Efficacy of the Mobile Health App Intellect in Improving Subclinical Obsessive Compulsive Disorder in University Students: Randomized Controlled Trial with a 4-Week Follow-up

Stephanie Lee Si Min, Madeline Lee Yoon Li, Marc Suendermann

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Abstract

Background: Obsessive compulsive disorder (OCD) is the third most prevalent mental health disorder in Singapore, with a high degree of burden and large treatment gaps. Self-guided programs on mobile applications are accessible and affordable interventions, with potential to address subclinical OCD before symptoms escalate.

Objective: In this randomized controlled trial, we examined the efficacy of a self-guided OCD program on the mobile health (mHealth) app Intellect in improving subclinical OCD and maladaptive perfectionism (MP) as a potential moderator of this predicted relationship.

Methods: University students (N=225) were randomized to an 8-day self-guided app program on OCD (intervention group) or cooperation (active control). Self-reported measures were obtained at baseline, after the program, and at 4-week follow-up. The primary outcome measure was OCD symptom severity (Obsessive Compulsive Inventory – Revised). Baseline MP was assessed as a potential moderator. Depression, anxiety, and stress (Depression Anxiety and Stress Scales - 21) were controlled for during statistical analyses.

Results: The final sample included 192 participants. The intervention group reported significantly lower OCI-R scores compared to the active control group after the intervention (partial eta-squared [?p2]=0.031; p=.017) and at 4-week follow-up (?p2=0.021; p=.044). A significant, weak positive correlation was found between MP and OCI-R levels at baseline (r=0.28; p<.001). MP was not found to moderate the relationship between condition and OCI-R scores at post-intervention (p=.70) and at 4-week follow-up (p=.88).

Conclusions: This study provides evidence that the self-guided OCD program on the Intellect app is effective in reducing subclinical OCD amongst university students in Singapore. Future studies should include longer follow-up durations and study MP as a moderator in a broader spectrum of OCD symptom severity. Clinical Trial: ClinicalTrials.gov NCT06202677; https://clinicaltrials.gov/study/NCT06202677

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Trial Registration: ClinicalTrials.gov NCT06202677; https://clinicaltrials.gov/study/NCT06202677

Keywords: mobile health app; self-guided interventions; obsessive compulsive disorder; cognitive behavioral therapy; maladaptive perfectionism; randomized controlled trial

Introduction

Background

Obsessive-compulsive disorder (OCD) is one of the most common mental health disorders, with an estimated lifetime prevalence of 3.6% in Singapore [1] and 2 to 3% globally [2]. OCD is characterized by the presence of recurrent unwanted thoughts, urges or images (obsessions) and/ or compulsions. Common contents of obsessions include preventing harm from mistakes or contamination, concern over order and incompleteness, and intrusive violent, religious, or sexual thoughts [3]. Typically, obsessions are ego-dystonic and inconsistent with one's fundamental beliefs and personality. Hence, obsessions evoke significant anxiety or distress which may drive the individual to carry out repetitive and excessive behaviors or mental acts (compulsions) that aim to neutralize the discomfort or avert the threat of a feared event.
OCD is associated with serious disability and decreased quality of life [4], leading to significant impairment in areas of family relations, social interactions, education, and work [5]. However, OCD-related impairment is not restricted to individuals who meet the full diagnostic criteria. OCD symptoms exist on a spectrum which varies in frequency and intensity across clinical and non-clinical populations [6]. Compared to the general population, individuals with subclinical OCD symptoms reported significantly lower life satisfaction and quality of life, and greater healthcare utilization [7]. In non-clinical populations, prevalence rates of intrusive thoughts have ranged from 74% to 99.4%, with individuals also found to carry out compulsive behaviors, such as checking, washing, or thought suppression [8,9]. Hence, recent research has emphasized early detection and intervention for individuals at risk of developing OCD [10].

The cognitive behavioral model of OCD posits that obsessional distress stems from an individual's appraisal of normal intrusive thoughts, images, and urges as extremely significant or threatening. Additionally, the individual appraises that the occurrence of the intrusion indicates their potential responsibility for causing harm [11]. These appraisals trigger distress and anxiety, which culminate in the decision to perform compulsions. Consequently, the short-term relief following compulsions negatively reinforces the behavior, leading to an increased behavioral tendency for compulsions over time [12]. As clinical obsessions develop from intrusive thoughts that most people experience [13], OCD symptoms in non-clinical samples are often investigated to uncover findings that can be extended to clinical populations.
The first-line psychotherapeutic treatment for OCD is cognitive behavioral therapy (CBT) with exposure and response prevention (ERP) [14]. In ERP, the individual gradually and repeatedly confronts their obsessions while refraining from performing compulsions. Consequently, ERP breaks the cycle of habitual compulsions when encountering obsessions by teaching the individual to tolerate distress without engaging in counterproductive behaviors. Over time, ERP aims to facilitate inhibitory learning as the individual forms non-threat associations which inhibit the retrieval of threat associations [15]. Extensive research has supported the superior efficacy of CBT in reducing OCD symptoms compared to placebo, relaxation therapy, and anxiety management [16,17]. The efficacy of CBT has been similarly demonstrated across countries, OCD severity, and treatment settings [18]. However, up to 50% of individuals drop out of treatment prematurely and approximately 25% refuse treatment [19]. Major barriers to initiating and completing CBT include treatment costs, insufficient availability of qualified practitioners, fears regarding societal stigma or treatment, and difficulty attending sessions [20,21]. Hence, only a minority of individuals with OCD access evidence-based treatment [22].

Computerized internet-based CBT (ICBT) programs have shown potential to reduce treatment barriers and overcome limitations of face-to-face psychological interventions. Digital interventions are accessible from any location with an internet connection, offer a broad reach, are cost-effective, and are available 24/7 [23]. ICBT has demonstrated comparable effectiveness to face-to-face CBT for OCD [24] and self-guided ICBT has been suggested as an alternative to remote clinical support [25]. Across age groups, self-guided ICBT has proven superior in reducing OCD symptom severity levels compared to wait-list and active control conditions [23,26]. Thus, self-guided digital interventions present a promising option for addressing the treatment gap and facilitating delivery of evidence-based care.

