

# Effectiveness of a Mobile-Based Mental Health Intervention on Reducing Depressive Symptoms among University Students: A Waitlist-Controlled Trial

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## Research Article

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# Abstract

## Background

Depression among university students is a growing global public health concern, particularly in low-resource settings where access to mental health services is limited. Mobile-based interventions have emerged as scalable tools to address this gap.

## Methods

This study aimed to evaluate the effectiveness of the MindHealth mobile application in reducing depressive symptoms among undergraduate students in Iraq. A randomized controlled trial with a waitlist control design was conducted among 120 undergraduate students at the University of Babylon. Participants were randomly assigned to either an intervention group receiving a four-week structured use of the MindHealth application or a control group receiving no intervention during the study period. Depression severity was measured using the Patient Health Questionnaire-9 at baseline and post-intervention. Data were analyzed using intention-to-treat principles, paired and independent t-tests, and analysis of covariance (ANCOVA) adjusting for baseline scores, age, and gender.

## Results

The intervention group showed a significant reduction in PHQ-9 scores (mean change =  $-4.7 \pm 2.9$ ;  $p < .001$ ; Cohen's  $d = 1.09$ ), compared to a minimal reduction in the control group ( $-0.8 \pm 2.1$ ;  $p = .004$ ;  $d = 0.20$ ). Post-intervention scores were significantly lower in the intervention group ( $9.1 \pm 3.8$ ) than in the control group ( $12.8 \pm 4.0$ ;  $p < .001$ ;  $d = 0.95$ ). The intervention effect remained significant after adjusting for baseline values, age, and gender ( $p < .001$ ). High adherence was observed (80.2%), with 85% of participants meeting the predefined usage threshold.

## Conclusion

The MindHealth mobile application significantly reduced depressive symptoms among university students and demonstrated high feasibility and engagement. These findings support the use of mobile-based mental health interventions as scalable solutions in resource-limited academic settings.

## Introduction

Depression is one of the most prevalent and disabling mental health disorders worldwide and a major contributor to the global burden of disease. According to the World Health Organization, over 280 million people are affected globally, and depression is projected to become the leading cause of disease burden in the coming decades [1]. It is associated with significant functional impairment, including reduced cognitive and occupational performance, impaired social functioning, and poor quality of life, as well as substantial economic costs [2–4]. University students represent a particularly vulnerable group due to academic demands, psychosocial stressors, transitional life challenges, and reduced social support, all

of which increase the risk of developing depressive symptoms [5, 6]. Evidence shows that the prevalence of depression among university students is higher than in the general population, ranging between 20% and 40% [7, 8]. Depression during this stage is linked to academic failure, dropout, and long-term psychiatric consequences such as recurrent depression, anxiety disorders, and suicidal ideation [9]. In recent years, digital mental health interventions have gained increasing attention as scalable and accessible tools for addressing psychological disorders. Mobile-based mental health applications provide cost-effective support through evidence-based strategies such as cognitive behavioral therapy, psychoeducation, behavioral activation, and mood monitoring, making them particularly suitable for young populations with high digital engagement [10, 11]. The ubiquity of smartphone ownership among university populations with global penetration rates exceeding 95% in many countries further supports the ecological validity and scalability of app-based approaches [12]. Additionally, the capacity of mobile applications to deliver continuous, longitudinal monitoring of mood states and behavioral patterns provides clinically valuable data that can inform both self-management strategies and professional clinical decision-making [13]. Notwithstanding the growing evidence base for digital mental health interventions in high-income countries, critical gaps persist regarding their effectiveness in low- and middle-income country (LMIC) contexts, where the majority of the global mental health burden is concentrated yet treatment resources remain severely limited [14, 15]. Iraq represents a particularly important yet understudied context in this regard. Decades of armed conflict, political instability, and economic adversity have placed extraordinary psychological demands on the Iraqi population while simultaneously constraining the development of its mental health infrastructure [16]. Iraqi university students, many of whom have been exposed to traumatic stressors and socioeconomic hardship, face compounded vulnerabilities that may amplify susceptibility to depression beyond that observed in more stable societal contexts. Moreover, unique cultural attitudes toward mental illness, limited availability of trained mental health professionals, and variable levels of digital literacy may substantially influence both the uptake and therapeutic effectiveness of mobile-based interventions in this setting [17]. The absence of empirically validated, culturally adapted digital mental health tools for the Iraqi population therefore represents a significant lacuna in the current literature [18, 19]. The present study was designed to address this gap by rigorously evaluating the effect of a mobile-based mental health application on depressive symptom severity among Iraqi university students, employing a pre–post intervention design with standardized psychometric assessment. Specifically, the study sought to quantify changes in depression levels following a structured period of guided application usage, and to explore potential moderating factors relevant to the Iraqi context. In doing so, this investigation contributes to the emerging evidence base on digital mental health interventions in LMICs and provides empirically grounded insights to inform the development of scalable, culturally sensitive mental health solutions for university student populations in resource-constrained settings. The findings are intended to support evidence-based policy development, digital health program design, and future clinical trial methodologies in the region.

