MBI on the outcomes of children with ADHD and their parents compared with a psychoeducation program across three time points of pre-test, post-test, and three-month follow-up. The secondary objective is to explore the mechanism of the online family MBI in affecting the outcomes of children with ADHD and their parents by investigating the mediating effects of EEs and parenting stress in predicting the outcomes of the online family MBI on both children's and parents' status. Based on the objectives, this study has three hypotheses accordingly:

1. Compared with the active control group of a psychoeducation program, parents who complete the online MBI are going to report a significant larger reduction of child ADHD symptoms as well as improvement in child executive functioning, parent sleep quality, and parental mental health status, including their reduced depression, anxiety, and increased well-being status.
2. Based on the previous study [37] and theoretical framework [34], parents who complete the online MBI will report significantly lower levels of parental stress and EEs, compared with the parents who participate in the active control group.
3. Based on the hypothesized positive changes in child ADHD symptoms, parental stress, and EEs, this study hypothesizes that the changes in parental stress and EEs will mediate the changes in child ADHD symptoms.

Methods

This study has been designed as a two-arm randomized controlled trial (RCT) study. The effects of the online MBI (arm 1) are examined by comparing it with the effects of the psychoeducation program (arm 2). The outcome measures will be assessed before the interventions (T0), after the interventions (T1), and at three-month follow-up (T2). Study flow has been depicted in Fig. 1.

Intervention

The interventions have been designed to consist of online courses and online group meetings. Based on the previous attempts of our research team [22, 33], an online MBI (arm 1) has been developed for parents and their children with ADHD symptoms. There are five modules in total, and the first four modules are developed for parents, including *Mindfulness and attention*, *Mindfulness and physical sensation*, *Mindfulness and parental stress*, *and Mindfulness and self-care*. The detailed contents of the online MBI can be seen in Appendix 1. Each module contains psychoeducation videos lasting 3–7 min with 5–15 min of audio mindfulness exercises. There were a total of 20 psychoeducation videos, and five of them provided additional guidance for parents to practice parent-child mindfulness exercises with their children. The fifth module of the online MBI was designed for children with ADHD symptoms. Considering their