While mobile health (mHealth) apps have been increasingly adopted for mental healthcare delivery with promising results for anxiety, stress, and depression [27], few have been developed for OCD and most lack empirical support [28]. Only a handful of studies have evaluated the efficacy of self-guided mHealth app-based OCD programs which use CBT with ERP. Two randomized controlled trials (RCTs) examined the effectiveness of *GG Relationships, Doubt, and Obsessions (GGRO)*. However, as *GGRO* was designed to target symptoms of relationship OCD, the study samples were more selective, requiring all participants to have romantic relationship experience [29,30]. An RCT and an open pilot trial investigated the effectiveness of the apps *OCfree* and *nOCD* for OCD symptoms and found statistically significant reductions in OCD symptom severity at post-intervention [31,32]. However, app usage was guided or integrated alongside in-person therapy. Hence, it remains unclear whether self-guided mHealth apps for OCD are effective without therapist support. Furthermore, the studies utilized samples with clinically significant OCD, which might limit generalizability to populations with mild and subclinical OCD symptoms who are recommended to utilize self-guided, low-intensity treatments [33]. The authors also highlighted limitations, such as small sample sizes ($N \leq 50$), the lack of a control group not undergoing CBT, and the necessity for replication in future RCTs. Other limitations include the absence of follow-up assessments in two out of four studies, and only one Asian sample being studied [30,32]. Overall, notable gaps in the literature regarding the effectiveness of self-guided mHealth app interventions for OCD in subclinical populations remain.

Moreover, variables affecting the efficacy of self-guided mHealth app programs for OCD are underexplored. Only Gamoran & Doron [34] examined moderators in a sample of 46,955 users of *OCD.app*. Initial OCD severity, age, gender, trait mood, and app usage data were identified as predictors of change. However, no psychological variables were analyzed as potential outcome moderators, leaving a gap in OCD treatment research [35]. A potential moderator of OCD outcomes from mHealth app programs is maladaptive perfectionism (MP). Perfectionism refers to one's tendency to demand and pursue unrealistically high standards of performance, accompanied by excessively critical self-evaluations [36]. Frost et al. [37] proposed a six-dimension measure of perfectionism, which involves being overly concerned about making mistakes (CM), setting and pursuing high personal standards (PS), perceiving high parental expectations (PE) and parental criticism (PC), doubting the quality of one's actions (DA), and preferring order and organization (O). As a multidimensional construct, perfectionism comprises adaptive and maladaptive aspects. While perfectionistic individuals seek excellence which may promote well-being [38], they may experience dysfunction when excessively fixating on mistakes and meeting external standards. Maladaptive perfectionism (MP) is commonly observed in individuals with OCD [39]. It is a risk factor for OCD development and has been

viewed as an essential predisposing trait [40]. Additionally, MP has been shown to impede OCD treatment [41]. As moderators can help to identify individuals who may face a poor prognosis and assist in matching individuals with appropriate treatments, it would be useful to examine how baseline MP levels can affect intervention outcomes for self-guided CBT-based mHealth app programs for OCD.

This Study

Using a randomized controlled design, we evaluated the efficacy of a self-guided program on a mHealth app in reducing subclinical OCD symptoms and severity amongst university students from Singapore. Additionally, we examined the association between MP and OCD symptom severity and investigated MP as a moderator of intervention outcomes.

Given that OCD ranks among the top three most prevalent mental health conditions in Singapore, with a lifetime prevalence that is approximately 0.4% to 1.6% higher than the global average, it is crucial to identify accessible and effective OCD interventions. In particular, Singaporeans aged 18 to 34 have the highest lifetime prevalence rates of OCD, at 6.7% [1]. Yet, OCD remains poorly recognized and has the second-largest treatment gap out of at least seven mental disorders studied in Singapore [42]. Given the typical onset of OCD in adolescence and early adulthood and its likely chronic course without appropriate intervention [43], it is critical for this population to access evidence-based interventions before symptoms escalate [1]. Young adults have responded positively to mHealth apps, citing their appeal due to flexibility, interactivity, and accessibility [44]. Furthermore, as a population with high smartphone usage and common obstacles to accessing traditional mental health services, mHealth apps offer considerable promise to engage Singapore's young adults [45,46].

Given Singapore's cultural context, MP is also a relevant variable to examine. Extensive research has indicated that Asians generally exhibit significantly higher levels of perfectionism compared to Africans and Caucasians [47,48], which may be due to cross-cultural differences in parenting. Asian parents were found to set higher expectations for their children than European American parents [49] and provide conditional love based on their children's achievements [50]. Additionally, Asian parents typically adopt more controlling and directive parenting styles compared to European parents [51], which is associated with the development of MP [52]. Thus, individuals who grew up in such demanding environments may develop perfectionism as they internalize these standards [53]. In a sample of 302 Singaporean children, a large proportion was found to exhibit high levels of MP [54]. This finding may be attributed to parental intrusiveness and the general emphasis on academic achievement in Singapore which have been identified as factors that predict increased perfectionistic strivings and concerns [55,56]. Hence, as findings on OCD and MP may be culturally influenced, these variables are pertinent to study in Singapore for the development of effective interventions.

The hypotheses of the study are in three parts. First, we expected participants in the OCD program to report significant reductions in OCD outcomes compared to the active control group at post-intervention and 4-week follow-up. Second, we hypothesized that baseline OCD symptom severity and MP will be positively correlated. Third, we predicted that participants with the lowest levels of MP would experience the greatest reduction in OCD symptoms and severity at post-intervention and 4-week follow-up (Figure 1).

Insert Figure 1 here

Methods

Design

This RCT used a 2×3 mixed factorial design with *Condition* (intervention vs. active control) as the between-subjects factor and *time of assessment* (baseline vs. post-intervention vs. 4-week follow-up) as the within-subjects factor. The intervention group participated in an 8-day self-guided OCD program, and the active control group participated in an 8-day self-guided cooperation program. The dependent variable measured was OCD symptom severity. Additionally, general psychological distress was measured to be controlled for during analyses, and MP was measured for correlation and moderation analyses. The study's ethics was approved by the National University of Singapore's (NUS) Institutional Review Board (NUS-IRB-2023-444). The study was also pre-registered with ClinicalTrials.gov (registration number: NCT06202677).