## Methodology

## Study Design

This study employed a randomized controlled trial (RCT) with two parallel arms (intervention and waitlist control) using a pre–post repeated measures design to evaluate the effectiveness of a mobile-based mental health application in reducing depressive symptoms among university students. Participants were randomly allocated to either the intervention group, which received access to the mobile application, or the waitlist control group, which continued with usual daily activities and was offered access to the intervention after study completion for ethical considerations. Randomization was performed using a computer-generated random sequence with allocation concealment to minimize selection bias. Due to the nature of the intervention, blinding of participants was not feasible; however, outcome data were collected via self-administered electronic questionnaires to reduce assessor-related bias.

## Study Setting and Participants

The study was conducted at the University of Babylon, Iraq. Undergraduate students from multiple colleges were recruited to ensure academic diversity and improve generalizability of findings. A probability-based sampling approach was applied. Eligible students were randomly selected and subsequently randomized into either the intervention or control group.

### Inclusion criteria include:

1. Registered undergraduate students
2. Ownership of a smartphone with stable internet access
3. Willingness to provide informed consent

### Exclusion criteria include:

1. Current use of antidepressant medication or psychiatric treatment
2. Incomplete baseline or follow-up data

## Sample Size Calculation

Sample size estimation was conducted using power analysis ( $\alpha = 0.05$ , power = 80%) to detect a moderate effect size (Cohen's  $d = 0.5$ ). The minimum required sample size was calculated as 102 participants (51 per group). To account for an anticipated attrition rate of 20%, the final target sample size was increased to 120 participants (60 per group).

## Intervention

The intervention consisted of a four-week structured engagement with the mobile mental health application MindHealth, a commercially available cognitive-behavioral therapy (CBT)-informed digital

tool designed to support emotional well-being through psychoeducation, mood tracking, and self-monitoring functions.

### **The application provides:**

1. Psychoeducational content targeting depressive symptoms
2. Mood tracking functionality
3. Self-monitoring and emotional reflection tools
4. Visual feedback on emotional progress
5. Participants in the intervention group were instructed to use the application three times daily, resulting in a total of 84 recommended sessions over the four-week period.

### **Adherence Monitoring**

Adherence was objectively assessed using in-app usage logs (frequency and duration) complemented by weekly self-reported check-ins. Adequate adherence was defined a priori as completion of  $\geq 70\%$  of the recommended sessions ( $\geq 59$  of 84 sessions). Participants with lower adherence were included in the intention-to-treat analysis and additionally examined in a per-protocol sensitivity analysis.

### **Control Group**

Participants allocated to the waitlist control group did not receive access to the application during the intervention period. They were instructed to continue their usual daily routines and were offered full access to the intervention upon study completion for ethical reasons.

### **Data Collection Procedure**

Data were collected at two time points: baseline (pre-intervention) and post-intervention (four weeks after baseline). All participants completed an electronic questionnaire assessing depressive symptoms at both time points. Standardized instructions were provided to ensure uniformity in data collection. To support engagement and minimize attrition, participants were contacted via WhatsApp/Telegram groups for technical support and reminders throughout the study period.

### **Measurement Tool**

Depressive symptoms were assessed using the Patient Health Questionnaire-9, a validated self-report instrument widely used for screening and measuring the severity of depressive symptoms. The PHQ-9 consists of nine items rated on a four-point Likert scale (0–3), yielding a total score range of 0 to 27, with higher scores indicating greater depressive severity. Standard cut-off scores classify depression as minimal, mild, moderate, moderately severe, and severe.

### **Statistical Analysis**

Data were analyzed using IBM SPSS Statistics version 26.0. Descriptive statistics (mean, standard deviation, frequencies, and percentages) were used to summarize participant characteristics. An intention-to-treat (ITT) approach was applied, including all randomized participants regardless of adherence level. Missing data were handled using multiple imputation (Multiple Imputation by Chained Equations, MICE).

**Inferential Analysis:**

Independent samples t-test was used to compare post-intervention PHQ-9 scores between groups

Paired samples t-test assessed within-group pre–post changes Analysis of covariance (ANCOVA) was conducted to adjust for baseline differences and control for potential confounders (age, gender, baseline PHQ-9 score). Effect size was calculated using Cohen’s d to quantify the magnitude of intervention effects. Statistical significance was set at  $p < 0.05$  (two-tailed).

