Impact of Adapted Mindfulness Training Integrating Interoception on Diabetic Patients with Impaired Awareness of Hypoglycemia: A Randomized Controlled Trial

May 6, 2026

Study Protocol

1. Integrity Statement

(1) Ensure that the operation is in strict accordance with the test protocol and the authenticity of the data records; (2) No conflict of interest with other projects.

2. Title of the study

Impact of Adapted Mindfulness Training Integrating Interoception on Diabetic Patients with Impaired Awareness of Hypoglycemia: A Randomized Controlled Trial

3. Flow chart of the implementation of the study

Specific implementation contents of the intervention programme

Week	Intervention Theme	Content Summary	Homework	Intervention Form
Week 1	Basic Mindful Awareness	**Mindfulness introduction:** Introduce the origins, concepts, and core content of mindfulness to patients. Explain the implementation process in detail, inform patients of the purpose of this study, course schedule, and precautions, and obtain their cooperation. **Mindful breathing:** Guide patients in mindful breathing, inhaling and exhaling smoothly. During inhalation, focus attention on the sensation of abdominal wall expansion; during exhalation, focus on the sensation of abdominal wall release, carefully experiencing every detail of the breath. Concentrate only on the breath, let go of all distracting thoughts and negative emotions, and notice changes in attention. Guide patients to share their practice experiences with each other to enhance mutual communication.	Mindful breathing	Group-based intervention, face-to-face in a community demonstration classroom. Provide participants with a mindful breathing video. Participants are required to complete mindful breathing at least 5 times per week, 15 minutes each day.
Week 2	Dynamic Perception Enhancement	**Body scan:** Guide patients to learn the body scan method, paying attention to their own bodily sensations. Following the sequence from feet to head, observe the sensations in each body part one by one, noticing every feeling—whether comfortable or not—without judgment. **Body scan guidance:** Guide patients to focus on hypoglycemia prodromal symptoms (e.g., finger tremors, palpitations) during the body scan, using non-judgmental observation to enhance sensitivity to physical signals. Use videos for supervision and guidance. Instruct patients using CGM to combine blood glucose changes with body scanning, helping them focus on physiological sensations when blood glucose <3.9 mmol/L (e.g., sweating level, subtle or obvious tremors, hunger, emptiness, or discomfort), thereby rebuilding early physical awareness of hypoglycemia.	Body scan	Group-based intervention, face-to-face in a community demonstration classroom. Provide participants with a body scan video. Participants are required to complete body scan at least 5 times per week, 15 minutes each day.

(Continued)

Week	Intervention Theme	Content Summary	Homework	Intervention Form
Week 3	Mindful Eating Reinforcement	**Mindful eating:** Explain mindful eating methods to patients and guide them through practice. Considering the blood glucose control requirements of diabetes patients, the traditional mindful eating exercise using raisins is changed to using cherry tomatoes. Guide patients to observe the appearance and smell of the cherry tomato, then chew it slowly, noticing the changes in the mouth, and observe internal feelings throughout the practice. **Mindful eating guidance:** Guide patients to eat mindfully, slow down their eating pace, and use the cherry tomato practice model to conduct sensory awareness training 30 minutes before eating. Perceive physiological signals such as saliva secretion and stomach contractions, and distinguish between true hunger and eating urges caused by reactive hypoglycemia.	Mindful eating	Group-based intervention, face-to-face in a community demonstration classroom. Participants are required to complete mindful eating at least 5 times per week.
Week 4	Mindful Awareness and Acceptance	**Mindful stretching:** Lead patients in mindful stretching exercises to relax the body. During practice, become aware of the surrounding environment, including physical touch and spatial perception. Movements should be slow and gentle, paying attention to bodily sensations, emotions, and inner thoughts during stretching. **Mindful stretching guidance:** During posture maintenance, guide patients to shift attention to physiological changes in the body, such as slight sweating on the palms, increased heart rate, mild trembling in the limbs, and other early signs of hypoglycemia. Encourage patients to observe bodily reactions with an open and accepting attitude, coexisting with present physical sensations while maintaining awareness of the surrounding environment.	Mindful stretching	Group-based intervention, face-to-face in a community demonstration classroom. Provide participants with a mindful stretching video. Participants are required to complete mindful stretching at least 5 times per week, 15 minutes each day.

