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Smartphone-Delivered Multicomponent Lifestyle Medicine Intervention for Depressive Symptoms: A Randomized Controlled Trial

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Objective: To evaluate the efficacy and credibility of a smartphone-delivered multicomponent lifestyle medicine (LM) intervention, *Lifestyle Hub*, as a primary modality for managing depressive symptoms in an adult Chinese population. ***Method:*** Participants with at least a moderate level of depressive symptoms (n = 79), as indicated by a Patient Health Questionnaire-9 score of ≥10, were randomly assigned to an LM intervention group (LMG; n = 39; eight weekly sessions) or a waitlist control group (WLG; n = 40). ***Results:*** The intention-to-treat analysis revealed significant improvements in depressive symptoms (d = 0.66), generalized anxiety symptoms (d = 0.93), insomnia symptoms (d = 0.20), functional impairment (d = 0.22), and health-related quality of life (HRQoL; d = 0.11) from Week 0 (baseline) to Week 9 (immediate post-intervention assessment) in the LMG relative to the WLG. Moreover, significantly more health-promoting behaviors (overall health behaviors, health responsibility, physical activity level, nutrition, spiritual growth, and stress management) (d = 0.40–0.89) and higher levels of total activity (d = 0.55) and walking activity (d = 0.55) were found at Week 9 in the LMG relative to the WLG. However, no significant differences were observed in interpersonal relationships, vigorous and moderate exercise levels, sedentary behavior levels, or food frequency questionnaire measures at Week 9 between the LMG and the WLG. From Week 9 to Week 13 (1-month follow-up assessment), a significant within-group reduction in HRQoL (d = 0.50) and an increase in alcohol intake (d = 0.41) were observed in the LMG. ***Conclusions:*** The smartphone-delivered multicomponent LM intervention *Lifestyle Hub* may serve as a primary modality for managing depressive symptoms.

What is the public health significance of this article?
This is the first study to demonstrate the efficacy and credibility of a smartphone-based multicomponent LM intervention as a primary modality for managing depressive symptoms. The LM approach, which addresses service users' needs and preferences, could be a viable approach to facilitate the management of depressive symptoms.

Keywords: lifestyle, mood, smartphone-based intervention, self-help, randomized controlled trial

Supplemental materials: https://doi.org/10.1037/ccp0000695.supp

Depressive symptoms are highly prevalent worldwide (World Health Organization, 2017) and are associated with impaired daily functioning, deteriorated health-related quality of life (HRQoL), and increased mental health service utilization and expenditure (Fried & Nesse, 2014; Gilman et al., 2017; Katon, 2003). Recently, findings from a meta-analysis revealed that the global prevalence of depressive symptoms had increased to 25% during the coronavirus disease (COVID-19) pandemic, which was seven times higher than the

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estimates in 2017 (Bueno-Notivol et al., 2021). In view of these emerging mental health issues, the provision of timely and easily accessible mental health interventions is vital from both clinical and societal perspectives (Cuijpers et al., 2014). However, the dominant model of delivering nonpharmacological treatments for depressive symptoms (i.e., in-person consultations delivered by mental health professionals) appears to be suboptimal to meet the pressing mental health needs (Kazdin, 2018; Kazdin & Rabbitt, 2013; Purtle et al., 2020). The inadequacy of this dominant model has become even more evident amid the COVID-19 pandemic because of workforce shortages and mental health service disruptions in 93% of countries worldwide (Turale & Nantsupawat, 2021; World Health Organization, 2020).

To bridge the demand-supply gap, a growing number of studies have highlighted the potential utility of smartphone-based interventions in ameliorating depressive symptoms (Luxton et al., 2011; Torous et al., 2020), given the current global smartphone penetration rate has been estimated to be 78% (O'Dea, 2021). Smartphones could offer an unprecedented opportunity to disseminate nonpharmacological treatments for depressive symptoms in a scalable and timely manner (Firth et al., 2017), overcome geographic and time constraints, and potentially enhance intervention outcomes via their built-in functions in smartphones (e.g., automated notifications and text messaging; Bakker et al., 2016). Emerging evidence has indicated that smartphone-based interventions are effective in reducing depressive symptoms (g = 0.26–0.41) (Kerst et al., 2020; Linardon et al., 2019; Weisel et al., 2019). However, high dropout rates remain a major challenge in their implementation (Himle et al., 2021; Torous et al., 2020; Webelhorst et al., 2020). For example, a recent meta-analytic review of randomized controlled trials (RCTs) found that the pooled dropout rate in smartphone-based interventions that specifically targeted depressive symptoms was 26.2% (Torous et al., 2020), and this figure increased to 48% after adjusting for publication bias. Another meta-analysis examining the dropout rate in smartphone-based interventions for depressive symptoms demonstrated similar results: the dropout rates at short-term (≤8 weeks from baseline) and long-term (>8 weeks from baseline) follow-ups were 35.5% and 32.1%, respectively (Linardon & Fuller-Tyszkiewicz, 2020).

As highlighted by previous reviews and treatment guidelines for depression, accommodating service users' preferences could be a promising way to increase intervention adherence in addition to in-person clinician feedback (Delevry & Le, 2019; Firth et al., 2017; Linardon & Fuller-Tyszkiewicz, 2020; Torous et al., 2020; Windle et al., 2020). Qualitative content analyses have shown that, to manage depressive symptoms, service users preferred smartphone-based interventions that focused on self-empowerment and self-management skills (Firth et al., 2017; Patoz et al., 2021; Pung et al., 2018; Tan et al., 2020). For example, integrating a range of lifestyle self-management modifications into daily routines was shown to be of particular interest to service users (Morgan & Jorm, 2009; Parker & Crawford, 2007; Pung et al., 2018; Sarris et al., 2014).

One innovative approach that could address the perceived needs of service users with depressive symptoms is lifestyle medicine (LM). Although there are various definitions of LM in the literature, the LM approach is broadly defined as an evidence-based approach that uses multicomponent LM interventions (diet, physical activity, sleep management, and/or stress management) as a primary modality to reduce the risk of lifestyle-related health problems (Egger et al., 2017; Katz & Karlsen, 2019). It should be noted that the LM approach was not intended to be a substitute for current clinical practice for depressive symptoms. Rather, the LM approach recognizes the clinical value of current practice, and it has been suggested that the two could be used in tandem to maximize treatment outcomes (Egger et al., 2009; Ripoll, 2012). While conventional treatments primarily focus on individual risk factors (e.g., biological and psychological markers), the LM approach works on a range of unhealthy lifestyle behaviors (e.g., poor diet quality, physical inactivity, poor quality of sleep, and stress) that are involved in several important biological pathways and/or processes (e.g., inflammation, oxidative stress, gastrointestinal microbiota, the stress response system, and neuroprogression) of depression (Firth et al., 2020; Lopresti et al., 2013; Sarris et al., 2014). Furthermore, the LM approach emphasizes that active participation in lifestyle modifications is the key to intervention success (Egger et al., 2017). It aims to empower service users to take a proactive role in managing their own health and intervention progress (Coventry et al., 2014), thus emphasizing that the responsibility for managing long-term health is not solely on healthcare professionals but also on service users (Egger et al., 2009).