**Ethical Considerations**

The study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the University of Babylon (Approval No. 746, dated January 20, 2026). All participants provided informed consent prior to participation. Confidentiality, anonymity, and data protection were strictly maintained throughout the study. Participation was voluntary, and participants retained the right to withdraw at any time without consequence.

**Results**

A total of 120 undergraduate students were enrolled and randomly assigned to the intervention group ( $n = 60$ ) or the waitlist control group ( $n = 60$ ). Table 1 presents the demographic characteristics of the full sample. The sample was predominantly female (57.5%), with a mean age of  $20.9 \pm 1.6$  years (range: 18–25). Participants were recruited from eight academic colleges. No statistically significant between-group differences were observed on any demographic variable (all  $p > 0.05$ ).

**Table 1. Demographic Characteristics of Participants (N = 120)**

| Characteristic             | Intervention Group (n = 60) | Waitlist Control Group (n = 60) | Total (N = 120) |
|----------------------------|-----------------------------|---------------------------------|-----------------|
| <b>Gender</b>              |                             |                                 |                 |
| Male                       | 26 (43.3%)                  | 25 (41.7%)                      | 51 (42.5%)      |
| Female                     | 34 (56.7%)                  | 35 (58.3%)                      | 69 (57.5%)      |
| <b>Age (years)</b>         |                             |                                 |                 |
| Mean $\pm$ SD              | 20.8 $\pm$ 1.6              | 21.1 $\pm$ 1.5                  | 20.9 $\pm$ 1.6  |
| Range                      | 18–25                       | 18–25                           | 18–25           |
| <b>College</b>             |                             |                                 |                 |
| Nursing                    | 9 (15.0%)                   | 8 (13.3%)                       | 17 (14.2%)      |
| Engineering                | 8 (13.3%)                   | 9 (15.0%)                       | 17 (14.2%)      |
| Science                    | 8 (13.3%)                   | 7 (11.7%)                       | 15 (12.5%)      |
| Education                  | 7 (11.7%)                   | 8 (13.3%)                       | 15 (12.5%)      |
| Administration & Economics | 8 (13.3%)                   | 8 (13.3%)                       | 16 (13.3%)      |
| Fine Arts                  | 7 (11.7%)                   | 7 (11.7%)                       | 14 (11.7%)      |
| Agriculture                | 7 (11.7%)                   | 7 (11.7%)                       | 14 (11.7%)      |
| Information Technologies   | 6 (10.0%)                   | 6 (10.0%)                       | 12 (10.0%)      |
| <b>Academic Year</b>       |                             |                                 |                 |
| First                      | 18 (30.0%)                  | 17 (28.3%)                      | 35 (29.2%)      |
| Second                     | 16 (26.7%)                  | 17 (28.3%)                      | 33 (27.5%)      |
| Third                      | 14 (23.3%)                  | 14 (23.3%)                      | 28 (23.3%)      |
| Fourth                     | 12 (20.0%)                  | 12 (20.0%)                      | 24 (20.0%)      |
| <b>Residence</b>           |                             |                                 |                 |
| Living with family         | 32 (53.3%)                  | 33 (55.0%)                      | 65 (54.2%)      |
| Student dormitory          | 16 (26.7%)                  | 15 (25.0%)                      | 31 (25.8%)      |
| Independent/rented         | 12 (20.0%)                  | 12 (20.0%)                      | 24 (20.0%)      |
| <b>Economic Status</b>     |                             |                                 |                 |
| Sufficient                 | 18 (30.0%)                  | 19 (31.7%)                      | 37 (30.8%)      |
| Moderate                   | 28 (46.7%)                  | 27 (45.0%)                      | 55 (45.8%)      |

| Characteristic | Intervention Group (n = 60) | Waitlist Control Group (n = 60) | Total (N = 120) |
|----------------|-----------------------------|---------------------------------|-----------------|
| Insufficient   | 14 (23.3%)                  | 14 (23.3%)                      | 28 (23.3%)      |

*Note. All  $p > 0.05$  (chi-square for categorical variables; independent t-test for age); randomization was successful.*

Table 2 presents the baseline distribution of PHQ-9 severity scores by group. The majority of participants in both groups scored in the moderate (10–14) or moderately severe (15–19) range. Mean baseline PHQ-9 scores were  $13.8 \pm 4.2$  (intervention) and  $13.6 \pm 4.1$  (control). The chi-square test indicated no significant difference in the severity distribution between groups ( $\chi^2 = 0.39$ ,  $p = .991$ ).