Power Calculation

A meta-analysis examining low-intensity, technology-delivered CBT programs for OCD found small effect size reductions in OCD symptoms post-treatment [57]. Using Cohen's *f* = 0.10, alpha = .05 and power = .80, G*power 3.1 revealed a minimum number of 164 participants. Attrition rates in similar mHealth app-based studies conducted amongst NUS students have ranged from 1% to 44.9% [58,59,60]. Additionally, accounting for 10% of invalid data typically encountered in online research studies [61], this study aimed to recruit a minimum of 206 participants.

Recruitment and Study Participants

The sample of 225 participants had a mean age of 21.68 years (*SD* = 1.71) and consisted of 171 females, 52 males, 1 non-binary and 1 other gender. Recruitment was carried out by word of mouth, and on the university recruitment platforms. Participants were reimbursed with either course credits or monetary cash. The inclusion criteria required participants to be a Singapore Citizen or Permanent Resident, be able to read and understand English, be a student from the NUS between the ages of 18 and 30, present with mild or subclinical OCD symptoms, and own a mobile phone to download the *Intellect* app for use in the study.

Materials

Intellect is a mHealth app which can be downloaded from the App Store and the Google Play Store. It hosts numerous self-guided programs that have been reviewed by clinical psychologists and cognitive behavioral therapists. The app adheres to the highest standards of data security and privacy, employing zero-knowledge encryption to ensure user data confidentiality. Various self-guided programs on the app have been validated in previous RCTs using samples of Singaporean university students: "Stress", "Improving your Body Image", and "Anxiety & Worry" [58,59,60]. In this study, participants used *Intellect* to access either the "Obsessive Compulsive Disorder" or "Cooperation" learning program, depending on their assigned condition.

Learning Programs

OCD Program (Intervention Condition)

This 8-day program utilized principles of CBT with ERP for OCD. Each daily session took approximately five minutes to complete. The program commenced with psychoeducation on obsessions and compulsions, and how to identify them. Subsequently, through a series of content learning and daily exercises that increase in difficulty, participants were guided to conduct exposure exercises while tolerating distress and refraining from compulsions. This program structure aimed to enable participants to actively practice utilizing the skills that were taught, while not overwhelming them. During the final program session, participants were guided to set goals for continual progress. Due to the challenging nature of ERP, the program also provided advice on concerns that are frequently encountered during ERP. An overview and timeline of the program are presented in Table 1 and Figure 2.

Table 1. Overview of OCD Program.

Topics	Content
Topic 1: Understanding OCD	● Identify personal obsessions and compulsions ● Identify when/where obsessions and compulsions arise ● Understand how the importance placed on obsessions causes distress ● Understand that obsessions are not based in reality ● Develop skills to reframe obsessions
Topic 2: Re-exposure	● Introduce the concept of re-exposure ● Understand the function of exposure and re-exposure exercises ● Develop skills to carry out re-exposure ● Develop skills to tolerate obsessional distress
Topic 3: Imaginal exposure	● Introduce the concept of imaginal exposure ● Develop skills to carry out imaginal exposure
Topic 4: Family accommodation and recovery	● Introduce the concept of family accommodation ● Understand how family accommodative behaviors can hinder recovery ● Develop skills to identify family accommodative behaviors
Topic 5: Exposure and response prevention (ERP)	● Introduce the concept of ERP ● Understand the importance of prioritizing long-term OCD reduction goals over short-term discomfort ● Develop skills to confront obsessions and resist compulsions ● Develop goal-setting skills for long-term ERP progress

Insert Figure 2 here

Cooperation Program (Active Control Condition)

Participants in the active control group were allocated to an 8-day self-guided program on cooperation. Having an active control group ensured that participants in both groups shared as many experiences as possible. This controlled for non-specific factors and attentional effects, which could impact the study's results [62]. The program aimed to improve participants' collaborative skills and interpersonal wellness through a series of content learning and practice exercises. To ensure that participants in both conditions spent a comparable amount of time and effort, the approximate duration for completing each daily session was matched to be five minutes.

Procedure

Interested individuals signed up for the study by responding to the online advertisement via a link to an online survey hosted on Qualtrics. First, they completed a pre-screening test comprising measures on OCD and demographics and were screened for eligibility according to the inclusion criteria. Eligible participants read the Participation Information Sheet, and after providing informed consent, completed measures on psychological distress, and perfectionism.

Thereafter, participants were randomly allocated to the intervention or active control condition. To minimize potential confounding effects, participants were instructed not to use any other mHealth apps for the study duration. Additionally, to reduce demand characteristics, participants were not informed of the conditions' functions, or the study's objective to evaluate the efficacy of the OCD program. Instead, participants were informed that the study examined wellbeing and the learning effectiveness of mental health-related topics using a smartphone application. Participants were then instructed to download the *Intellect* app, create an account, and access the program of their allocated condition. Participants in the intervention group underwent 8 days of the OCD program, while participants in the active control group underwent 8 days of the cooperation program. Participation in each program took approximately five minutes per day. To encourage study adherence, participants were sent a daily reminder to complete app activities via WhatsApp Messenger or Telegram Messenger. To verify program completion, participants sent a screenshot of their learning logs to the investigator.

After verification, participants were sent a post-intervention survey link to complete the measures on OCD, psychological distress, and the App Engagement Scale (AES). Four weeks upon program completion, participants were sent a follow-up survey link to complete measures on OCD and psychological distress. To further control for demand effects and confounders, participants were asked to guess the study's hypothesis and indicate whether they had undergone mental health treatment during the past four weeks. Thereafter, they were debriefed on the study's objectives and hypotheses. Participants who participated in the cooperation program were given access to the OCD program and vice versa. Participants were reimbursed with either SGD 10 or 2 course credits after completion of the post-intervention survey, and an additional SGD 2.50 or 0.5 course credits after the follow-up survey. Figure 3 presents the study procedure.

Insert Figure 3 here

Measures

Obsessive Compulsive Inventory – Revised

OCI-R [63] is an 18-item questionnaire which assesses OCD symptoms across six subscales: washing, checking, neutralizing, obsessing, ordering, and hoarding. Items are rated on a 5-point Likert scale (0 = Not at all; 4 = Extremely). OCD symptom severity can be derived by summing all the items to obtain a total score. Total OCI-R scores correspond to mild (OCI-R = 0 to 15), moderate (OCI-R = 16 to 27) and severe (OCI-R = 28 to 72) OCD symptom severity [64]. In this study, the OCI-R was used as a measure of OCD symptom severity at baseline, post-intervention and 4-week follow-up. Participants with scores of 21 and above were screened out due to a likely presence of clinically significant OCD [63]. The OCI-R showed acceptable internal consistency, with Cronbach's α of 0.68.