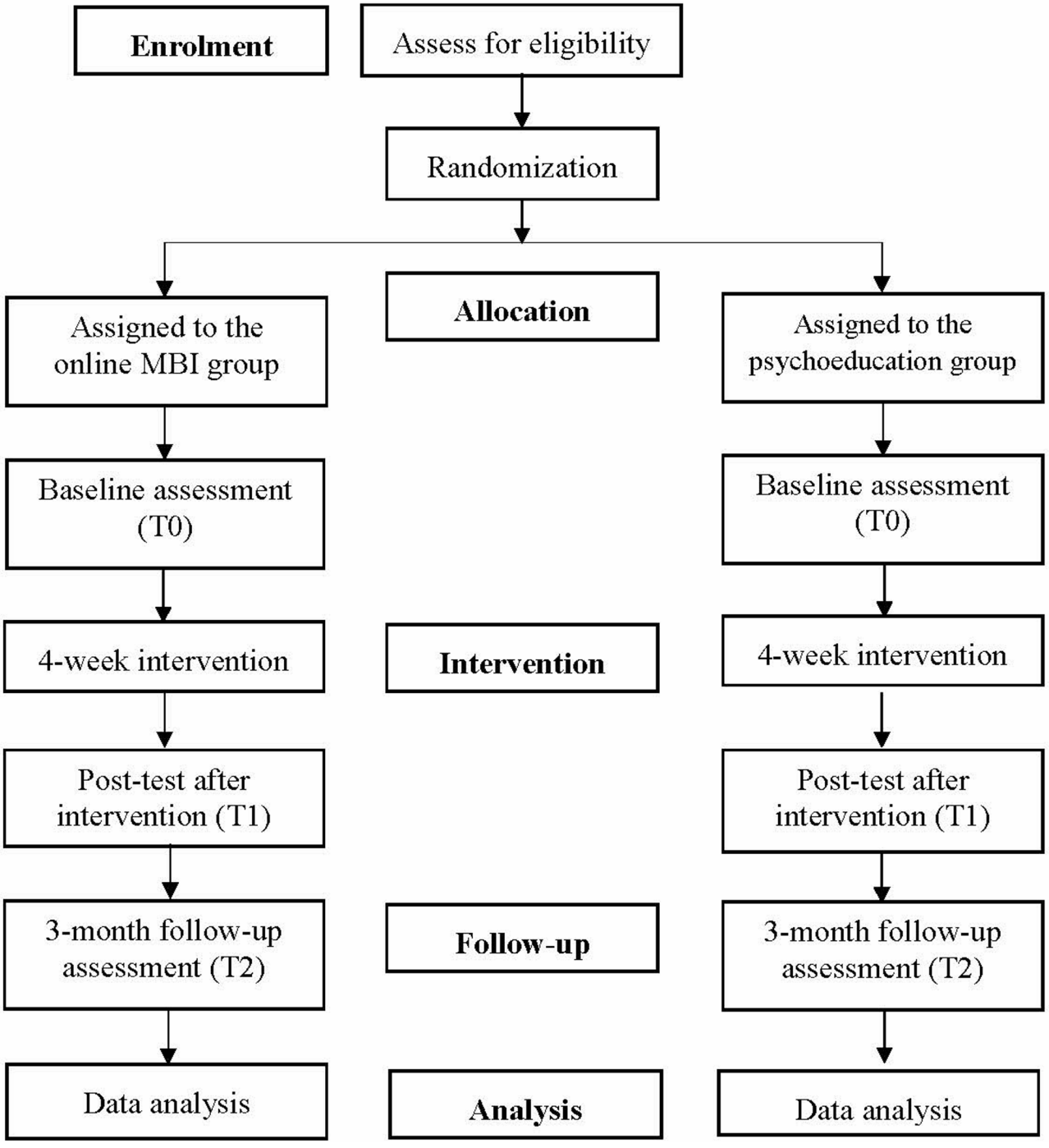

Fig. 1 The flow diagram of this study

attention span, each psychoeducation video with audio of mindfulness exercises only lasts 3–5 min. The online psychoeducation program (arm 2) adopted the parent training mostly developed by Russell Barkley, which has been widely applied in treating child ADHD and other behavioral disorders [43, 44]. There are five modules in arm 2, including *Understanding of ADHD symptoms*, *General behavior management principles*, *Positive reinforcement and attending skills*, *The use of reward and token system*, *and Children problem solving skills* [44, 45]. Each model has five videos for parents and one video for children. For the detailed contents of the psychoeducation program please refer to Appendix 2.

Two arms are parallel programs, and each program contains 24 psychoeducation videos lasting 5 to 7 min. Apart from daily online psychoeducation videos, both

arms include four weekly online group meetings for parents. In arm 1, the group meeting will conduct real-time mindfulness exercises led by instructors, share exercise experiences at home, and discuss the application of mindfulness in their daily parenting. Arm 2 includes training in behavioral skills, role play, and discussion about how to apply behavioral principles in daily life. The instructors in arm 1 are professional practitioners in MBI, and in arm 2, the instructors are practitioners with a master's degree or above in social work, clinical psychology, counseling, and other related fields. All of the instructors have experience with ADHD symptoms as well as working with families, parents, and children.

Recruitment and randomization

This research commenced in February 2024 and is intended to conclude by December 2026, with the expected completion date for recruitment being December 31, 2025. This study is advertised through leaflets and emails of the project, and also on social media. Through promotional activities with schools and NGOs, school teachers and social workers also refer potentially eligible families to participate in the research. The interested parents in Hong Kong complete an online screening questionnaire related to the inclusion and exclusion criteria, and the answers from the same IP address will be screened out. The eligible parents should complete their informed consents after confirming their participation on a voluntary basis.

After the eligible parents confirm their participation in the research, the research assistant in the research team will use stratified randomization to allocate them into either the intervention arm of the online family MBI or the active control arm of the psychoeducation program by using the R package *blockrand*. The ratio of randomization will be 1:1. In each stratum (i.e., ADHD only or with comorbidities), the R package is going to generate several unique IDs to randomly allocate them into the minimum available block size of 2 or 4 for keeping a balance of the sample sizes in two groups. Parents and outcome assessor will be blinded for the allocation and no unblinding circumstance will be allowed until the end of the project. For avoiding potential placebo influence, the recruitment advertisements will only mention both arm 1 and arm 2 as "Psychoeducation Program". For the research team responsible for outcome assessment, the allocation of participants to either arm 1 or arm 2 will also be blinded. Parents who complete the intervention (T1) and follow-up test (T2) will receive cash remuneration coupons of HKD 200 (around USD 25) as an incentive at T1 and T2, respectively. All data will be stored on a secure server at the Hong Kong Polytechnic University, and this study obtained an ethical approval from its Institutional Review Board (HSEARS20221018008), including data management and data protection procedures.