**Table 2. Baseline PHQ-9 Depression Severity Distribution by Group**

| Depression Category             | Intervention (n = 60)            | Control (n = 60)                 | Total (N = 120)                  | p           |
|---------------------------------|----------------------------------|----------------------------------|----------------------------------|-------------|
| Minimal (0–4)                   | 4 (6.7%)                         | 4 (6.7%)                         | 8 (6.7%)                         | .991        |
| Mild (5–9)                      | 11 (18.3%)                       | 12 (20.0%)                       | 23 (19.2%)                       | .991        |
| Moderate (10–14)                | 26 (43.3%)                       | 25 (41.7%)                       | 51 (42.5%)                       | .991        |
| Moderately Severe (15–19)       | 14 (23.3%)                       | 14 (23.3%)                       | 28 (23.3%)                       | .991        |
| Severe (20–27)                  | 5 (8.3%)                         | 5 (8.3%)                         | 10 (8.3%)                        | .991        |
| <b>Mean <math>\pm</math> SD</b> | <b><math>13.8 \pm 4.2</math></b> | <b><math>13.6 \pm 4.1</math></b> | <b><math>13.7 \pm 4.1</math></b> | <b>.873</b> |

*Note. Chi-square test for severity distribution; independent t-test for mean PHQ-9. p-values are for between-group comparison.*

Table 3 presents within-group PHQ-9 changes from baseline to post-intervention. The intervention group showed a mean reduction of 4.7 points (SD = 2.9;  $t(59) = 12.58$ ,  $p < .001$ ;  $d = 1.09$ ). The control group showed a mean reduction of 0.8 points (SD = 2.1;  $t(59) = 2.95$ ,  $p = .004$ ;  $d = 0.20$ ).

Figure 1 shows mean PHQ-9 scores ( $\pm$  SD) at baseline and post-intervention. The intervention group demonstrated a marked reduction compared to the control group ( $p < .001$ ).

**Table 3. Within-Group Pre- and Post-Intervention PHQ-9 Scores (Paired t-Test)**

| Group                     | Pre Mean $\pm$ SD | Post Mean $\pm$ SD | Change Mean $\pm$ SD | t     | p      | Cohen's d |
|---------------------------|-------------------|--------------------|----------------------|-------|--------|-----------|
| Intervention (n = 60)     | 13.8 $\pm$ 4.2    | 9.1 $\pm$ 3.8      | -4.7 $\pm$ 2.9       | 12.58 | < .001 | 1.09      |
| Waitlist Control (n = 60) | 13.6 $\pm$ 4.1    | 12.8 $\pm$ 4.0     | -0.8 $\pm$ 2.1       | 2.95  | .004   | 0.20      |

*Note. Paired samples t-test. Cohen's d benchmarks: 0.20 = small, 0.50 = medium, 0.80 = large (Cohen, 1988).*

Post-intervention PHQ-9 scores differed significantly between groups ( $t(118) = 5.41, p < .001$ ). The intervention group mean was  $9.1 \pm 3.8$  versus  $12.8 \pm 4.0$  in the control group, a mean difference of 3.7 points (95% CI: 2.33–5.07;  $d = 0.95$ ). Results are presented in Table 4.

**Table 4. Between-Group Comparison of Post-Intervention PHQ-9 Scores (Independent t-Test)**

| Outcome         | Intervention Mean $\pm$ SD | Control Mean $\pm$ SD | Mean Difference (95% CI) | t    | p      |
|-----------------|----------------------------|-----------------------|--------------------------|------|--------|
| Post-test PHQ-9 | 9.1 $\pm$ 3.8              | 12.8 $\pm$ 4.0        | 3.7 (2.33–5.07)          | 5.41 | < .001 |

**Effect Size: Cohen's d = 0.95 (Large)**

*Note. Independent samples t-test. CI = Confidence Interval.*

An ANCOVA was conducted with post-intervention PHQ-9 as the dependent variable and baseline PHQ-9, age, and gender as covariates. The group main effect was statistically significant ( $F(1,115) = 14.34, p < .001$ , partial  $\eta^2 = 0.110$ ). Adjusted post-intervention means were 9.3 (intervention) and 12.6 (control). Baseline PHQ-9 was the strongest covariate ( $F(1,115) = 68.34$ , partial  $\eta^2 = 0.369$ ). Age ( $p = .337$ ) and gender ( $p = .122$ ) were not statistically significant covariates. Results are presented in Table 5.