Indeed, researchers in the fields of lifestyle psychiatry and clinical psychology are showing an increasing interest in implementing lifestyle interventions for depressive symptoms (Firth et al., 2020; Sarris et al., 2014). This is likely because of an emerging body of evidence that has revealed the correlations between poor diet quality (Kosulwat, 2002; Law, 2019), physical inactivity and sedentary behaviors (Christofoletti et al., 2020; Vandelanotte et al., 2016), poor sleep quality (Ekirch, 2015; Hoyos et al., 2015), and stress (Hammen, 2015; Sarris et al., 2014) with the onset and development of depressive symptoms (Firth et al., 2020; Sarris et al., 2014). However, to date, the majority of pure lifestyle interventions for depressive symptoms have focused on a single lifestyle factor (e.g., exercise, diet, mindfulness, or yoga) and have demonstrated small to moderate effect sizes (d = 0.16–0.53) compared with nonpharmacological treatments (e.g., cognitive behavioral therapy and acceptance and commitment therapy; Bellón et al., 2021; Brinsley et al., 2020; Firth et al., 2017, 2019, 2020). Considering that the risk factors for depressive symptoms are multifactorial and intercorrelated (Ripoll, 2012), the LM approach that aims to modify multiple risk factors related to depressive symptoms simultaneously may provide synergistic therapeutic benefits (Walsh, 2011). This proposition has been supported by recent RCTs that have investigated the effects of multicomponent LM interventions on depressive symptoms. For example, Chang et al. (2018) implemented a multicomponent LM intervention (physical activity, dietary recommendation, and stress management) as a primary modality for geriatric depressive symptoms. Their findings demonstrated a medium effect size (d = 0.70) on depressive symptoms relative to a care-as-usual control group. A more recent RCT evaluating a Web-based self-help multicomponent LM intervention (physical activity, dietary recommendation, social activity, and sleep management) as a primary modality for depressive symptoms in individuals with a history of major depression also demonstrated encouraging results (Abbott et al., 2020). The results suggested that individuals receiving the LM intervention for 44 days had significantly fewer depressive symptoms (d = 1.08) compared with a waitlist control group at immediate post-intervention assessment. Moreover, a recent meta-analysis of RCTs examining the effects of multicomponent LM

interventions (that targeted at least two of the following lifestyle factors: nutrition, physical activity, sleep management, and/or stress management) on depressive symptoms demonstrated favorable results but with smaller effect sizes (d = 0.20–0.22) (Wong et al., 2021). The authors explained that the smaller clinical effect was likely because most of the included participants had a minimal level of depressive symptoms or had depressive symptoms secondary to a physical disease at baseline with limited room for improvement.

A growing yet limited body of research has investigated the effects of multicomponent LM interventions as a primary modality for depressive symptoms, but the efficacy and credibility of a smartphone-based multicomponent LM intervention for depressive symptoms remain unclear. Considering the limited accessibility of nonpharmacological treatments for depressive symptoms and the various needs and preferences of service users, a smartphone-based multicomponent LM intervention could potentially benefit individuals with depressive symptoms in a clinically effective and cost-effective way. We conducted the first RCT to evaluate the efficacy and credibility of a smartphone-delivered multicomponent LM intervention, *Lifestyle Hub*, as a primary modality for individuals with depressive symptoms in an adult Chinese population.

Method

In this RCT, 79 participants were randomized to either the lifestyle medicine group (LMG) or the waitlist control group (WLG). Ethical approval was sought from the Survey and Behavioral Research Ethics Committee (SBREC), the Chinese University of Hong Kong (Reference No. SBRE-19-303). The trial was preregistered on ClinicalTrials.gov (registration no. NCT04152850) and followed the Consolidated Standards for Reporting Trials (CONSORT) guidelines for reporting.

Study Population and Procedure

The recruitment period lasted for 4 weeks starting from April 1, 2020. Potential participants were recruited from the local community through the mass mailing system of the Chinese University of Hong Kong, advertisements in local print media, and social media (e.g., Facebook and Instagram). Participants were included if they (a) were Hong Kong residents; (b) aged ≥18 years; (c) had a Patient Health Questionnaire-9 (PHQ-9) score ≥10 (Moriarty et al., 2015; Spitzer et al., 1999); (d) were able to read Chinese and type in Chinese or English; (e) had an Internet-enabled mobile device (iOS or Android operating system); and (f) were willing to provide informed consent and comply with the trial protocol. Given the self-help nature of this study, the following exclusion criteria were assessed based on a self-report checklist: (a) current involvement in psychotherapy or recent changes in medication for depression; (b) Beck Depression Inventory (BDI-II) Item 9 score of at least 2, indicating a current moderate suicidal risk that requires active crisis management (referral information to professional services was provided to those with a serious suicidal risk) (Beck et al., 1961; Green et al., 2015; Shiner et al., 2016); (c) self-disclosure of having unsafe health conditions for which physical activity or a change in diet was contraindicated by physicians; and (d) self-disclosure of a diagnosis of any major psychiatric, medical or neurocognitive disorders that make participation unsuitable or that may interfere with the adherence to the lifestyle modifications.

Potential participants were then asked to complete a set of online screening questionnaires on the Qualtrics platform. Eligible participants were invited to participate in this study by a research assistant (RA) via phone contact (approximately 10 min). During the call, the RA explained the consent form to eligible participants and instructed them to download an in-house smartphone app (*Longitudinax*) for online informed consent and data collection. Participants who completed the baseline assessment were then randomly assigned to either the LMG or the WLG at a 1:1 ratio. Randomization was performed by an independent assessor using a computer-generated list of numbers. Thereafter, the LMG participants received the download instructions and unique login details for *Lifestyle Hub* from the RA via text message. In addition, a brief reminder regarding the self-help nature and intervention structure of the *Lifestyle Hub* (i.e., the eight 60-min sessions delivered on a weekly basis) was sent along with the login details. Throughout the study period, participants were allowed to contact the RA via text messaging for any technical errors or adverse events (i.e., any unintended physical injury resulting from the intervention). Nine participants from the LMG contacted the RA for technical support. Their reasons for contact included requesting login details (n = 6), encountering bugs when using *Lifestyle Hub* (n = 2), and insufficient phone storage (n = 1). No adverse event was reported throughout the study. The WLG participants were asked to maintain their typical activities during the 8-week waiting period, and they were given access to the *Lifestyle Hub* following the completion of the immediate post-intervention assessment at Week 9. Compensation of HK $100 (equivalent to US$13) was offered to those who completed all of the study and assessment procedures to acknowledge the contribution of their time and effort.

Intervention

Lifestyle Hub is an integrative multicomponent LM smartphone application developed by the study authors based on recent research findings, clinical guidelines, and local dietary guidelines. Its development was guided by the theoretical constructs of the transtheoretical model (TTM), including consciousness-raising, dramatic relief, counterconditioning, self-re-evaluation, environmental re-evaluation, self-liberation, contingency management, and stimulus control, to increase self-efficacy for lifestyle modifications and improve adherence (Gholami et al., 2019; Prochaska & DiClemente, 1983; Romain et al., 2018). A team of healthcare professionals (a clinical psychologist, a psychiatrist, a traditional Chinese medicine practitioner, a dietitian, and a physical instructor) was responsible for validating the included content. Moreover, the intervention content was tested in a pilot RCT of a group-based lifestyle intervention for depressive symptoms in a Chinese population (Ip et al., 2021).