Frost Multidimensional Perfectionism Scale

The FMPS [37] is a 35-item scale which assesses perfectionism across 6 subscales: CM, PS, PE, PC, DA, and O. Items are rated on a 5-point Likert scale (1 = Strongly disagree; 5 = Strongly agree). The FMPS has demonstrated good internal consistency and convergent validity with other measures of perfectionism within non-clinical and clinical samples [37]. In this study, the MP dimension (FMPS-MP) was obtained by summing scores on the subscales of CM, DA, PE and PC [65]. The FMPS and FMPS-MP showed excellent internal consistency with Cronbach's α of 0.91 and 0.92, respectively.

Depression Anxiety Stress Scale-21

The DASS-21 [66] is a set of three scales assessing depression, anxiety, and stress, and is commonly used in student samples [67]. Each subscale contains seven items, which are rated on a 4-point Likert scale (0 = Did not apply to me at all; 3 = Applied to me very much or most of the time). In this study, the DASS-21 total score was computed by summing the scores of all items and used as a measure of general psychological distress [66]. Additionally, as depression, stress and anxiety have been identified in the pathogenesis and maintenance of OCD [69,70,71], baseline total DASS-21 scores were controlled for during analyses to disentangle the effect of the intervention on OCD symptoms from depression, stress, and anxiety. Internal consistency of the DASS-21 was excellent, with Cronbach's α of 0.91.

App Engagement Scale

The AES [72] is a 7-item scale which assesses app engagement. Each item is rated on a 5-point Likert scale (1 = Definitely disagree; 5 = Definitely agree). The total score is derived by summing all the items. Internal consistency of the AES is good, with Cronbach's α of 0.88.

Analytic Approach

Data Cleaning

Incomplete responses and participants who indicated that they received psychotherapy during the study's duration were excluded. Invalid data due to careless or insufficient effort responding were then sequentially identified in two steps and removed using a multiple hurdles approach

[61]. First, response times of <500s on the baseline survey, <215s on the post-intervention survey, and <180s on the follow-up survey suggested that participants may have rushed through the questionnaires and app activities. Long string analysis and attention checks were carried out to confirm if these participants' responses were invalid. Responses were identified and removed if the same option was selected across the entire scale of any measure or responses to attention-check items were incorrect. Finally, data was screened for univariate outliers beyond three standard deviations from the mean. Winsorization was conducted to address these outliers by substituting them with the closest non-outlying value [73]. Subsequently, all analyses were conducted with and without the outliers. As the results were consistent, only results from the initial dataset were reported.

SPSS (version 26.0, IBM Corp) was used for all statistical analyses. Independent 2-tailed *t*-tests, Mann-Whitney U tests, and chi-square tests were conducted to analyze differences between the intervention and active-control groups on baseline and demographic variables. Missing data was tested for attrition-related biases. Independent 2-tailed *t*-tests, chi-square tests, and Mann-Whitney U tests determined if participants who failed to complete post-intervention or follow-up assessments differed significantly from participants who completed all assessments on any outcome or demographic variables. As all missing data was verified to be missing at random, they were addressed using intent-to-treat (ITT) analyses [74], whereby missing data on the post-intervention and follow-up assessment were substituted with data from the last completed questionnaire. Missing AES data were replaced using the mean score.

Preliminary Analyses

Main Analyses

Analysis of covariance (ANCOVA) examined if changes in OCD symptom severity at post-intervention and follow-up were significantly different between the intervention and active control groups. ANCOVA is recommended for inferential testing intervention effects [75], as controlling for baseline scores ensures that results at post-intervention and follow-up are attributable to the intervention [76]. ANCOVA was conducted on post-intervention and follow-up OCI-R scores, with baseline OCI-R and DASS-21 scores as the covariates. The alpha level was set at $p<.05$. Cohen's [77] guidelines for eta square were used to interpret effect sizes (η_p^2), whereby 0.01 to 0.05 indicates a small effect, 0.06 to 0.13 indicates a moderate effect, and 0.14 and above indicates a large effect.

Correlation and Moderation Analyses

Pearson's correlation was conducted to test if baseline OCI-R scores were correlated with FMPS-MP scores. Due to non-normality of baseline OCI-R scores, the bias-corrected and accelerated method (BCa) with 1,000 bootstrap iterations was used to generate 95% confidence intervals (CIs) for Pearson's correlation coefficients [78]. Pearson's correlation analysis with BCa is robust to non-normality and retains Type I error control by generating more accurate CIs [79,80]. Subsequently, Hayes PROCESS (version 4.2, IBM Corp, macro model 1) were used for moderation analyses. A total of two models were analyzed. Post-intervention and follow-up OCI-R scores were used as the dependent variable in the first and second model, respectively. Each model ran a simple moderation analysis to investigate the moderating effects of MP on the relationship between condition and OCI-R scores at post-intervention or follow-up. Baseline OCI-R and DASS-21 scores were entered as the covariate for all analyses. 95% CIs were used, with 5,000 bootstrap iterations. The interaction term between condition and FMPS-MP was

interpreted, whereby $p<.05$ indicates that MP moderates OCI-R scores at post-intervention or follow-up.

Results

Participant Characteristics

In total, 1049 responses were screened. 225 participants met the eligibility criteria, completed the baseline survey, and were randomized to either the intervention or active control condition. Of these, one participant withdrew from the study before the post-intervention assessment. 215 participants (95.56%) completed the post-intervention assessment, and 204 (90.67%) participants completed the follow-up assessment. 32 participants were excluded from analyses after failing data quality checks. This resulted in a total of 192 participants for all subsequent statistical analyses (Figure 4).

At baseline, 111 participants exhibited mild OCD symptom levels and 81 participants exhibited moderate OCD symptom levels. Scores for DASS-21 at baseline (M=11.45; SD=8.66), post-intervention (M=9.93, SD=8.37) and follow-up (M=11.59; SD=9.46), indicated that the average participant was mildly psychologically distressed.

Insert Figure 4 here

Preliminary Analyses

The intervention and active control groups did not differ significantly on baseline demographic and outcome variables (Tables 2 and 3).