**Table 5. Analysis of Covariance (ANCOVA) – Adjusted Post-Intervention PHQ-9 Scores**

| Source                                                    | SS     | df  | MS    | F     | p      | Partial $\eta^2$ |
|-----------------------------------------------------------|--------|-----|-------|-------|--------|------------------|
| Baseline PHQ-9                                            | 892.4  | 1   | 892.4 | 68.34 | < .001 | 0.369            |
| Age                                                       | 12.1   | 1   | 12.1  | 0.93  | .337   | 0.008            |
| Gender                                                    | 31.6   | 1   | 31.6  | 2.42  | .122   | 0.021            |
| Group (Intervention vs. Control)                          | 187.3  | 1   | 187.3 | 14.34 | < .001 | 0.110            |
| Error                                                     | 1500.2 | 115 | 13.05 | —     | —      | —                |
| <b>Adjusted Means – Intervention: 9.3   Control: 12.6</b> |        |     |       |       |        |                  |

*Note. SS = Sum of Squares; df = degrees of freedom; MS = Mean Square;  $\eta^2$  = Eta squared.*

Table 6 presents stratified PHQ-9 change scores by gender. Among intervention participants, females showed a mean change of  $-5.3 \pm 2.8$  ( $d = 1.30$ ) and males showed  $-3.8 \pm 2.9$  ( $d = 0.90$ ). In the control group, changes were  $-0.9 \pm 2.0$  (females;  $d = 0.23$ ) and  $-0.7 \pm 2.2$  (males;  $d = 0.17$ ).

**Table 6. Gender-Stratified Analysis of PHQ-9 Change Scores**

| Gender        | Group                 | Pre Mean $\pm$ SD | Post Mean $\pm$ SD | Change $\pm$ SD                  | p      | Cohen's d   |
|---------------|-----------------------|-------------------|--------------------|----------------------------------|--------|-------------|
| <b>Female</b> | Intervention (n = 34) | 14.3 $\pm$ 4.1    | 9.0 $\pm$ 3.6      | <b>-5.3 <math>\pm</math> 2.8</b> | < .001 | <b>1.30</b> |
| <b>Female</b> | Control (n = 35)      | 14.1 $\pm$ 4.0    | 13.2 $\pm$ 3.9     | -0.9 $\pm$ 2.0                   | .007   | 0.23        |
| <b>Male</b>   | Intervention (n = 26) | 13.1 $\pm$ 4.3    | 9.3 $\pm$ 4.1      | <b>-3.8 <math>\pm</math> 2.9</b> | < .001 | <b>0.90</b> |
| <b>Male</b>   | Control (n = 25)      | 12.9 $\pm$ 4.2    | 12.2 $\pm$ 4.1     | -0.7 $\pm$ 2.2                   | .091   | 0.17        |

*Note. Paired samples t-test within each subgroup. Shaded rows = intervention subgroups.*

Table 7 presents the post-intervention PHQ-9 severity distribution. In the intervention group, 60.0% of participants fell in the minimal-to-mild range (0–9) versus 30.0% in the control group. Chi-square analysis indicated a statistically significant difference in the post-intervention severity distribution between groups ( $\chi^2 = 14.82$ ,  $p = .005$ ).

**Table 7. Post-Intervention PHQ-9 Depression Severity Distribution by Group**

| Depression Category              | Intervention (n = 60) | Control (n = 60) | $\chi^2$     | p                |
|----------------------------------|-----------------------|------------------|--------------|------------------|
| <b>Minimal (0–4)</b>             | 12 (20.0%)            | 5 (8.3%)         | <b>14.82</b> | <b>&lt; .001</b> |
| <b>Mild (5–9)</b>                | 24 (40.0%)            | 13 (21.7%)       | —            | —                |
| <b>Moderate (10–14)</b>          | 17 (28.3%)            | 24 (40.0%)       | —            | —                |
| <b>Moderately Severe (15–19)</b> | 6 (10.0%)             | 14 (23.3%)       | —            | —                |
| <b>Severe (20–27)</b>            | 1 (1.7%)              | 4 (6.7%)         | —            | —                |

*Note. Chi-square test for overall distribution difference between groups at post-intervention.*

Figure 2 shows that the intervention group demonstrated a clear shift toward lower depression severity levels, with a higher proportion of participants in the minimal-to-mild range compared to the control group. This difference was statistically significant ( $\chi^2 = 14.82$ ,  $p = .005$ ).

Table 8 summarizes adherence data for the intervention group. Participants completed a mean of  $67.4 \pm 9.8$  sessions out of 84 recommended (adherence rate: 80.2%). A total of 51 participants (85.0%) met the

pre-specified  $\geq 70\%$  adherence threshold. Mean daily usage was  $18.3 \pm 6.4$  minutes.

**Table 8. Adherence Summary — Intervention Group (n = 60)**

| Metric                           | Mean $\pm$ SD     | Min   | Max  |
|----------------------------------|-------------------|-------|------|
| Sessions completed (out of 84)   | $67.4 \pm 9.8$    | 41    | 84   |
| Overall adherence rate (%)       | $80.2 \pm 11.7$   | 48.8% | 100% |
| Met $\geq 70\%$ threshold, n (%) | <b>51 (85.0%)</b> | —     | —    |
| Did not meet threshold, n (%)    | 9 (15.0%)         | —     | —    |
| Daily usage (minutes)            | $18.3 \pm 6.4$    | 8     | 35   |

*Note. Adherence monitored via in-app usage logs and weekly self-report check-ins.*

A sensitivity analysis compared ITT and per-protocol outcomes (Table 9). The ITT analysis (n = 60) yielded  $d = 0.95$  ( $p < .001$ ). The per-protocol subgroup (n = 51;  $\geq 70\%$  adherence) yielded  $d = 1.12$  ( $p < .001$ ). Participants with low adherence (n = 9;  $< 70\%$ ) yielded  $d = 0.47$  ( $p = .041$ ).