The *Lifestyle Hub* intervention comprised eight 60-min weekly sessions with six components: (a) lifestyle psychoeducation, (b) physical activity, (c) dietary recommendations, (d) stress management, (e) sleep management, and (f) motivation and goal-setting techniques. A screenshot of the Home page of the *Lifestyle Hub* application is presented in Figure 1A. To facilitate understanding, each weekly session was divided into five to six submodules (i.e., 45 submodules in a total of eight sessions) supported by animated videos lasting from 8 to 15 min. Video scripts were provided beneath each animated video (Figure 1B). Detailed descriptions of the intervention content are presented in Table 1. All the

Figure 1

Sample Screenshots of Lifestyle Hub

Note. (A) shows the Home page of Lifestyle Hub in which participants could access the 8-week intervention session. (B) shows the content of a sub-module, in which the video scripts were provided beneath the animated video. (C) shows the Record page of Lifestyle Hub, in which participants could review their intervention progress and homework activities. (D) shows a selection of sample lifestyle goals in the Goal Setting page. (E) shows the Explore page of Lifestyle Hub, in which the continuous weekly updated recipes, exercise instructions, yoga, mindfulness, and diaphragmatic breathing demonstrations are presented. (F) shows a selection of recipes in the Explore page. See the online article for the color version of this figure.

participants from the LMG received the same intervention sessions for at least 60 min per week and completed the same homework activities that lasted for 10–20 min per day starting from Week 1 to Week 9. Participants could review their intervention progress and homework activities in the Record page of *Lifestyle Hub* (Figure 1C). To facilitate the incorporation of lifestyle recommendations into their daily life, the participants could use the built-in goal-setting function in *Lifestyle Hub* to set their personal goals. A total of 60 sample lifestyle goals with brief descriptions and potential benefits were included for reference (Figure 1D). The intervention content was delivered using animated videos, audio, texts, pictures, and gamified quizzes to maximize engagement by arousing the participants' interest.

Throughout the intervention, a series of reflective and open-ended questions based on the principles of motivational interviewing (MI) (i.e., expressing empathy, avoiding argumentation, rolling with resistance, developing discrepancy, and supporting self-efficacy) were embedded within the eight intervention sessions to encourage long-term maintenance and enjoyment of the many self-management skills that the participants have learned from *Lifestyle Hub* (Miller & Rollnick, 2012). MI was also used to promote SMART goal setting, planning, review, implementation, and maintenance. One of the prominent features of *Lifestyle Hub* is the Explore page (Figure 1E), which provided continuous weekly updates of locally tailored recipes (some containing video demonstrations) (Figure 1F), exercise instructions, and/or yoga, mindfulness, and diaphragmatic breathing demonstrations to increase intervention adherence. Moreover, a daily lifestyle challenge (e.g., walk 8,000 steps today) was sent to the participants every morning throughout the trial period to keep them motivated for continuous lifestyle modifications. In addition, a daily motivational quote (e.g., "if you want it, work for it") was sent out every day throughout the trial period to help increase self-efficacy and affinity. If the notification function was enabled, the participants would receive new updates on the Explore page, daily challenges, and reminders on self-created personal goals.

To ensure participation, a backend platform for account management and adherence data recording was created. The monitoring function of this platform could capture embedded routine data, including participants' login time, login duration, and usage of sessions and submodules.

Table 1
Intervention Overview

Session	Objectives	Content	Homework activity
1–2	• Increasing participants' perception of current lifestyle behaviors • Raising doubts on problematic lifestyle habits	• Overview of *Lifestyle Hub* • Introduction to lifestyle medicine • A brief assessment of physical activity • Introduction to low-intensity exercise (with demonstration videos) • Explaination of the association between physical activity and mental health • Introduction to calories (with a gamified quiz) • Tips for healthy eating • Explaination of the relationship between micronutrient and mental health • SMART goal-setting	• Setting short-term and mid-term goals • Daily lifestyle tasks (physical activity and diet)
3–4	• Identifing pros and cons of unhealthy lifestyle habits • Developing reasons for changes	• Introduction to flexibility and balancing exercise (with demonstration videos) • Introduction to food nutrition labels • Introduction to progressive muscle relaxation • Explaination of the association between sleep and mental health	• Setting short-term goals • Daily lifestyle tasks (physical activity and diet) • Progressive muscle relaxation
5–6	• Preparing and establishing a practical action plan for lifestyle modifications	• Introduction to moderate-intensity (cardiovascular and muscle training) exercise (with demonstration videos) • Wake-up and wind-down routine • Sleep hygiene and sleep-wake regularity • Stimulus control • Worry time • Problem-solving strategies	• Setting short-term goals • Daily lifestyle tasks (physical activity and diet) • Wake-up and wind-down routine practice • Worry time and problem-solving practice
7	• Strengthening self-efficacy in overcoming obstacles • Reaffirming long-term benefits in lifestyle modification	• Introduction to yoga and abdominal breathing exercise • Explaination of the association between mindfulness and mental health • Introduction to positive psychology	• Setting short-term goals • Daily lifestyle tasks (physical activity and diet) • Mindfulness and diaphragmatic breathing practice • Gratitude journal
8	• Consolidating the implemented lifestyle modifications • Preventing relapse in the long-term	• Revision of all session content • Review of *Lifestyle Hub* • Review of self-setting goals and lifestyle modification progress	• Recommendating daily practice of lifestyle modifications • Setting long-term goals

Data Collection

Self-report assessments of depressive and generalized anxiety symptoms, insomnia severity, HRQoL, health-promoting behaviors (HPBs), functional disability, food frequency, physical activity level, and intervention expectancy and credibility were collected at the baseline (Week 0), immediate post-intervention (Week 9), and 1-month follow-up (Week 13). Note that the WLG was not assessed for intervention expectancy and credibility at Week 9 or for any measure at Week 13 to avoid unnecessary intervention delay. Participants in both groups were given a maximum of 3 days to complete the baseline assessments via *Longitudinax*. Daily notifications (i.e., a total of three messages) were sent via *Longitudinax* to remind the participants to complete the assessments. In addition, the RA reminded the participants in both groups to complete the outcome measures via daily text message (maximum 3 days).

Screening and Outcome Measures

Screening

BDI-II item 9 was used to assess participants' suicidal thoughts or intention 2 weeks before the baseline assessment (Beck et al., 1961; Green et al., 2015; Shiner et al., 2016). This item includes explicit language about suicidal ideation on a 4-point scale, including (0) "I don't have any thoughts of killing myself," (1) "I have thoughts of killing myself, but would not carry them out," (2) "I would like to kill myself," and (3) "I would kill myself if I had the chance."

Outcomes

The primary outcome of the present study was depressive symptoms measured using the Patient Health Questionnaire (PHQ-9; Kroenke et al., 2001), a 9-item questionnaire used for screening, diagnosing, and measuring the severity of depression. The participants responded to each item on a 4-point Likert-type scale ranging from 0 (*not at all*) to 3 (*nearly every day*). The total PHQ-9 score is the sum of the scores on the nine items and ranges from 0 to 27. A higher score indicates more severe depressive symptoms. The Cronbach's α for the PHQ-9 in the present study was 0.92.