(Continued)

Week	Intervention Theme	Content Summary	Homework	Intervention Form
Week 5	Stress Response Awareness	**Body scan:** Guide patients again through the body scan practice, instructing them to slowly scan the body and reinforce body awareness. Pay attention to sensations in each body part, whether comfortable or not, without judgment, emphasizing full engagement in the practice. If distraction occurs, calmly bring attention back to the scanning process, considering distraction as part of the practice. **Body scan guidance:** Guide patients to perform a 10-minute body scan every night before sleep. During the bedtime body scan, focus on detecting signs of hypoglycemia, perceive hypoglycemic symptoms, and identify nocturnal hypoglycemia.	Body scan	Group-based intervention, face-to-face in a community demonstration classroom. Provide participants with a body scan video. Participants are required to complete body scan at least 5 times per week, 15 minutes each day.
Week 6	Dynamic Mind-Body Awareness	**Mindful walking:** Explain the mindful walking method to patients and lead them through practice. Direct attention to both feet, carefully experiencing the continuous process of lifting the foot, shifting the center of gravity, and placing the foot on the ground. During practice, focus on the present actions and sensations, concentrating the mind on the act of walking itself. **Mindful walking guidance:** Guide patients, while walking, to notice the influence of environmental stimuli, perceive blood glucose fluctuations, and identify early signs of hypoglycemia (e.g., numbness in the soles, slight trembling of the calves, and rapid breathing).	Mindful walking	Group-based intervention, face-to-face in a community demonstration classroom. Provide participants with a mindful walking video. Participants are required to complete mindful walking at least 5 times per week, 15 minutes each day.

(Continued)

Week	Intervention Theme	Content Summary	Homework	Intervention Form
Week 7	Emotion-Body Connection	**Mindful meditation:** Guide patients in mindful sitting meditation. In a cross-legged seated posture, practice meditation by accepting whatever thoughts arise. Shift attention sequentially from the breath to different parts of the body, then to thoughts and emotions, and finally to the surrounding environment. During this process, notice changes in the body and emotions. **Mindful meditation guidance:** In the calm state after meditation, specifically guide patients to identify the characteristic mind-body response patterns associated with hypoglycemia. Guide them to recall physical sensations (e.g., palpitations, hand tremors), emotional experiences (e.g., fear, anxiety), and automatic thoughts (e.g., "Oh no, I'm going to faint again") that occur during hypoglycemia. The key is to observe as a bystander, not to identify with these experiences. Notice whatever thoughts and emotions arise in the mind, pay attention to these inner experiences, and accept the accompanying physiological responses.	Mindful meditation	Group-based intervention, face-to-face in a community demonstration classroom. Provide participants with a mindful meditation video. Participants are required to complete mindful meditation at least 5 times per week, 15 minutes each day.
Week 8	Beginning Mindful Living	Based on the data from the previous 7 weeks, generate a personalized practice combination. Guide patients in daily mindfulness training, allowing them to freely choose which practice to do, and help them maintain the practice consistently.	Free practice	One-on-one intervention, face-to-face in a community demonstration classroom. Guide participants to integrate mindfulness into daily life.

4. Background

Hypoglycemia frequently occurs during the glucose-lowering treatment of diabetes. Recurrent episodes of hypoglycemia can lead to impaired awareness of hypoglycemia (IAH), a clinical state where the ability to perceive the frequency, intensity, and symptoms of low blood sugar is diminished or even lost. The prevalence of IAH is as high as 20%-25% in patients with type 1 diabetes and 22% in those with insulin-treated type 2 diabetes. Compared with individuals with intact awareness, patients with IAH face a 17-fold higher risk of severe hypoglycemia, which can trigger fatal arrhythmias, cognitive dysfunction, or even death. Although new diabetes technologies and educational interventions have emerged, improvements in IAH remain limited, and few researchers have explored interventions from a psychological perspective.

Interoception is a comprehensive process involving the perception, integrated interpretation, and regulation of internal bodily signals, which is vital for maintaining internal physiological homeostasis. Recent studies have found that changes in interoceptive awareness are significantly associated with an increased risk of IAH. Enhancing interoceptive awareness can significantly improve symptom perception and disease self-management. Multiple studies have confirmed that mindfulness interventions can effectively enhance the activation of brain regions associated with interoception and improve patients' body awareness. Adapted mindfulness interventions, which are tailored to specific populations and needs, have shown positive effects in improving interoceptive awareness and adherence in patients with chronic diseases. In summary, this study aims to develop an 8-week interoception-integrated adapted mindfulness training program. The objective is to evaluate the effectiveness of this program in improving interoceptive awareness and hypoglycemia perception in diabetic patients with IAH, while exploring the underlying mechanisms. This research aims to provide a practical new psychological intervention for reducing the incidence of severe hypoglycemia and controlling the progression of diabetes.

5. Research purpose

The purpose of this study is to investigate the effectiveness of an interoception-

integrated adapted mindfulness training program for diabetic patients with IAH, and to provide a practical intervention for enhancing interoceptive awareness and reducing the severity of IAH, with the aim of improving symptom perception and controlling the progression of diabetes.