**Table 9. Sensitivity Analysis — ITT versus Per-Protocol Results (Intervention Group)**

| Analysis                                             | n         | Post PHQ-9 Mean $\pm$ SD        | Change      | Cohen's d   | p                             |
|------------------------------------------------------|-----------|---------------------------------|-------------|-------------|-------------------------------|
| ITT (n = 60)                                         | 60        | $9.1 \pm 3.8$                   | -4.7        | 0.95        | $< .001$                      |
| <b>Per-Protocol (<math>\geq 70\%</math>, n = 51)</b> | <b>51</b> | <b><math>8.4 \pm 3.5</math></b> | <b>-5.4</b> | <b>1.12</b> | <b><math>&lt; .001</math></b> |
| Low Adherence ( $< 70\%$ , n = 9)                    | 9         | $11.8 \pm 4.1$                  | -2.0        | 0.47        | .041                          |

*Note. ITT = Intention-to-Treat. All analyses restricted to the intervention group.*

## Discussion

This randomized controlled trial demonstrated that a four-week engagement with the MindHealth mobile application produced a statistically significant and clinically meaningful reduction in depressive symptoms among undergraduate students (mean PHQ-9 change: -4.7 points; Cohen's  $d = 0.95$ ), compared to a negligible decline in the waitlist control group ( $d = 0.20$ ). The large between-group effect size, sustained across both intention-to-treat and per-protocol analyses, indicates that the observed benefit is robust and not attributable to differential attrition or threshold effects. These results contribute empirical evidence from an Iraqi academic context a setting that remains substantially underrepresented in the mHealth intervention literature. The current findings align with evidence supporting app-based interventions for depression in student populations. Musiat et al. [20] evaluated a CBT-based mobile application (Feel Stress Free) against a waitlist control in a university sample and reported significant

reductions in depressive symptoms — a design closely mirroring the present trial. Similarly, Raevuori et al. [21] found significant PHQ-9 reductions in a therapist-guided smartphone programme for young adults, noting that comparable trials reported between-group effect sizes of 0.31 to 0.78. The effect size observed here ( $d = 0.95$ ) exceeds the pooled estimate of  $g = 0.28$  reported by Linardon et al. [22] across 176 RCTs. This difference should be interpreted cautiously: the meta-analytic estimate aggregates highly heterogeneous designs, populations, and control conditions, and the present trial's waitlist design, elevated baseline severity, and structured usage protocol are each factors independently associated with larger effect sizes in app-based interventions. [23] specifically demonstrated that effects are significantly larger in samples with more severe baseline depression — consistent with the predominantly moderate-to-moderately-severe profile of the current cohort. Adherence in this trial (80.2%; 85% meeting the  $\geq 70\%$  threshold) exceeded benchmarks commonly reported in digital intervention studies. Structured researcher contact via messaging platforms and a concrete daily usage target likely reinforced engagement, consistent with evidence that supported mHealth delivery produces stronger outcomes than fully autonomous app use [21]. Female participants demonstrated a larger intervention effect ( $d = 1.30$ ) than male participants ( $d = 0.90$ ). This pattern is consistent with established gender differences in depression prevalence and help-seeking behaviour [24]: women report higher rates of depressive symptoms and are more likely to engage with psychoeducational and self-monitoring content the primary features of the MindHealth application. Arnautovska et al. [25] highlighted that gender-specific risk profiles are rarely incorporated into digital mental health prevention programmes, and the present findings support the value of gender-stratified analyses in future mHealth trials to inform tailored intervention design. The current results must be contextualised within a mixed literature. Lu et al. [26] reported non-significant effects on depression (Hedges  $g = -0.08$ ) across app-based mHealth trials and concluded that evidence for clinical use remains inconclusive. Hernandez-Gomez et al. [27] similarly found no significant symptom reduction when apps were compared against active controls in clinically diagnosed samples. These discrepancies are largely attributable to design differences: null findings predominantly arise in trials using active comparators or clinically diagnosed populations, whereas the present trial employed a waitlist design and recruited students self-reporting subthreshold-to-moderate symptoms a group with documented responsiveness to brief digital interventions [28]. The absence of an active control condition is a key limitation. Non-specific effects including Hawthorne reactivity, natural symptom fluctuation, and the motivational impact of study enrolment cannot be fully excluded. Deady et al. [28] demonstrated in a 2,200-participant RCT that even a smartphone app with behavioural activation content produced only a small effect compared to an attention-control app, underscoring the importance of credible comparison conditions. Future trials in this context should incorporate an active control arm, extend follow-up to at least three months, and collect mediation data to identify which app components drive symptom change.