Sample size

The sample size has been estimated by using G*power V.3.1 [46]. The estimation is based on the results of the pilot study of this research [27], indicating an effect size of 0.44 in ADHD symptoms. After the analysis adopting the two-tailed α error of 5% and 80% power, the sample size of this research is 166 in total. This study has expanded 20% of the sample size estimation regarding a potential drop-out rate, and a total of 208 parents should be included in the final sample.

Participants

The parents who participate in the study should meet the following inclusion criteria: (1) The participants should be the parents of children diagnosed with ADHD by a psychiatrist and psychologist according to DSM-5 [2]. (2) Their children should age from 6 to 12 years old with the ability to speak and understand Cantonese. (3) The parents should be the primary caregivers of their children with ADHD in the last year. (4) Children either not taking any medication or maintaining a stable dosage of the same ADHD medication for at least 3 months prior to study enrollment and having no plans to change medication and dosage during the study period. The exclusion criteria include: (1) Parents who have been diagnosed with developmental disabilities, psychosis, or other cognitive impairments, who may thus have difficulties in reading and comprehending the contents of the research. (2) Children with another developmental disability such as autistic spectrum disorder or intellectual disability. (3) Parents who completed an eight-week MBI or equivalent program.

Outcome measures

This study is going to collect the demographic information of parents and their children with ADHD. For parents, we will collect their age, gender, marital status, education levels, income, and their potential ADHD symptoms. For their children with ADHD symptoms, their age, gender, number of family members and ADHD children, and other ADHD comorbidities will be collected.

In this study, the primary outcome variable will be the child ADHD symptoms. The secondary outcome variables will include the executive functioning of children and mental health status of parents, including their depression, anxiety, and psychological well-being. The parents' sleep quality, parental stress, and EEs will also be rated as the secondary outcome variables. The mediators in this study include parental stress and EEs.

Child ADHD symptoms The Strengths and Weaknesses of ADHD Symptoms and Normal Behaviors (SWAN) Rating Scale will be used in this study to measure the ADHD symptoms of children [47]. There are a total of 18 items in the scale for measuring the behavioral characteristics of the children with ADHD by assessing their inattention and hyperactivity/ impulsivity. Parents rate their children's behaviors based on their comparison with other children of similar age. The 7-point Likert rating scores range from "-3" (far below average) to "3" (far above average). The Chinese version has been validated for its good psychometric properties by a previous study and our pilot study with Cronbach's alpha ranging from 0.92 to 0.95 [33, 48].

Depression This study will adopt the 10-item version of the Center for Epidemiologic Studies Depression Scale (CES-D) to measure depression of parents [49]. This is a 4-point Likert scale based on parents' self-report (e.g., "*My sleep was restless*"), and they are required to rate from "0" (none of the time)" to "3" (most of the time). The Chinese version has been validated with Cronbach's alpha ranging from 0.78 to 0.85, indicating its good psychometric properties in the Chinese population [33, 50].

Anxiety The Hospital Anxiety and Depression Scale - Anxiety subscale (HAD-A) will be used to assess the anxiety of parents (e.g. "*I feel restless as I have to be on the move*") [51]. This is a self-reported 4-point Likert scale with 7 items ranging from "0" (not at all) to "3" (very much indeed). The Chinese version has been tested and its Cronbach's alpha ranges from 0.77 to 0.82 [33, 52].

Psychological well-being This study is going to use the 5-item World Health Organization Well-Being Index (WHO-5) to measure the subjective well-being among parents (e.g., "*My daily life has been filled with things that interest me*") [53]. This is a widely used self-reported scale and each item ranges from "0" (none of the time) to "5" (all of the time). The Chinese version has been validated for its good internal consistency ($\alpha = 0.82$) [54].

Sleep quality The Insomnia Severity Index (ISI) is a 7-item scale to assess the parents' sleep quality [55]. The 7-item scale assesses the severity of initial, middle and late insomnia, distress about sleep difficulties, interference of insomnia with daytime functioning, and notice of sleep problems by others. Parents rated the items on a 4-point Likert scale from not at all (0) to extremely (2). A Chinese version has been validated with good psychometric properties with Cronbach's alpha ranging from 0.84 to 0.89 [56].