For participants lost to post-intervention and follow-up, Mann-Whitney U tests, chi-square tests and independent 2-tailed *t*-tests revealed no attrition-related biases across demographic and outcome variables. ITT analysis was conducted to address participants' missing data by bringing forward scores from their last completed survey. Mean substitution was conducted to address missing AES scores.

Independent 2-tailed *t*-tests indicated that participants in both conditions enjoyed using the app, with no significant differences (*P*=.81) found between the intervention group (*M*=25.33; *SD*=3.90) and the active control group (*M*=25.47; *SD*=4.01) on the AES.

Mann-Whitney U tests indicated that participants who correctly guessed the study's hypothesis did not differ significantly from participants who incorrectly guessed the hypothesis on all measures at post-intervention and follow-up.

Table 2. Descriptive statistics for demographic variable of gender by condition.

Demographic variable	Full sample (n=192), n (%)	Intervention condition (n=94), n (%)	Active control condition (n=98), n (%)	*P value*
Gender				.474
Female	147 (76.6)	74 (78.7)	73 (74.5)	
Male	43 (22.4)	19 (20.2)	24 (24.5)	
Non-binary	1 (0.5)	1 (1.1)	0 (0.0)	
Others	1 (0.5)	0 (0.0)	1 (1.0)	

Table 3. Descriptive statistics for baseline demographic and outcome variables by condition (n=192).

Variable	Intervention condition (n=94), mean (SD)	Active control condition (n= 98), mean (SD)	*P* value
FMPS-MP[a]	61.21 (14.56)	57.93 (12.60)	.096
Age (Years)	21.69 (1.46)	21.74 (1.82)	.823
OCI-R[b]	12.83 (5.41)	13.01 (5.18)	.856
DASS-21[c]	11.83 (9.32)	11.09 (8.00)	.792

[a]FMPS-MP: Frost Multidimensional Perfectionism Scale – Maladaptive Perfectionism.
[b]OCI-R: Obsessive Compulsive Inventory – Revised.
[c]DASS-21: Depression Anxiety Stress Scale-21.

Main Analyses

The assumptions for ANCOVA were met, except for the assumption for normality. However, due

to the robustness of ANCOVA against deviations from normality when sample sizes are larger than 100 [79,80], analysis using ANCOVA proceeded. At both post-intervention and follow-up, the intervention group reported significantly lower OCI-R scores compared to the active control group,   with   a   small   effect   size   (Table   3).

Table 3. Means, standard deviations, univariate F values, and effect sizes for OCI-R scores at post-intervention and 4-week follow-up.

Variable	Baseline		Post-intervention					Follow-up				
	Intervention, mean (SD)	Control, mean (SD)	Intervention, mean (SD)	Control, mean (SD)	F test (*df*)	*P* value	ES[a]	Intervention, mean (SD)	Control, mean (SD)	F test (*df*)	*P* value	ES[a]
OCI-R[b]	12.83 (5.41)	13.01 (5.18)	11.03 (7.40)	13.04 (6.53)	5.79[c] (1)	*.017*[d]	.030	10.53 (7.36)	12.37 (7.46)	4.11[c] (1)	*.044*[d]	.021

[a]Effect size of 0.01 = small, .06 = moderate, .14 = large [77].
[b]OCI-R: Obsessive Compulsive Inventory – Revised.
[c]$P < .05$.
[d]Italicized values indicate a significant *P* value at .05.

Correlation and Moderation Analyses

Results from Pearson's correlation analysis revealed that OCI-R and FMPS-MP were significantly correlated ($P<.001$) with a weak positive correlation ($r=.28$) and the BCa bootstrap 95% CI [0.14, 0.41] did not include zero.

Moderation analyses indicated a significant effect in the overall moderation model with OCI-R scores as the dependent variable and FMPS-MP as the moderator. At post-intervention, the model showed ($R^2 = .38$, $F(5, 186) = 22.57$, $P < .001$, and at follow-up, it showed $R^2 = .29$, $F(5, 186) = 15.23$, $P < .001$. However, the interaction term between condition and FMPS-MP was not statistically significant at post-intervention and follow-up. Results are displayed in Table 4.

Table 4. Standardized coefficients, standard errors (SEs), t-values, P values and 95% confidence intervals for moderation analyses.

Model	Variable	OCI-R[d]				95% Confidence Interval	
		b	SE	P value	t	Lower limit	Upper limit
1 (T1[a]-T2[b])	Constant	4.85	5.93	.41	0.82	-6.85	16.56
	Condition	-3.49	3.69	.34	-0.95	-10.77	3.78
	FMPS-MP[e]	0.01	0.10	.95	0.07	-0.19	0.21
	Condition*FMPS-MP[e]	0.02	0.06	.70	0.39	-0.10	0.14
	DASS-21[f]	0.08	0.05	.12	1.55	-0.02	0.18
	OCI-R[d]	0.70	0.08	<.001[h]	8.19	0.53	0.86
2 (T1[a]-T3[b])	Constant	-0.51	6.72	.94	-0.077	-13.77	12.74
	Condition	-1.65	4.18	.69	-0.39	-9.88	6.59
	FMPS-MP[e]	0.14	0.11	.23	1.21	-0.09	0.36
	Condition*FMPS-MP[e]	-0.01	0.07	.88	-0.16	-0.15	0.12
	DASS-21[f]	0.16	0.06	.01[g]	2.79	0.05	0.28
	OCI-R[d]	0.29	0.10	<.001[h]	4.26	0.22	0.60

[a]T1: Pre-intervention.

[b]T2: Post-intervention.

[c]T3: Follow-up.

[d]OCI-R: Obsessive Compulsive Inventory – Revised.

[e]FMPS-MP: Frost Multidimensional Perfectionism Scale – Maladaptive Perfectionism.

[f]DASS-21: Depression Anxiety Stress Scale-21.

[g]$P<.05$.

[h]$P <.001$.

Discussion

Principal Findings

This study evaluated the efficacy of an 8-day self-guided OCD program on a mHealth app compared with an active control in reducing subclinical OCD symptoms and severity in a sample of Asian university students. The study further investigated the correlation between MP and OCD symptomatology, and MP as a factor that might help identify individuals who will benefit most from the self-guided program. The study addresses important gaps in the literature regarding the dearth of RCTs studying evidence-based mHealth app programs for OCD and the factors which influence the efficacy of such programs.