The PHQ-9 was selected as the primary outcome measure on the basis of its well-established validity and reliability as a depression severity instrument [29], and its widespread use across app-based intervention trials ensures direct comparability with the existing literature. Baseline PHQ-9 scores in the present cohort (mean 13.7) are consistent with regional prevalence data: Kathem et al. [30] reported

depression symptom rates exceeding 45% among Iraqi healthcare students, and Al-Hadithi et al. [31] confirmed elevated mental health burden across Iraqi universities during the post-pandemic period. This epidemiological context reinforces the practical relevance of accessible, low-cost digital interventions.

Iraq represents a setting where a severely under-resourced mental health infrastructure [13] limits access to conventional treatment for the majority of students experiencing depressive symptoms. The demonstrated feasibility, acceptable adherence, and moderate-to-large effect of a self-guided mobile application in this context suggests that mHealth tools may offer meaningful population-level reach when traditional services are unavailable or stigmatised [32]. Nonetheless, Bautista and Schueller [32] caution that simply providing apps without institutional support and digital literacy guidance may be insufficient to sustain engagement — a consideration relevant to any future implementation in Iraqi universities.

## **Recommendations**

Future studies should: (1) employ active control conditions to isolate app-specific effects; (2) extend follow-up to at least three to six months to assess durability of gains; (3) replicate findings across multiple universities to strengthen external validity; (4) conduct mediation analyses to identify which app components psychoeducation, mood tracking, or self-monitoring are primary drivers of symptom reduction; and (5) develop gender-sensitive features informed by the differential response patterns observed here.

## **Conclusion**

This randomized controlled trial demonstrates that a four-week structured use of the MindHealth mobile application significantly reduced depressive symptoms among undergraduate students, with a large effect size and high adherence, indicating that the intervention is both effective and feasible. These findings suggest that mobile-based mental health applications can serve as scalable and accessible tools for supporting student mental health, particularly in resource-limited academic settings such as Iraq.

## **Limitation**

Several methodological considerations should be acknowledged. The use of a waitlist control may limit the ability to fully isolate intervention-specific effects. The single-site design may influence the generalizability of the findings, while the relatively short follow-up period does not allow assessment of long-term outcomes. In addition, reliance on self-reported measures may introduce potential response bias, and the absence of an active comparator limits deeper understanding of the intervention mechanisms.

# Abbreviations

ACEs: Adverse Childhood Experiences

PTSD: Post-traumatic Stress Disorder

CM: Child Maltreatment

CSA: Childhood Sexual Abuse

IPV: Intimate Partner Violence

SAD: Social Anxiety Disorder

DISC: Diagnostic Interview Schedule for Children

CTS: Childhood Trauma Screener

CIDI: Composite International Diagnostic Interview

ETI: Early Trauma Inventory

CTQ: Childhood Trauma Questionnaire

OR: Odds Ratio

CI: Confidence Interval

# Declarations

## Clinical Trial Registration

Not applicable.

## Authors' Contributions

The author independently designed the study, carried out all stages of the research process including literature review, data collection, statistical analysis, and manuscript preparation, and approved the final version of the manuscript.

## Funding

No funding was received for this study.

## Data Availability

No datasets were generated or analyzed during the current study.

## Declarations

## Ethics Approval and Consent to Participate

Not applicable.

## Consent for Publication

All authors provided consent for publication.

## Competing Interests

The authors declare no competing interests.