Parental stress The Parenting Stress Index Short Form (PSI-SF) contains 36 items to measure parenting stress from aspects of parental distress, parent-child dysfunctional interaction, and difficult child [57]. The 5-point Likert item scores from "1" (strongly disagree) to "5" (strongly agree), and a higher total score summed up by each item indicates a higher level of perceived parenting stress (e.g. "*quite a few things bother me*"). The Chinese version has been validated and its Cronbach's alpha ranges from 0.92 to 0.94 [33, 58].

Expressed emotions The Five Minute Speech Sample (FMSS) invites parents to talk freely about their thoughts and feelings towards their child [54]. Speech samples are rated on warmth, relationship and initial statement and frequency counts of positive and negative comments to provide a measure of parental EE. High EE is indicated by the presence of a negative rating indicating a higher number of negative comments than positive comments. The measure discriminates between mothers of children with ADHD and mothers of typically developing children [59, 60].

Executive functioning The Behavior Rating Inventory of Executive Function, Second Edition (BRIEF2) contained 63 items that cover nine areas of executive functioning that can be categorized under the domains of behavior regulation, emotional regulation, and cognitive regulation [61]. It will be completed by parents. A recent study of Chinese children confirmed the factorial validity, with Cronbach's alpha 0.86, 0.89, and 0.93 in three domains of executive functioning respectively [62].

Program satisfaction After parents complete the online MBI, they will be invited to rate their satisfaction with the program using a 5-point questionnaire. Their perceived helpfulness will also be rated by using scores from 0 (very unhelpful) to 4 (very helpful). In the interviews, they will be asked about their satisfaction with the program duration, length of video content and audio content, and frequency of Zoom meetings.

Data analysis

Intent-to-treat principle will be adopted to conduct the data analysis [63], and the missing data is going to be addressed by full information maximum likelihood. Descriptive analysis will be used to analyze the demographic and clinical information of parents and their children with ADHD. Chi-squared difference tests and *t*-tests will be performed to compare the differences between groups, and a linear mixed model will be conducted to examine the time effects and time × group effects.

Mediation analysis will be conducted to see the mediating roles of parenting stress and EEs. The

mediation analysis will be conducted in the computational tool PROCESS in SPSS by using model 4, adopting a 5000-sample bias-corrected bootstrapping procedure in 95% confidence intervals to examine the total effect, direct effect, and indirect effect. The significant indirect effects indicate the mediation effects of the intervention programs on outcomes via mediators. All of the analysis will control the basic demographic and clinical variables of parents and their children with ADHD as co-variates. The analysis will use IBM SPSS 23.0 and the PROCESS SPSS macro [64].

The EEs measured by the Five Minute Speech Sample will be scored by the coding procedure based on the contents of the parents talking freely about their thoughts and feelings towards their children. The audio recording will be transcribed, and two researchers will extract codes separately according to the transcripts to guarantee the credibility of the findings. Based on the codes, the speech samples will be rated from the aspects of warmth, relationship and initial statement and frequency counts of positive and negative comments to provide a measure of parental EEs [59].

Dissemination

For dissemination, our research team will consider publishing the findings in peer-reviewed journals and presenting them at related internal or international conferences.

Discussion

This study aims to examine the effects of an online family MBI compared to an active control group with a randomized controlled trial. The investigation into the online family MBI will assist researchers and practitioners in identifying its advantages and in further developing the intervention in online or blended formats. For instance, considering the parents of children with ADHD might make an effort to gain work-family balance, the online short video guidelines and audio mindfulness exercises allow them to catch the fragment time for their daily practice following their own preference and pacing. The online MBI also significantly enhances the accessibility of mental health care for these parents by not only guiding their daily exercises but also providing weekly professional group support from other parents and healthcare providers.

This study transfers the promising effect of online MBI to clinical populations, particularly for parents of children with chronic conditions, and the children themselves. Successful completion of the study and confirmation of the hypotheses will contribute to the evidence on the effectiveness of online MBIs for parents and caregivers of individuals with health and mental health conditions, and their children. The low intensity of the intervention will provide a sustainable treatment option for policymakers, service providers, family caregivers, and other stakeholders. Online MBI may also be considered for caregivers of other developmental challenges and common mental disorders such as autistic spectrum disorder (ASD), major depressive disorder, and early psychosis as the caregivers of people with these mental health issues often suffer comparable stress levels [65, 66].