The secondary outcomes included generalized anxiety symptoms, insomnia severity, HRQoL, HPBs, functional disability, intervention expectancy and credibility, food frequency, and physical activity level. Generalized anxiety symptoms were measured using the Generalized Anxiety Disorder-7 (GAD-7) assessment (Tong et al., 2016), a 7-item questionnaire used for assessing the severity of generalized anxiety over the past 2 weeks. The participants responded to each item on a 4-point Likert-type scale ranging from 0 (*not at all*) to 3 (*nearly every day*). The total GAD-7 score is the sum of the scores on the seven items and ranges from 0 to 21. A higher score indicates more severe generalized anxiety symptoms. The Cronbach's α for the GAD-7 in the present study was 0.89.

Insomnia severity was evaluated using the Insomnia Severity Index (ISI; Bastien et al., 2001), a 7-item questionnaire that uses a 5-point Likert-type scale to measure the severity of insomnia. The total ISI score is the sum of the scores on the seven items and ranges from 0 to 28. A higher score indicates more severe insomnia symptoms. The Cronbach's α for the ISI in the present study was 0.89.

HRQoL was evaluated using the Short Form (Six-Dimension) Health Survey (SF-6D; Lam et al., 2008). The participants selected the levels (up to four or six levels) that best described their physical functioning, role limitation, social functioning, bodily pain, mental health, and vitality. A preference-based single index measure was calculated by adding the scores of the six dimensions using a scoring algorithm. The total SF-6D score ranges from 0.315 (the worse HRQoL) to 1 (full health). The Cronbach's α for the SF-6D in the present study was 0.80.

HPBs were measured using the Health Promotion Lifestyle Profile II (HPLP-II; Walker et al., 1987), a 52-item questionnaire scored on a 4-point Likert-type scale ranging from 1 (*never*) to 4 (*routinely*). The HPLP-II measures the overall health-promoting lifestyle and six subdomains of HPBs, which include health responsibility, physical activity, nutrition, spiritual growth, interpersonal relations, and stress management. The overall health-promoting lifestyle score is the sum of the scores on the 52 items and ranges from 52 to 208, whereas the score of each subdomain is the sum of the scores on the specific items (eight or nine items) within that subdomain and ranges from 8 to 32 or 9 to 36. A higher score indicates more HPBs. In the present study, the Cronbach's α was 0.95 for the overall scale and varied between 0.64 and 0.89 for the HPLP-II subdomains.

Functional impairment was measured using the Sheehan Disability Scale (SDS; Sheehan, 1983), a brief 3-item self-report tool that assesses functional impairment in work/school, social life, and family life. The global functional impairment score, ranging from 0 (*unimpaired*) to 30 (*highly impaired*), is the sum of the scores of the three items. The Cronbach's α for the SDS in the present study was 0.81.

Intervention acceptability was evaluated using the Credibility-Expectancy Questionnaire (CEQ; Devilly & Borkovec, 2000), a 6-item questionnaire that assesses the credibility of the intervention and the expectations of intervention success. The average score of the first four items in the CEQ was used to measure the overall intervention credibility, whereas the mean score of the remaining two items was used to assess the overall intervention success expectancy. A higher score indicates higher intervention credibility and success expectancy. The Cronbach's α for the credibility and expectancy domains in the present study were 0.80 and 0.74, respectively.

Food frequency was measured by the Food Frequency Questionnaires (FFQs; Zhang & Ho, 2009), an 18-item scale measuring the frequency of food intake over the past 3 months. The participants responded to each item on a 7-point Likert-type scale ranging from 0 (*never*) to 6 (*more than four portions per day*). The 18 items were summarized into 11 categories, including carbohydrates; vegetables; fish and other seafoods; red meat; white meat; beans, nuts, and seeds; dairy products; products containing caffeine; sugary products; alcohol; and tobacco. The average score for each category ranges from 0 (*never*) to 6 (*more than four portions per day*). The Cronbach's α for the FFQ categories in the present study varied from 0.50 to 0.68.

The physical activity level was evaluated using the International Physical Activities Questionnaire—Chinese version (IPAQ-C; Lee et al., 2011; Macfarlane et al., 2007), a 5-item questionnaire that measures the amount of sitting time, walking time, and moderate and vigorous exercise during the last 7 days. All of the responses were converted to minutes from hour(s) and reported as a continuous variable (metabolic equivalent task [MET] minutes a week) except for the responses for sitting time, which were reported as hour(s) per week. MET is defined as energy expenditure at rest. In the IPAQ-C,

walking is assigned a value of 3.3 METs; moderate exercise, 4 METs; and vigorous exercise, 8 METs. The total activity level is the sum of walking time and moderate and vigorous exercise. A higher score indicates a higher activity level. The Cronbach's α for the IPAQ-C in the present study was 0.68.

Statistical Analyses

The effect size estimation was based on an RCT that evaluated the efficacy of a Web-based self-help multicomponent LM intervention (physical activity, dietary recommendation, social activity, stress management, and sleep management) as a primary modality for depressive symptoms (Abbott et al., 2020). Using G*Power 3 (Faul et al., 2007), considering a 5% α error probability, 80% power in a two-tailed test, an estimated effect size of 0.8, and an estimated dropout rate of 30% (Linardon & Fuller-Tyszkiewicz, 2020; Torous et al., 2020), the estimated sample size to detect a significant between-group difference in depressive symptoms was 76 (38 participants in each group).

All statistical analyses were conducted using the Statistical Package for the Social Sciences Version 25.0 based on the intention-to-treat (ITT) principle. Two-tailed tests with a p value of less than .05 were used to determine statistical significance. Cohen's d was used to calculate the between-group and within-group effect sizes, with magnitudes of 0.2, 0.5, and 0.8 considered as small, moderate, and large, respectively (Cohen, 2013). The baseline characteristics of the LMG and WLG were compared using the chi-square test of independence or independent samples t-test, as appropriate. The efficacy of *Lifestyle Hub* was evaluated using a linear mixed-effects model (LMM) from baseline to Week 9, with intervention conditions as the between-subject group factor and time as the within-subject factor. The LMM uses maximum likelihood estimation and handles data that are assumed to be missing at random (Dziura et al., 2013; Little et al., 2012). Paired sample t-tests were used to assess the within-group differences from Week 9 to Week 13 in all of the outcome measures in the LMG. A conservative approach was adopted to establish clinical significance. Participants who had at least a 5-point reduction in the PHQ-9 score from baseline to immediate postintervention were considered to have reached clinical significance (Kroenke et al., 2016, 2020; Löwe et al., 2004). The chi-square test of independence was used to assess whether there was any significant difference in the number of participants who reached clinical significance and in the proportion of participants who had achieved a PHQ-9 score of <10 at Week 9 assessment between the two groups.