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## Figures

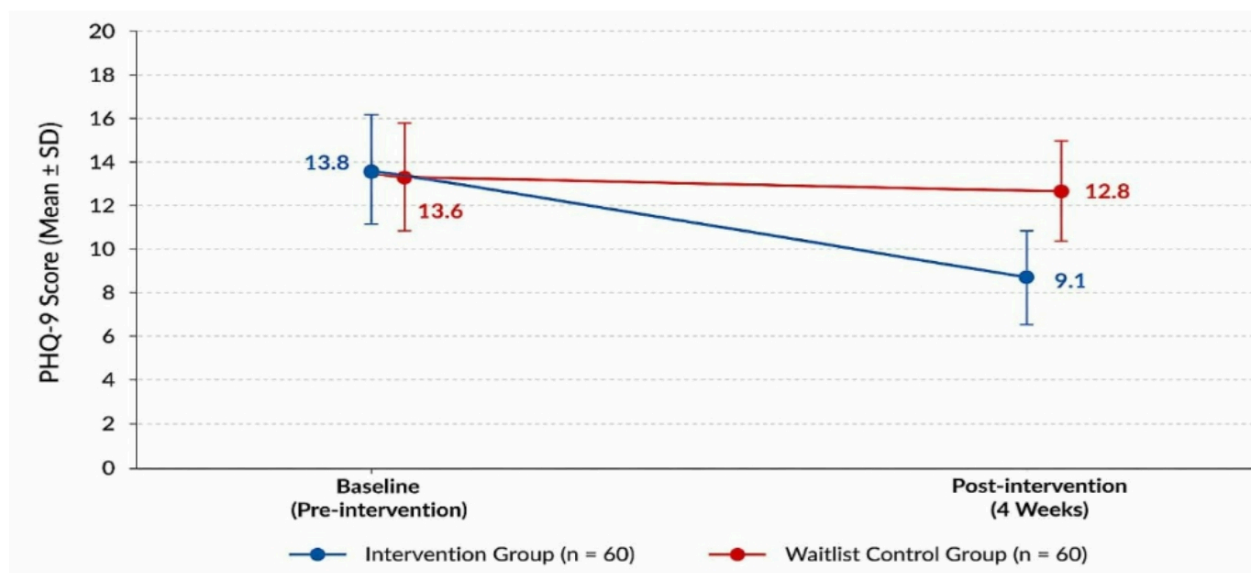


Figure 1

Change in PHQ-9 Scores from Baseline to Post-Intervention by Group

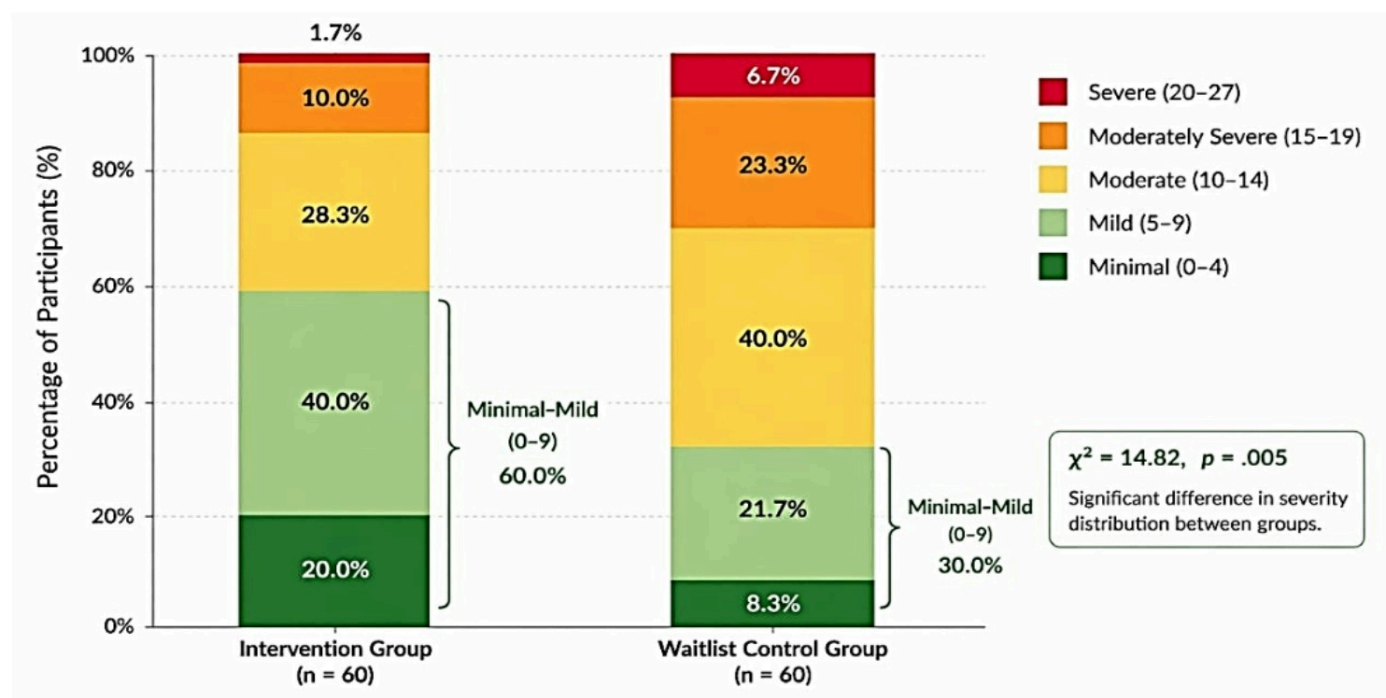


Figure 2

Group Differences in Post-Intervention Depression Severity (PHQ-9)