Our hypotheses regarding the efficacy of the app-based OCD program were supported. The intervention group reported significant reductions in OCD symptom severity compared to the active control group at both post-intervention and follow-up. Consistent with past studies on longer ICBT or in-person interventions, our findings revealed that an 8-day self-guided program using principles of CBT with ERP can reduce OCD symptoms and severity [16,23,83]. The small effect size reductions for OCD symptom severity in our OCD program are also comparable with a 12-week self-guided ICBT program for OCD at post-intervention [82]. Taken together, these findings suggest that OCD gains can be obtained in a shorter duration through self-guided mHealth app programs. However, as there is limited research regarding the optimal duration of self-guided interventions, future research should examine how the efficacy of self-guided, low-intensity interventions for OCD might vary with program duration. While longer interventions may offer more comprehensive content and exercises, shorter interventions may offer increased convenience and improve program completion rates.

Our study also extended the findings from Hwang et al.'s [32] guided 6-week-long app-based program, demonstrating that even without therapist support, app-based CBT can be beneficial for individuals with OCD symptoms. However, compared to Hwang et al.'s [32] study which utilized a sample with clinical OCD, our study's subclinical sample did not yield large effect size reductions for OCD. Despite our study's overall small effect sizes, this result is larger or comparable to effect sizes found after using the self-guided *OCD.app* app for approximately 8.52 days. Specifically, Gamoran and Doron [34] found null effect sizes for participants with mild OCD symptom levels, and small effect sizes for participants with moderate OCD symptom levels. Research from previous RCTs has suggested that mHealth app usage leads to greater decreases in symptoms for participants with moderate to severe OCD symptom levels [85], compared to those with less severe OCD symptom levels [30]. As such, because our study's sample comprised participants with both mild and moderate OCD symptom severity, it is possible that analyzing their data collectively diluted the effect size. Moreover, participants with OCI-R scores near zero were included in our study. Such participants would expectedly have limited reduction in OCD symptom severity after the intervention. As participants in both groups generally reported low OCI-R scores at baseline, it is possible that a floor effect limited intervention effects. Hence, it would be fruitful for future RCTs to investigate how effect sizes may vary across different levels of OCD symptom severity after using self-guided app-based OCD programs. Additionally, the efficacy of such programs should be tested in samples with clinically significant levels of OCD symptom severity to better understand their clinical utility.

Overall, these findings provide preliminary support for the use of CBT with ERP on mHealth apps to reduce OCD symptom severity in Asian university students. As such, our findings align

with the National Institute for Health and Care Excellence [33] stepped-care approach for managing OCD-related symptoms using low-intensity treatments. Additionally, the 4-week follow-up effects were encouraging as they suggest that the app-based OCD program can produce sustained effects, addressing the lack of follow-up data in mHealth app research [86]. As ICBT for OCD has been found to produce treatment effects maintained after two years [87], future mHealth app studies for OCD may seek to administer longer follow-up assessments to evaluate the long-term maintenance of treatment gains.

Our hypothesis that MP predicts OCD symptom severity was also supported. This finding corroborated with prior research that MP is highly prevalent in individuals with OCD [39]. Based on the cognitive behavioral model of OCD, exhibiting higher levels of MP increases the risk of OCD as individuals are prone to beliefs that there is a perfect method to performing any task (e.g. "I must order my books perfectly parallel to each other"). Additionally, individuals with high MP often have an inflated sense of responsibility over obsessions, anticipating that small mistakes and failures will have catastrophic consequences which they are responsible for preventing [88]. Consequently, obsessive distress and anxiety drive the individual to perform compulsions to dispel the threat of their obsessions [89]. However, the strength of correlation found between MP and OCD symptoms in our study was weaker than that of prior research [90]. This may be due to a range restriction of OCI-R scores. Given that participants with clinically significant levels of OCD were excluded from our sample, our study's participants represent a narrower segment of the OCD severity spectrum than the general, broader OCD population. By limiting the variability in OCD symptom severity, the true strength of the correlation between MP and OCD symptom severity may have been obscured [91].

Furthermore, our hypothesis that MP would moderate the decrease of OCD symptoms at post-intervention and follow-up was not supported. This result was unexpected, given that MP has been found to impede OCD treatment [41,92]. The weak correlation between MP and OCD symptom severity may have consequently led to and explained the lack of moderation effect of MP on the decrease of OCD symptoms at post-intervention and follow-up. Another possible explanation for the lack of significant moderation effect could be due to the sample's high mean MP and small spread (M = 59.46, SD = 13.72) [90,93]. As such, there might have been insufficient variability in MP scores needed to detect a moderating effect. Future studies may consider further examining MP as a moderator in samples with a wider range of OCD symptom severity.

Strengths and Limitations

The randomized controlled design enabled the establishment of causal conclusions from the study's intervention and results [94]. Additionally, utilizing an active control group controlled for attentional influences and nonspecific variables. Our study also had an attrition rate of 9.33%, which is much lower than participant dropout rates of up to 44.44% in similar studies on app-based OCD programs [85]. Furthermore, no attrition-related biases were detected in participants who discontinued the study. Altogether, these factors strengthened the overall validity of our results.

However, our study had several limitations. First, data regarding how long participants spent applying skills from the programs in their daily lives were not collected. CBT research has found that greater application of CBT skills improves treatment outcomes [95], hence it is probable that participants who practiced the skills taught in our programs more frequently would have made increased gains. Moreover, there was no objective assessment of participant engagement and

effort expended on the intervention programs as the time participants spent using the app was not tracked or controlled for. However, as poor engagement with mHealth apps has been associated with reduced gains [96], measures were taken to encourage adherence and ensure that app activities were fully completed. Participants received daily reminders to complete the app activities, and the app was programmed such that participants could only proceed to the next session if all preceding sessions were completed. Crucially, all participants were verified to have completed their assigned program. Given that no significant differences were found on the AES, both groups likely shared similar levels of engagement and time spent on the programs. Regardless, future studies should control for duration of mHealth app usage and investigate how duration of app engagement may impact treatment outcomes.