The within-group differences in intervention credibility and expectancy in the LMG were assessed using paired sample t-tests. The study dropout rate was defined as the withdrawal rate throughout the entire study, comprising withdrawals during the intervention and at the Week 9 and Week 13 assessments. The chi-square test of independence was used to identify any significant difference in the dropout rate between the two groups. In addition to the ITT analysis, a sensitivity analysis was conducted to examine the impact of nonadherence on intervention outcomes. Participants in the LMG who completed fewer than 70% of the submodules (i.e., <32 submodules) were considered to be nonadherent to the intervention (Fleming et al., 2018). In addition, the participants were considered to have successfully completed a session if their intervention usage was ≥60 min per week as designed. Intervention usage was defined as the completion of the eight 60-min weekly sessions; this did not include the participant's time spent doing homework activities, setting their personal goal(s), browsing the Explore page, or changing the app setting in the Setting page.

Results

Participant Characteristics

A total of 79 participants were included in this RCT, 39 and 40 of whom were randomly assigned to the LMG and the WLG, respectively (Figure 2). The participants were predominantly females (84.8%), and their mean age was 32.9 ($SD = 12.5$) years. All of the lifestyle, psychosocial, and demographic characteristics were comparable between the LMG and WLG at baseline ($p > .05$), except for age, which was significantly different between the two groups ($p = .02$) (Tables 2 and 3 and Supplemental Table 1).

Intervention Dropout and Usage

The dropout rates in the LMG and WLG were 12.8% and 12.5%, respectively, which were not significantly different ($\chi^2 = 0.00$, $p = .97$). Reasons for dropout are listed in Figure 2. As for the intervention usage, the LMG participants had completed an average of 24 of the 45 submodules by the Week 9 assessment. Specifically, 10 participants had completed 1–10 submodules, 6 had completed 11–20 submodules, 4 had completed 21–30 submodules, 7 had completed 31–40 submodules, and 7 had completed 41–45 submodules.

Between-Group Comparisons

The LMM analyses revealed that depressive symptoms ($p < .01$); generalized anxiety symptoms ($p < .01$); insomnia symptoms ($p < .05$); functional impairment ($p < .05$); HRQoL ($p < .05$); the HPLP-II total ($p < .01$), health responsibility domain ($p < .01$), physical activity domain ($p < .01$), nutrition domain ($p < .05$), spiritual growth domain ($p < .05$), and stress management domain ($p < .05$) scores; the IPAQ total activity domain score ($p < .05$); and the IPAQ walking activity domain score ($p < .05$) were significantly improved from baseline to Week 9 in the LMG relative to the WLG (Table 3 and Supplemental Table 1). However, no between-group difference was observed in the HPLP-II interpersonal relationship domain score, IPAQ vigorous exercise domain score, IPAQ moderate exercise domain score, IPAQ sedentary behavior domain score, and FFQ measures.

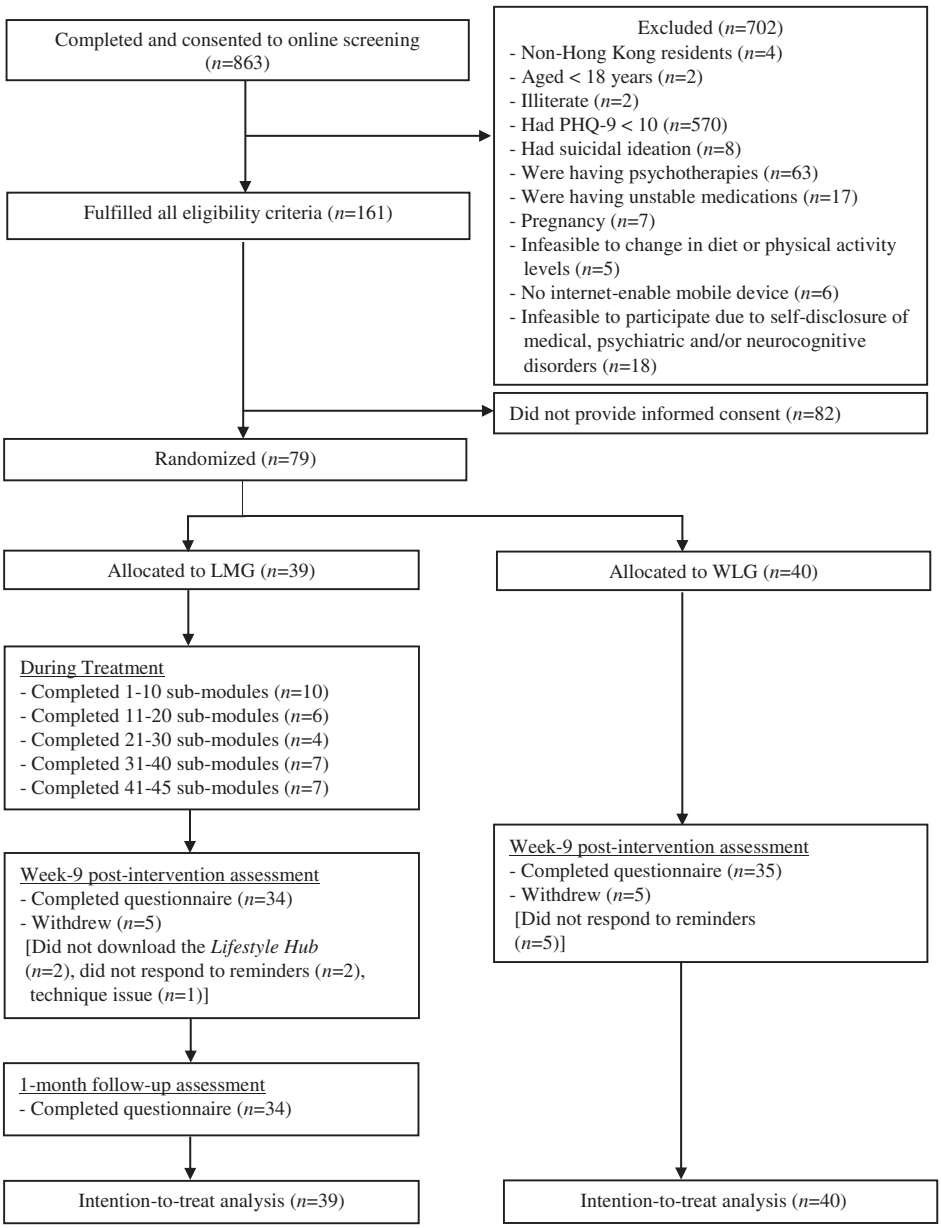
Within-Group Comparisons

Paired sample t-tests revealed a significant reduction in HRQoL, as measured by the SF-6D ($p < .01$), and an increase in alcohol intake, as measured by the FFQ ($p < .05$), from Week 9 to Week 13 in the LMG (Table 3 and Supplemental Table 1). No significant change was observed in any other outcome from Week 9 to Week 13 ($p > .05$).

Sensitivity Analysis

A statistical summary of the sensitivity analysis is presented in Table 4 and Supplemental Table 2. The LMM analysis was repeated to examine the intervention effects on participants who had

Figure 2
CONSORT Study Flow Diagram



completed at least 70% of the submodules (equivalent to 32 submodules) by Week 9. The LMM analyses revealed that depressive symptoms ($p < .001$); generalized anxiety symptoms ($p < .01$); insomnia symptoms ($p < .05$); HRQoL ($p < .05$); functional impairment ($p < .05$); and the HPLP-II total ($p < .01$), health responsibility domain ($p < .01$), physical activity domain ($p < .01$), nutrition domain ($p < .05$), and stress management domain ($p < .05$) scores were significantly improved from baseline to Week 9 in the LMG compared with the WLG. However, no between-group differences were observed in the HPLP-II spiritual growth domain score, HPLP-II interpersonal relationship domain score, IPAQ scores, and FFQ measures ($p > .05$).