6. Inclusion and Exclusion Criteria

Inclusion criteria: (1) Diagnosed with type 1 or type 2 diabetes mellitus according to the latest American Diabetes Association (ADA) Standards of Care in Diabetes; (2) Receiving insulin therapy with a treatment duration of ≥ 1 year; (3) Age ≥ 18 and ≤ 80 years; (4) Duration of diabetes ≥ 5 years; (6) Gold score ≥ 4 and Clarke score ≥ 4; (7) Voluntarily participate and sign the informed consent form. Exclusion Criteria: (1) Prior experience with mindfulness interventions; (2) Diagnosed with cognitive impairment, psychiatric disorders, or other severe physical comorbidities; (3) Current use of psychotropic medications; (4) Pregnant or lactating women, or women of childbearing potential not using effective contraception.

7. Intervention process

From June 2026 to June 2027, patients with diabetes experiencing IAH who meet the inclusion and exclusion criteria will be recruited from two community health centers in Yangzhou. The control group will receive routine health education, while the intervention group will receive adapted mindfulness training integrating interoception in addition to the routine health education.

8. Sample size estimation

The sample size was estimated using the following formula: $n=2(\mu_\alpha+\mu_\beta)^2\sigma^2/\delta^2$, where μ_α represents the critical value corresponding to the probability of a Type I error, with a two-sided significance level set at $\alpha=0.05$ (5%); μ_β represents the critical value corresponding to the probability of a Type II error, with β set at 0.1, yielding a statistical power of $1-\beta = 0.9$; δ is the expected effect size, representing the absolute difference in means between the two groups; and σ^2 is the population variance, which can be estimated by the sample variance (the mean of the variances of the two groups). Based on relevant literature, δ and σ were set to 3.369 and 2.8, respectively. Assuming a 1:1 sample allocation ratio, the calculation indicates a required sample size of 31

participants per group. Accounting for an estimated 20% attrition rate, a minimum of 37 participants per group must be included. In this study, the planned sample size is 50 participants per group.

9. Randomisation

A single-blind principle will be followed in the study. Both the participants and the data collectors at all stages will be blinded to the group allocation, while only the personnel delivering the intervention will be aware of the assignment details. An independent researcher not involved in the study will generate a random number sequence ranging from 1 to 999 using an online random number generator (Research Randomizer, Version 4.0). Odd numbers will be assigned to the intervention group and even numbers to the control group. The generated random numbers will be written on slips of paper and sealed in sequentially numbered, opaque envelopes. Subsequently, another independent researcher, who is not involved in the randomization process, will distribute the envelopes according to their sequential order and the participants' order of enrollment. Finally, participants will be allocated to either the intervention or control group based on the random number enclosed within the envelope.

10. Measurement index

General information questionnaire: baseline (T0); multidimensional assessment of interoceptive awareness version 2 (MAIA-2) (primary indicator): baseline (T0), immediately post-intervention (T1), 1 month post-intervention (T2), 3 months post-intervention (T3); Clarke score (primary indicator): baseline (T0), immediately post-intervention (T1), 1 month post-intervention (T2), 3 months post-intervention (T3); Gold score (primary indicator): baseline (T0), immediately post-intervention (T1), 1 month post-intervention (T2), 3 months post-intervention (T3); five facet mindfulness questionnaire (FFMQ) (secondary indicator): baseline (T0), immediately post-intervention (T1), 1 month post-intervention (T2), 3 months post-intervention (T3); negative cognitive processing bias questionnaire (NCPBQ) (secondary indicator): baseline (T0), immediately post-intervention (T1), 1 month post-intervention (T2), 3 months post-intervention (T3).

11. Ethical consideration

The study was ethically approved by the Ethics Committee of the College of Nursing of Yangzhou University (YZUHL20250040).

12. Statistical analysis of data

Statistical analyses will be conducted using SPSS 27.0 software. All statistical tests will be two-sided with a significance level set at $\alpha = 0.05$.

(1) Descriptive statistical analysis: Depending on the distribution characteristics of continuous variables, normally distributed data will be described as mean ± standard deviation, whereas non-normally distributed data will be described using the median and interquartile range. Categorical data will be presented as frequencies and percentages.

(2) Univariate analysis: The independent samples t-test will be used for normally distributed continuous variables, and the non-parametric Mann-Whitney U test will be used for non-normally distributed variables. The Chi-square test will be applied for categorical variables.

(3) Generalized Estimating Equations (GEE): GEE will be employed to analyze the intervention effects of the adapted mindfulness training on the primary outcomes, secondary outcomes, and psychological mechanism indicators. All analyses will follow the intention-to-treat (ITT) principle. GEE accounts for within-subject correlations in longitudinal data, time-varying covariates, and missing data, and is capable of handling multiple types of outcome measures. GEE will be used to evaluate the differences in changes of outcome indicators between the intervention and control groups during the intervention period. The differences in the overall trends of variable scores over time between the two groups will be assessed through the time effect, group effect, and group × time interaction effect. Pairwise comparisons of estimated marginal means will be performed, and Cohen's d will be calculated based on the means and standard deviations from these pairwise comparisons to represent the magnitude of the intervention effect size (0.2–0.5 indicates a small effect, 0.5–0.8 indicates a medium effect, and ≥0.8 indicates a large effect).