Furthermore, by examining EEs within the family context, the findings might shed light on the mechanism of the online MBI in affecting the mental health outcomes of parents and, subsequently, the ADHD symptoms and executive functioning of their children. In the pilot study of this research [33], parents reported decreased parenting stress after participating in the online family MBI, and improvements were noted in their children's ADHD symptoms. Based on the theoretical framework of this study, a reduction in EEs could potentially explain the positive changes observed, as parents may develop a more accepting awareness of their situation and learn better emotion regulation strategies [16]. Therefore, combined with the sharing of experiences from parents who completed the online family MBI, the findings of this study can contribute to the development of the online family MBI in its content structure and mechanism of action and further facilitate its application in parents and their children with ADHD symptoms within the family context.

Apart from the contributions of the study, the limitations should be acknowledged. First, children with ADHD symptoms might have comorbidities with other disorders such as conduct/oppositional disorders, depression, and anxiety [67]. This study chooses to recruit children with ADHD diagnosis without excluding the other comorbidities to ensure a sufficient sample size, but this may complicate the researchers' ability to determine whether parenting stress is solely due to ADHD symptoms or other issues. Second, this study will evaluate the outcome based on parents' self-reported and it may be subject to the bias of participants' subjective experiences and perceptions. After the parents complete the online MBI, it is likely that parents' personal experiences of the program will result in their perceptions of the children's ADHD symptomatology, instead of their actual behavioral changes. Future measures could include behavioral observations and biomarkers to gain a deeper understanding of the online MBI's outcomes and mechanisms [68].

Appendix 1 online mindfulness-based program for parents of children with ADHD

Module	Session	Audio Practice	Informal Practice	Video content
1. **mindfulness and attention**	1	Mindfulness & breathing (I)	Observing a daily routine	Managing distraction
	2	Mindfulness & breathing (II)	Observing a daily routine	Mindful parenting (1)
	3	Mindful eating	eating a meal or snack	Parenting with a beginner's mind (2)
	4	Mindfulness of breathing & sound (I)	Observing child with a beginner's mind	The intention of mindfulness of sounds
	5	Mindfulness of breathing & sound (II)	Mindful breathing together with a child	Mindful breathing with a child
	6	**+Mindfulness & breathing (Child)**	**Mindful breathing together with a child**	**Breath of the Heart (Child's Version)**
	7	self-selected	self-selected	/
Week 1 Online meeting				
Orientation, Expectations of the program, Live Mindfulness Exercise lead by instructor, Inquiry, Q & A				
2. **mindfulness and physical sensation**	8	Body scan (I)	Observing a child with beginner's mind	Mindfulness of physical sensation in parenting
	9	Body scan (II)	Observing physical sensation in child-parent interaction	Mindfulness of physical sensation in child-parent interaction
	10	Mindful stretching (I)	Observing physical sensation in child-parent interaction	Being with unpleasant physical sensations
	11	Mindful stretching (II)	Child-parent stretching	Accepting limits in mindful stretching
	12	Mindful stretching (III)	Child-parent stretching	Accepting limits of our children with special needs
	13	**+ Body scan (Child)**	**Sharing the awareness of physical awareness**	**My Body (Child's Version)**
	14	Self-selected	self-selected	/
Week 2 Online meeting				
Live Mindfulness Exercise led by instructor, Inquiry, Discussion of guiding child mindfulness exercise at home				
3. **mindfulness and parental stress**	15	Breathing space	3 min breathing	The intention of developing breathing space
	16	Breathing space	3 min breathing	Developing space in a parenting
	17	Mindfulness of sounds & thoughts (I)	3 min breathing	The intention of mindfulness of thoughts
	18	Mindfulness of sounds & thoughts (II)	3 min breathing	Thoughts in mindful parenting
	19	Mindfulness of sounds & thoughts (III)	Guiding a breathing for your child	Awareness of speaking and listening and child-parent interaction
	20	**+ Distraction in child-parent exercise**	**Sharing the awareness of physical awareness**	**Breathing space (Child's Version)**
	21	Self-selected	self-selected	/
Week 3 Online meeting				
Live Child-Parent parallel Mindfulness Exercise led by instructor, Inquiry, Half way review				
4. **mindfulness and self-care**	22	Soles of the feet (I)	3 min breathing	Strong emotions in parenting
	23	Soles of the feet (II)	3 min breathing	Accepting our limitations in parenting
	24	Befriending (I)	3 min breathing	Sending kind wishes to ourselves
	25	Befriending (II)	Mindful games in child parent interaction	Sharing mindfulness with your child
	26	Review and reflection	self-selected	Everyday reminders of mindful parenting
	27	**+ Befriending exercise (Child)**	**self-selected**	**Befriending (Child's Version)**
	28	self-selected	self-selected	/
Week 4 Online meeting				
Live Mindfulness Exercise led by instructor, Inquiry, Discussion on application of mindfulness in future life				