Clinical Significance

Thirteen of the 34 participants in the LMG and 4 of the 35 participants in the WLG showed at least a 5-point reduction in the PHQ-9 score from baseline to Week 9. The χ^2 test revealed that compared with the WLG, a significantly higher proportion of participants in the LMG achieved a clinically significant reduction in depressive symptoms from the baseline to Week 9 ($\chi^2 = 11.82$, $p < .01$). Moreover, 21 of the 34 participants in the LMG and 16 of the 35 participants in the WLG achieved a PHQ-9 score of <10 at Week 9 assessment. The χ^2 test indicated no statistically significant difference in this score between the two groups at Week 9 assessment ($\chi^2 = 1.79$, $p = .23$).

Table 2
Baseline Characteristics of Participants

Variable	LMG group (n = 39)	WLG group (n = 40)	Total (n = 79)	p value
Age, years, M (SD)	36.4 (13.5)	29.7 (10.6)	32.9 (12.5)	.02*
Female, n (%)	34 (87.2)	33 (82.5)	67 (84.8)	.56
Marital status, n (%)				.30
Single	26 (66.7)	33 (82.5%)	59 (74.7)	
Married	11 (28.2)	7 (17.5%)	18 (22.8)	
Divorced/widowed	2 (5.2)	0 (0%)	2 (2.6)	
Number of children, n (%)				.43
0	34 (87.2)	37 (92.5)	71 (89.9)	
1	2 (5.1)	2 (5)	4 (5.1)	
≥2	3 (7.7)	1 (2.5)	4 (5.1)	
Educational status, n (%)				.33
Junior secondary	0 (0)	0 (0)	0 (0)	
Senior secondary	1 (2.6)	0 (0)	1 (1.3)	
Diploma/certificate	5 (12.8)	0 (0)	5 (6.3)	
Associate degree	4 (10.3)	4 (10)	8 (10.1)	
Bachelor's degree	21 (53.8)	30 (75)	51 (64.6)	
Master's degree or above	8 (20.5)	6 (15)	14 (17.7)	
Employment status, n (%)				.07
Full-time	18 (46.2)	19 (47.5)	37 (46.8)	
Part-time	3 (7.7)	10 (25)	13 (16.5)	
Not applicable	18 (46.2)	11 (27.5)	29 (36.7)	
Occupation, n (%)				.52
Managers	4 (10.3)	1 (2.5)	5 (6.3)	
Professionals	3 (7.7)	7 (17.5)	10 (12.7)	
Technicians/associate professionals	3 (7.7)	1 (2.5)	4 (5.1)	
Clerical support workers	3 (7.7)	5 (12.5)	8 (10.1)	
Service workers/shop sales workers	2 (5.1)	2 (5)	4 (5.1)	
Students	11 (28.2)	16 (40)	27 (34.2)	
Homemakers	3 (7.7)	1 (2.5)	4 (5.1)	
Retired	1 (2.6)	0 (0)	1 (1.3)	
Unemployed	7 (17.9)	5 (12.5)	12 (15.2)	
Others	2 (5.1)	2 (5)	4 (5.1)	
Monthly income, n (%)				.19
≤HK$ 5,000	18 (46.2)	21 (52.5)	39 (49.4)	
HK$ 5,001–10,000	1 (2.6)	5 (12.5)	6 (7.6)	
HK$ 10,001–20,000	7 (17.9)	4 (10.0)	11 (13.9)	
HK$ 20,001–30,000	3 (7.7)	6 (15.0)	9 (11.4)	
HK$ 30,001–50,000	6 (15.4)	2 (5.0)	8 (10.1)	
HK$ 50,001–70,000	4 (10.3)	2 (5.0)	6 (7.6)	
HK$ 70,001–90,000	0 (0.0)	0 (0.0)	0 (0.0)	
>HK$ 90,000	0 (0.0)	0 (0.0)	0 (0.0)	

* $p < .05$.

Intervention Evaluation

The paired samples t-test revealed no significant difference in intervention credibility, $t(38) = -1.72$, $p = .09$, and intervention expectancy, $t(38) = -0.90$, $p = .37$, from baseline to Week 9 in the LMG.

Discussion

Our RCT demonstrated that *Lifestyle Hub*, a smartphone-delivered multicomponent LM intervention, improved not only depressive symptoms but also generalized anxiety symptoms, insomnia symptoms, functional impairment, HRQoL, HPBs, and total activity levels relative to the WLG at the immediate post-intervention assessment (Week 9). However, *Lifestyle Hub* did not demonstrate significant effects on interpersonal relationships, vigorous exercise or moderate exercise levels, sedentary behaviors, or dietary quality. From the immediate post-intervention (Week 9) to the 1-month follow-up (Week 13), a significant within-group reduction in HRQoL and an increase in alcohol intake were observed in the LMG. Moreover, the credibility of *Lifestyle Hub* was supported by a modest score on the CEQ and a low dropout rate when compared with the existing multicomponent LM interventions (Wong et al., 2021) and smartphone-based interventions for depressive symptoms (Linardon & Fuller-Tyszkiewicz, 2020; Torous et al., 2020). Taken together, our findings demonstrated that *Lifestyle Hub* is an efficacious and credible multicomponent LM intervention for depressive symptoms.

The effect of *Lifestyle Hub* on depressive symptoms at immediate post-intervention in our study ($d = 0.66$) was superior to the effects of other smartphone-based interventions for depressive symptoms reported in recent meta-analyses ($d = 0.26$–0.41) (Firth et al., 2017; Linardon et al., 2019; Weisel et al., 2019) as well as multicomponent LM interventions for depressive symptoms reported in another meta-analysis ($d = 0.22$) (Wong et al., 2021). The difference in

Table 3

Effects of Lifestyle Hub at the Immediate Post-Intervention (Week 9) and 1-Month Follow-Up (Week 13) Assessments (Based on ITT Principle)

	Baseline	Week 9 assessments	Week 13 assessments	Within-group (baseline to Week 9 assessments)	Within-group (Week 9 to Week 13 assessments)	Group × Time effect	Between-group
Variable	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*d*	*d*	*p* value	*d*
PHQ-9							
LMG	13.5 (4.0)	8.8 (3.8)	8.8 (5.2)	1.04	0.01	<.01**	0.66
WLG	12.3 (3.6)	11.6 (4.7)		0.14			
GAD-7							
LMG	12.0 (4.2)	7.8 (3.2)	7.8 (4.4)	1.00	0.00	<.01**	0.93
WLG	12.0 (4.2)	11.5 (4.6)		0.10			
SDS							
LMG	10.7 (7.6)	7.0 (5.9)	6.2 (5.5)	0.54	0.12	<.05*	0.22
WLG	9.3 (8.6)	8.5 (7.8)		0.10			
ISI							
LMG	13.7 (4.4)	11.1 (5.2)	10.0 (6.1)	0.43	0.27	<.05*	0.20
WLG	15.1 (6.2)	12.2 (5.6)		0.41			
SF-6D							
LMG	0.6 (0.1)	0.7 (0.1)	0.6 (0.1)	0.65	0.50**	<.05*	0.11
WLG	0.6 (0.1)	0.7 (0.1)		0.66			
CEQ credibility							
LMG	5.4 (1.5)	5.9 (1.4)		0.28			
WLG	5.8 (1.5)						
CEQ expectancy (%)							
LMG	47.8 (16.6)	49.9 (17.7)		0.10			
WLG	53.9 (14.5)						