Next, self-report measures are susceptible to individual biases, which could have contributed to the study's results. Social desirability bias is a concern because participant blinding was not fully feasible, given that the study's hypothesis might be guessed based on the content of the allocated program. However, participants who correctly guessed the study's hypothesis did not report significantly different results on OCD outcomes compared to incorrect participants, which gives us some confidence that the effect of social desirability bias was limited. Nonetheless, our results should be interpreted with caution. Retrospective recall biases may also be present as the OCI-R required participants to report their experiences in the past month. To strengthen the accuracy of participants' self-reports on treatment outcomes, future studies may employ daily journaling methods which can minimize memory distortion from prolonged recall periods [97].

Finally, as participants were recruited from one university and comprised mostly of female students, the external validity of our study may be limited. Future studies may replicate our findings with a more diverse sample of young adults.

Conclusion

Overall, our study provides preliminary support for the efficacy of a self-guided mHealth app program utilizing principles of CBT with ERP in improving OCD symptom severity in young adults, producing gains maintained after four weeks. While MP was found to predict OCD symptom severity, MP did not moderate treatment outcomes. Identifying moderators can optimize outcome and treatment delivery on OCD-related mHealth apps. Hence, the impact of MP on treatment outcomes should be further studied in a broader spectrum of OCD symptom severity. Given the potential for cost-effective and accessible mHealth app programs to reach young adults and overcome traditional treatment barriers, future studies should aim to improve the efficacy of these programs.