Appendix 2 online psychoeducation program for parents of children with ADHD

Module	Session	Video content
1. **Understanding ADHD symptoms**	1	Program Introduction
	2	Understanding ADHD
	3	Psychological, parents' characteristics, family stress
	4	Family dynamics of children with ADHD
	5	The role of parent training in children with ADHD
	6	**Managing feelings and self-monitoring(Child)**
	7	Self-selected
Week 1 Online meeting e.g. Behavioural skills, Role play, Discussion, Q & A		
2. **General behavioral management principles**	8	Building reciprocal interaction for positive child behaviors
	9	Attending skills for positive child behaviors
	10	Common issues and challenges in behavioral management
	11	Modeling, practicing, and homework
	12	More strategies to increase child compliance
	13	**Self-evaluation (Child)**
	14	Self-selected
Week 2 Online meeting e.g. Behavioural skills, Role play, Discussion, Q & A		
3. **Positive reinforcement and compliance training**	15	Teaching Your Child not to Interrupt
	16	Developing a point system
	17	Starting the point system
	18	Use of time out (1)
	19	Use of time out (2)
	20	**Goal setting (Child)**
	21	Self-selected
Week 3 Online meeting e.g. Behavioural skills, Role play, Discussion, Q & A		
4. **Manage behaviors in other contexts**	22	Other possible disciplinary methods
	23	Managing children's problems in public places
	24	Strategies to improve school behavior
	25	Handling future behavior problems
	26	Review and reflection
	27	**Self-reinforcement and conclusion (Child)**
	28	Self-selected
Week 4 Online meeting e.g. Behavioural skills, Role play, Discussion, Q & A		

Appendix

Abbreviations

ADHD Attention	Deficit/Hyperactivity Disorder
BRIEF2	The Behavior Rating Inventory of Executive Function, Second Edition
CES-D	The Center for Epidemiologic Studies Depression Scale
EEs	Expressed Emotions
FMSS	The Five Minute Speech Sample
HAD-A	The Hospital Anxiety and Depression Scale-Anxiety Subscale
ISI	The Insomnia Severity Index
MBI	Mindfulness-based Intervention
PSI-SF	The Parenting Stress Index Short Form
RCT	Randomized Controlled Trial
SWAN	The Strengths and Weaknesses of ADHD Symptoms and Normal Behaviors
WHO-5	The 5-item World Health Organization Well-Being Index

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions
ZJZ: the original draft preparation, validation, methodology, statistical oversight, and review and editing. HHML: pre-registration, conceptualization, validation, methodology, review and editing, supervision, and project administration. SMB, RYMC, ENL, EKL, SN, AA, and WTY: validation, methodology, review and editing. All of the authors have reviewed the final draft of the manuscript with agreement to the submission to BMC Psychology.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Ethical approval has been obtained from the Institutional Review Board of the Hong Kong Polytechnic University (HSEARS20221018008). This study has been registered with ClinicalTrials.gov (NCT06298136||https://www.clinicaltrials.gov/), and the registration date was 7th March, 2024. The sequential amendments in the research process will be reported to the ethics committee and clinical trial registry. Informed consent will be obtained from all study participants before enrollment in the study. Human subjects' data generated throughout this project will be anonymized and safeguards will be in place to ensure protection of human subjects' data. All information related to the participants will be kept confidential and identified through codes known only to researchers in PI's research team. Apart from the informed contents obtained from participants, the intervention and data collection shall not have any negative influence on their physical and psychological health. There will be no consequence if they would like to skip any procedures or terminate their participation. Professional referrals can be offered if necessary.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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