Note. The sample size used for the ITT analysis was 79 (LMG: 39; WLG: 40). CEQ = Credibility-Expectancy Questionnaire; GAD-7 = Generalized Anxiety Disorder-7; ITT = intention to treat; LMG = lifestyle medicine group; PHQ-9 = Patient Health Questionnaire-9; SDS = Sheehan Disability Scale; ISI = Insomnia Severity Index; SF-6D = Short Form (Six-Dimension) Health Survey; WLG = waitlist control group.
* $p < .05$. ** $p < .01$.

the magnitude of treatment effects between our study and the meta-analysis of Wong et al. (2021) was perhaps due to different study samples. Most of the participants included in their meta-analysis (Wong et al., 2021) had mild depressive symptoms secondary to a physical illness at baseline, whereas the participants recruited in our study had at least a moderate level of depressive symptoms. Nevertheless, in line with our findings, Wong et al. (2021) demonstrated that the clinical effects tended to be stronger in participants with a higher level of depressive symptoms ($d = 0.45$). In comparison with other individual RCTs that implemented multicomponent LM interventions as a primary modality for depressive symptoms ($d = 0.70–1.08$) (Abbott et al., 2020; Chang et al., 2018), our results demonstrated consistent findings but a smaller effect size. Although speculative, the smaller effect size in our study may be explained by two reasons. First, this study was commenced during the second wave of the COVID-19 pandemic in Hong Kong, during which stringent social distancing measures and lockdown were enforced. The reduced social connection might have increased the level of perceived loneliness (Luchetti et al., 2020), which is a significant risk factor for depressive symptoms (Hawkley & Cacioppo, 2010). Second, *Lifestyle Hub* did not include social relationships as an intervention component. Studies have found that poorer social relationships had durable predictive power on the development and progression of depressive symptoms (Teo et al., 2013). In view of this, the addition of social relationships as a component in multicomponent LM interventions would be beneficial to the clinical management of depressive symptoms, particularly amid the current pandemic crisis.

Given the limited data in the literature on the efficacy of multicomponent LM interventions for generalized anxiety symptoms, the large effect size ($d = 0.93$) of *Lifestyle Hub* on generalized anxiety symptoms was beyond our expectation. Our findings demonstrated that *Lifestyle Hub* is comparable to the current first-line treatments (e.g., cognitive behavioral therapy, antidepressant medication, and their combination) (Carpenter et al., 2018) and superior to the various smartphone-based psychological interventions for generalized anxiety symptoms (e.g., cognitive bias modification, acceptance and commitment therapy, and gamified diaphragmatic breathing) (Firth et al., 2017). In comparison with previous RCTs examining multicomponent LM interventions for generalized anxiety symptoms (Forsyth et al., 2015; Nie et al., 2019), the larger effect size observed in our study may be attributed to the differences in methodological and intervention design variability. First, the addition of stress and sleep management as components in *Lifestyle Hub* may have had synergistic effects in improving generalized anxiety symptoms, considering that more lifestyle risk factors that are involved in the development and progression of generalized anxiety symptoms were being addressed. Second, the results of previous RCTs that examined multicomponent LM interventions for generalized anxiety symptoms may subject to the floor effect, leaving little room for improvement throughout the course of treatment. Third, the comparison group (i.e., the WLG) used in the present study was different from those used in the studies by Forsyth et al. (2015) and Nie et al. (2019), which were an attention control group and a usual care control group, respectively. Thus, the effect size resulted in our study might have been inflated due to the

Table 4
Effects of Lifestyle Hub at the Immediate Post-Intervention (Week 9) Assessment (Sensitivity Analysis)

	Baseline	Week 9 assessments	Within-group (baseline to Week 9 assessments)	Group × Time effect	Between-group
Variable	*M* (*SD*)	*M* (*SD*)	*d*	*p* value	*d*
PHQ-9					
LMG	13.8 (3.7)	8.6 (2.7)	1.42	<.001***	0.70
WLG	12.3 (3.6)	11.6 (4.7)	0.14		
GAD-7					
LMG	12.5 (3.3)	8.0 (2.8)	1.91	<.01**	0.82
WLG	12.0 (4.2)	11.5 (4.6)	0.10		
SDS					
LMG	9.6 (8.0)	6.2 (6.3)	0.34	<.05*	0.31
WLG	9.3 (8.6)	8.5 (7.8)	0.10		
ISI					
LMG	16.5 (2.2)	12.6 (3.8)	1.07	<.05*	0.08
WLG	15.1 (6.2)	12.2 (5.6)	0.41		
SF-6D					
LMG	0.6 (0.1)	0.7 (0.1)	0.30	<.05*	0.01
WLG	0.6 (0.1)	0.7 (0.1)	0.66		

Note. The sample size used for the sensitivity analysis was 53 (LMG: 13; WLG: 40). GAD-7 = General Anxiety Disorder-7; LMG = lifestyle medicine group; PHQ-9 = Patient Health Questionnaire-9; SDS = Sheehan Disability Scale; ISI = Insomnia Severity Index; SF-6D = Short Form (Six-Dimension) Health Survey; WLG = waitlist control group.
* $p < .05$. ** $p < .01$. *** $p < .001$.

use of a WL control group (Cuijpers et al., 2016; Furukawa et al., 2014).

In the follow-up analyses, a significant within-group reduction in HRQoL and an increase in alcohol intake were observed from Week 9 to Week 13 in the LMG. Caution is advised when interpreting these findings, as the validity of our results might have been threatened by the absence of a comparison group and the potential impact of the third wave of the COVID-19 outbreak in Hong Kong.[1] Notwithstanding the above limitations, our results on HRQoL were consistent with those of the recent studies that examined the effect of COVID-19 on individuals with depressive symptoms (Holmes et al., 2020; Liu et al., 2020; Pfefferbaum & North, 2020). The further tightening of social distancing measures (e.g., sudden neighborhood lockdown and evening dine-in ban) together with high uncertainties (e.g., employment, health, and economy) during the COVID-19 pandemic were found to be associated with poorer HRQoL. Hence, the deterioration of HRQoL at Week 13 could partly be explained by the impact of COVID-19 surge in Hong Kong. Similarly, the significantly increased alcohol intake at Week 13 may be a maladaptive coping strategy to deal with COVID-19-related stressful experiences. As posited by the negative reinforcement models of substance use, the emergence of negative emotions due to disasters (e.g., earthquake, tsunami, and pandemic) could increase the likelihood of using alcohol and/or other substances as a coping response (Rogers et al., 2020; Wardell et al., 2020).