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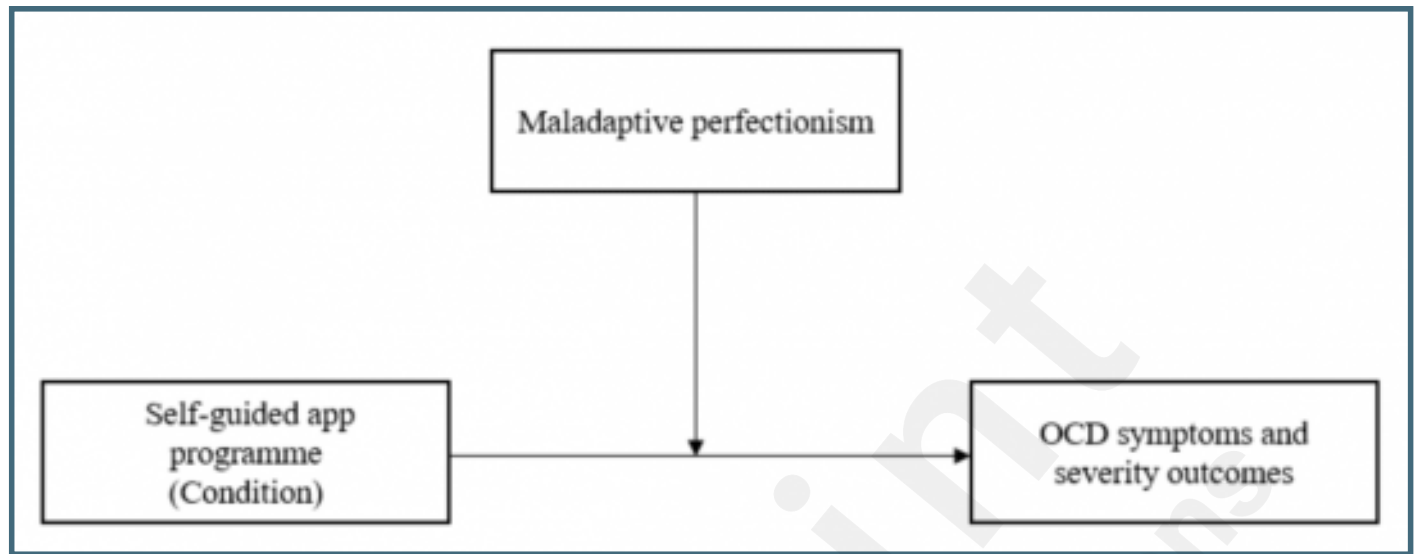
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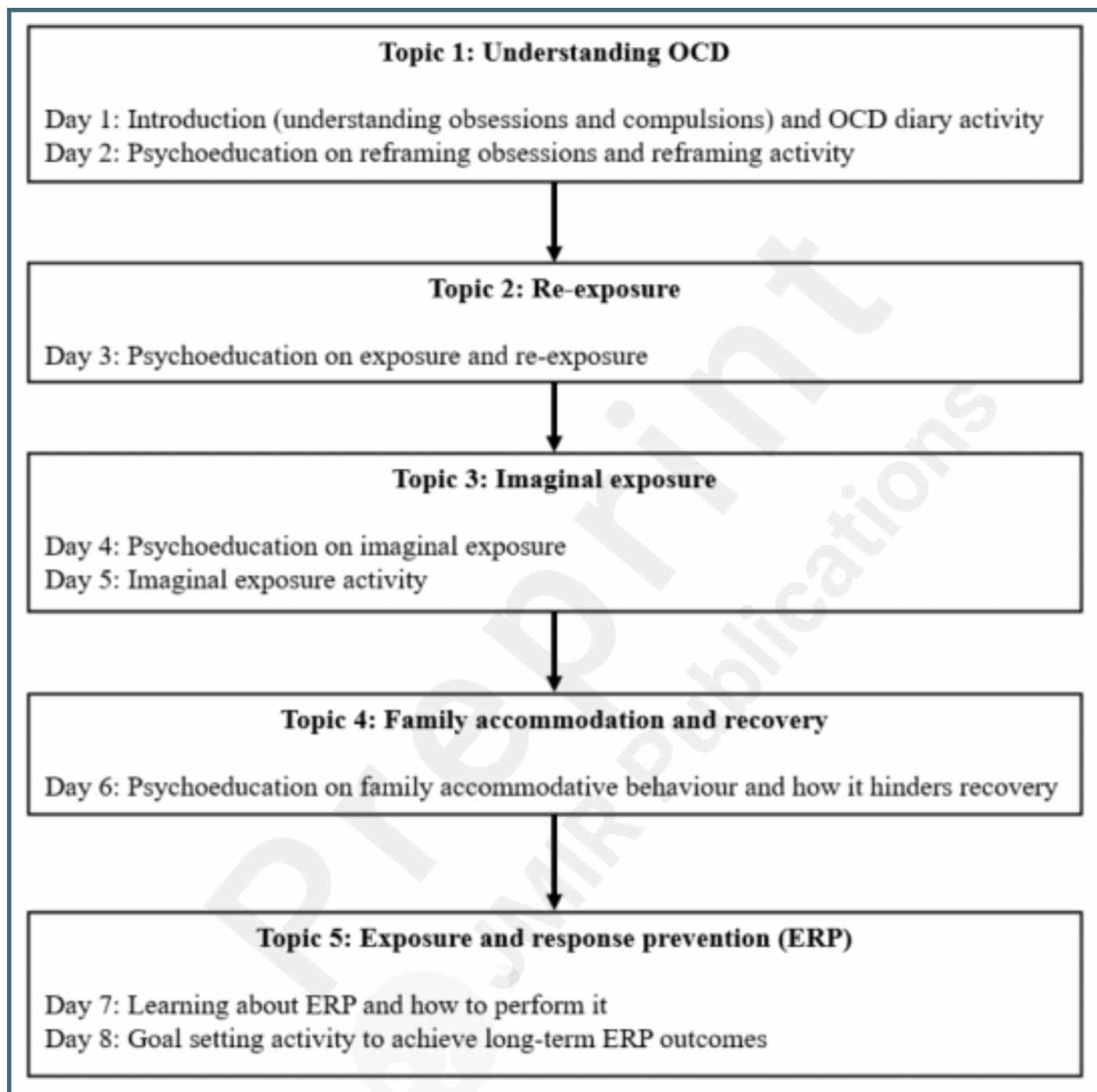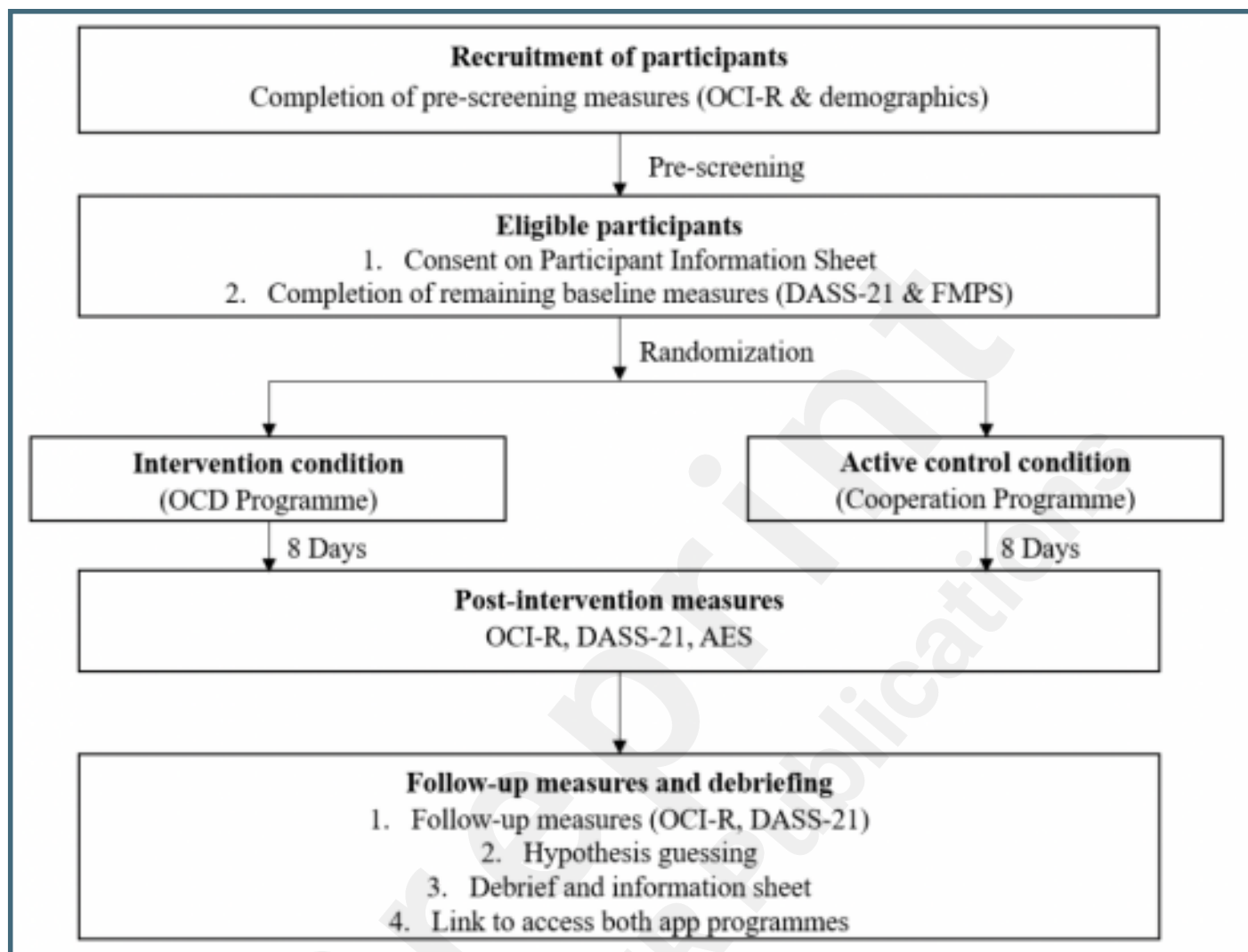
Supplementary Files

Figures

Predicted Relationship with Maladaptive Perfectionism as a Moderator of the Direct Effect of the Self-Guided App Program on OCD Symptom and Severity Outcomes.

Timeline of OCD Program.

Topic 1: Understanding OCD

Day 1: Introduction (understanding obsessions and compulsions) and OCD diary activity
Day 2: Psychoeducation on reframing obsessions and reframing activity

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Topic 2: Re-exposure

Day 3: Psychoeducation on exposure and re-exposure

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Topic 3: Imaginal exposure

Day 4: Psychoeducation on imaginal exposure
Day 5: Imaginal exposure activity

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Topic 4: Family accommodation and recovery

Day 6: Psychoeducation on family accommodative behaviour and how it hinders recovery

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Topic 5: Exposure and response prevention (ERP)

Day 7: Learning about ERP and how to perform it
Day 8: Goal setting activity to achieve long-term ERP outcomes

Study flowchart.

CONSORT (Consolidated Standards of Reporting Trials) flow diagram. ITT: Intention to treat.