The nonsignificant between-group difference in vigorous and moderate exercises at immediate postintervention was expected. We adopted the stage-of-change model to guide our intervention design; accordingly, high-intensity exercises were deliberately introduced in the last two sessions. Thus, a longer time was required to see significant improvements in vigorous and moderate exercises. In addition, our findings revealed no significant improvement in any food frequency measures at the Week 9 assessment. According to the stage-of-change model, commitment was the best predictor of healthy dietary changes from the action stage to the maintenance stage (Kelly, 2011). We postulate that significant changes in the FFQ measures could be observed in a long-term follow-up among those with acceptable adherence to the intervention. Future RCTs with long-term follow-ups (e.g., 3-month follow-up) are warranted to verify this hypothesis. Another possible explanation for the insignificant results in the FFQ measures could be the relatively long recall period (i.e., the past 3 months) over the 8-week LM intervention, which may have diluted the observed food frequency changes.

The LM approach places a strong emphasis on active participation (Egger et al., 2009); therefore, a sensitivity analysis was conducted to examine the intervention effects on participants who had completed at least 70% of the submodules by the Week 9 assessment relative to the WLG. The findings demonstrated that *Lifestyle Hub* had a moderate effect on depressive symptoms ($d = 0.70$) and a large effect on generalized anxiety symptoms ($d = 0.82$) but a small effect on functional impairment ($d = 0.31$), insomnia symptoms ($d = 0.08$), and HRQoL ($d = 0.01$). These findings suggest that enhancing the intervention usage and adherence could maximize the efficacy of multicomponent LM interventions for depressive symptoms. Future studies are recommended to include a range of self-management skills and motivational techniques (e.g., self-monitoring, MI, feedback, and goal-setting) along with core lifestyle components to enhance treatment adherence. Likewise, brief booster sessions could potentially consolidate the intervention benefits and promote long-term maintenance of a healthy lifestyle in depressed individuals.

In the present study, a dropout rate of 12.8% was observed in the *Lifestyle Hub* intervention, which is lower than the rate reported in other smartphone-based interventions for depressive symptoms (range: 32.1%–48%) and multicomponent LM interventions for

[1] The 1-month follow-up assessment was conducted coincidentally with the third wave of the COVID-19 outbreak in Hong Kong (mid-July 2020).

depressive symptoms (20.6%) (Wong et al., 2021). Surprisingly, our dropout rate was comparable to those in the smartphone-based interventions for depressive symptoms that offered real-person feedback (11.7%) (Torous et al., 2020). Indeed, the high dropout rates in smartphone-based interventions for depressive symptoms have long been regarded as a major challenge for translating empirical data into real-world use. The low dropout rate observed in this study suggests that the LM approach, which accommodated the perceived needs of service users, could be a viable approach to expedite the management of depressive symptoms.

Several limitations of this study should be noted. First, the findings in this study might have been inflated because of the use of a WL control group. Future studies are recommended to replicate this study by using an active control group to provide more robust results regarding the intervention effects. Second, considering the self-help nature of *Lifestyle Hub* and practicality in real-world settings, all of the outcome measures were based on self-report questionnaires that are prone to subjectivity bias. Future studies may use clinical diagnostic tools (e.g., structured clinical interviews) to enhance the precision and credibility of the findings. Moreover, a range of wearable devices (e.g., pedometer, accelerometer, and actigraphy) could be used to objectively and continuously monitor physical and physiological changes, as well as ecological momentary assessment to repeatedly sample individuals' states of mood and behaviors in real time within natural environments (Shiffman et al., 2008). Third, blinding of the participants was not possible; thus, our findings may be subject to performance bias. Fourth, we did not examine the mechanisms of change because this study was a pioneering attempt to elucidate the effects of a smartphone-delivered multicomponent LM intervention as a primary modality for depressive symptoms. Future studies are warranted to obtain a stronger evidence base for this intervention. Fifth, the validity of our findings might have been threatened by a range of covarying factors (drug use, levels of perceived loneliness, attitudes toward COVID-19 and social distancing, and personality traits) that could explain the intervention effects. Sixth, as reflected by the completion rate, future studies can consider collecting qualitative data regarding the design of the intervention (e.g., duration and frequency of the intervention). The final important limitation of this RCT is that the current findings might have limited generalizability, given that our participants were primarily unmarried, childless, and highly educated.

In conclusion, this study was the first to demonstrate the potential of a smartphone-delivered multicomponent LM intervention, *Lifestyle Hub*, as a primary modality for depressive symptoms. Our results suggested that *Lifestyle Hub* is an efficacious and credible multicomponent LM intervention for depressive symptoms. Such smartphone-based multicomponent LM interventions that accommodate the perceived needs and preferences of service users could be a viable option for alleviating the growing burden of depressive symptoms. Future RCTs with high methodological quality are needed to provide more robust evidence for such interventions.

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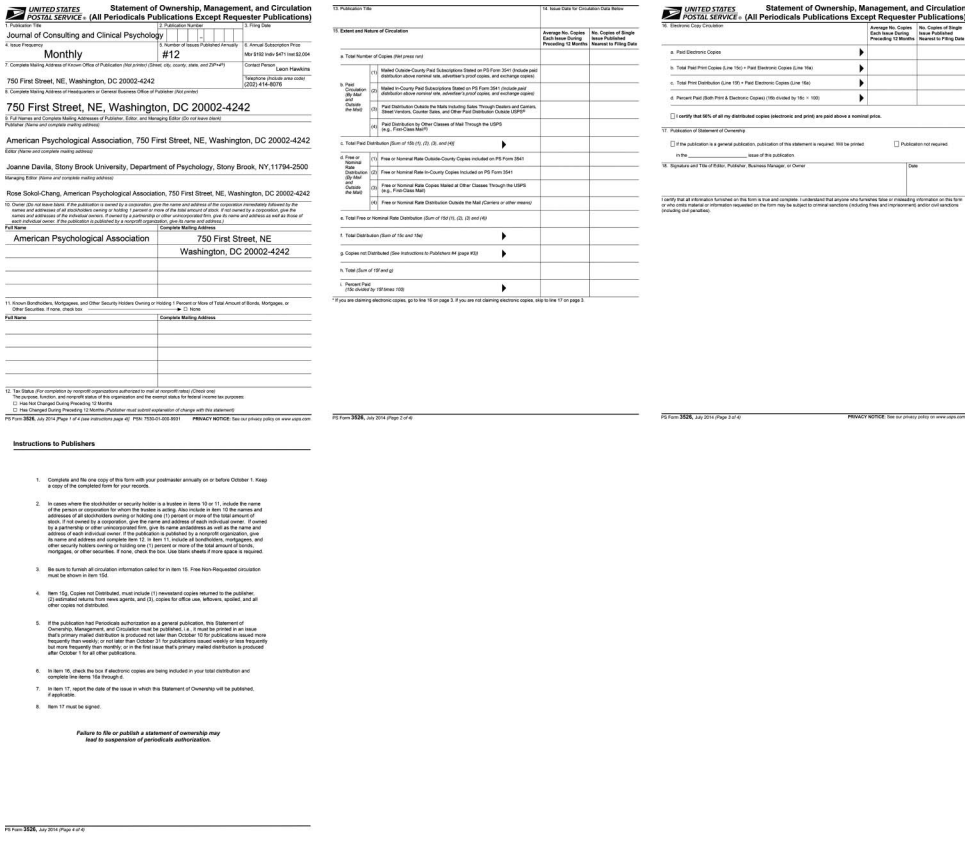

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