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# Development and Psychometric Evaluation of a Graphical Braden Scale for Pressure Injury Risk Assessment

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## Abstract

# Objective

To graphically improve the Braden Pressure Injury Risk Assessment Scale and evaluate the reliability and validity of the revised graphical version.

# Methods

From January to February 2026, a convenience sample of 102 clinical nurses were selected to assess 88 patients for pressure injury risk. The formal graphical Braden scale was developed through Delphi expert consultation and a pre-survey. Its reliability and validity were tested using Cronbach's α coefficient, split-half reliability, test-retest reliability, content validity index (S-CVI/ave), exploratory factor analysis, and criterion-related validity.

# Results

The graphical Braden scale demonstrated a Cronbach's α of 0.849, split-half reliability of 0.892, and test-retest reliability of 0.875 ($P < 0.001$). The content validity (S-CVI/ave) was 0.98. Exploratory factor analysis extracted one common factor, accounting for 58.448% of the total variance. The criterion-related validity was 0.938 ($P < 0.001$).

# Conclusion

The graphical Braden scale exhibits good reliability and validity, meets psychometric standards, can effectively assess patients' pressure injury risk, and possesses high clinical application value.

## INTRODUCTION

Pressure injury (PI) refers to localized damage to the skin and/or underlying tissue, usually over a bony prominence, due to pressure or pressure in combination with shear.[1] PI not only aggravates the patient's condition and prolongs hospitalization but also significantly increases healthcare resource consumption, imposing a heavy economic burden on patients and their families. Prevention is crucial, and risk assessment lies at the heart of prevention. The Braden Scale is a widely used tool for assessing the risk of pressure injury. Although it has good predictive validity and reliability,[2] its clinical application is limited. Nurses' grasp of the scale details is insufficient, with correct cognition rates ranging from 36.1% to 61.6%. This is especially prominent among junior nurses, who demonstrate inaccurate understanding of various criteria, leading to biases or errors during assessment.[3] Furthermore, extensive textual descriptions increase the difficulty of information interpretation, affecting assessment efficiency.

Graphical scales, as innovative assessment tools, convey information through visual elements and demonstrate unique advantages in health assessment and medical decision-making fields. Compared to traditional text-based scales, they offer higher user appeal and information transmission efficiency. Desmet et al.[4] noted that graphical scales are easy to operate, time-saving, highly reliable, and adaptable to diverse research scenarios. However, research on graphical scales remains insufficient, with issues such as inconsistent quality and non-standardized development and validation processes.[5] Therefore, this study aimed to transform the Braden Scale into an intuitive graphical representation and test its reliability and validity, with the goal of providing clinical workers and other users with a more easily understandable and usable graphical tool for pressure injury risk assessment.

## SCALE DEVELOPMENT PROCESS

# 1.1 Graphical Transformation of the Braden Scale

# 1.1.1 Theoretical Basis

The scale was originally developed by Braden and Bergstrom in 1987. This study adopted the Chinese version of the Braden Scale.[6] The main assessment items include sensory perception, moisture, activity, nutritional status, mobility, and friction/shear. The total score ranges from 6 to 23 points, with lower scores indicating a higher risk of pressure sores. Research shows that the scale has a Cronbach's α of 0.743, sensitivity of 0.740, specificity of 0.590, and a prediction sensitivity for high-risk individuals of 90%-100%.

# 1.1.2 Drafting the Initial Graphical Braden Scale

Guided by User Interface (UI) design mentors and students from Central South University and with the professional guidance on pressure injury from hospital Enterostomal Therapists (ETs), the textual content of each item was transformed into pictorial form, resulting in the initial draft of the graphical scale.

The key points of each item's specific connotation in the Chinese version of the Braden Scale were summarized. Basic graphics were formed based on these key points, and then enriched according to the different scoring levels within each item. Table 1 shows the key points for each item.

Table 1
Key points of the connotation of each item of Braden scale

| Item | Key point 1 | Key point 2 | Key point 3 |
|---|---|---|---|
| 1.Perception | Feelings and pain | Response to stimuli | Perceived restricted area |
| 2.Humidity | The frequency of changing sheets due to dampness | | |
| 3.Motility | Model of action | Duration of activity | |
| 4.Incomotivity | Whether can move | The part that can move | The range of movement |
| 5.Nutriture | Appetite intake | Protein intake | Fluid intake |
| 6.Frictional/Shearing Force | Degree of assistance required for posture change | Degree of sitting descent | |

# 1.1.3 Delphi Expert Consultation

From January to February 2026, 15 experts were invited for consultation via face-to-face distribution and email. Consultation was terminated when expert opinions converged. Expert inclusion criteria: 1) Bachelor's degree or higher; 2) Intermediate professional title or higher; 3) In-depth knowledge or practice in PI or wound/ostomy care, nursing, or research, with relevant project approvals and publications in open-access journals; 4) Active interest in this study.

The consultation questionnaire consisted of five parts: preface, basic expert information, familiarity with and basis for judgment on the Braden Scale for PI risk assessment, and content validity evaluation. The degree of conformity between the pictures and each sub-item was assessed using a Likert 5-point scale, ranging from "does not conform" (1) to "strongly conforms" (5). Experts could also provide modification or deletion suggestions. The criteria for item screening were an importance score mean ≥ 4.0 and a coefficient of variation ≤ 0.2. The consultation was terminated when Kendall's W coefficient was > 0.7 ($P < 0.05$).[7] Based on expert opinions and research team discussions, item graphics were supplemented, deleted, or modified to form a revised graphical scale.

# 1.1.4 Pilot Survey

In January 2026, 20 clinical nurses were conveniently selected for a pilot survey. Cognitive interviews were conducted with these 20 nurses to understand their comprehension and suggestions regarding the graphical items. Based on the collected feedback, the expert panel compared, discussed, and revised the scale, resulting in the final version of the graphical Braden Scale(Fig. 1).

# 1.2 Psychometric Testing of the Scale

# 1.2.1 Participants

Using convenience sampling, 102 clinical nurses were selected in January 2026 to assess 88 patients for pressure injury risk. Inclusion criteria for nurses: 1) Registered practicing nurses; 2) Nurses with over one year of clinical nursing experience who voluntarily participated. Exclusion criteria: 1) Nurses on business trips, vacations, or otherwise not on duty; 2) Nurses unable to complete the scale for various reasons. Included inpatients were those whose condition had stabilized after implementing PI prevention measures, with no significant fluctuation in PI risk in the short term. This study was conducted in accordance with the Declaration of Helsinki and the Ethical Review Methods for Life Science and Medical Research Involving Humans (2023). The study protocol was approved by the Medical Ethics Review Committee of Xiangya Hospital Central South University (Approval No. 2025122351). All subjects (participants), including nurses and patients, signed the informed consent form.

## 1.2.2 Study Instruments

Included a general information questionnaire, the Chinese version of the Braden Scale, and the final graphical Braden Scale. The general information questionnaire was self-designed by the research team based on literature review and clinical practice, covering demographic characteristics of clinical nurses (e.g., gender, age, department, professional title, education level) and the ID numbers of the assessed patients.

## 1.2.3 Data Collection Methods and Quality Control

After obtaining approval from the hospital nursing department and head nurses of relevant departments, research team members explained the study purpose and scale completion methods to participants in various departments in February 2026. Following informed consent, nurses used the graphical Braden Scale to assess patients for PI risk. Clarifications were provided on-site for any queries, and questionnaires were collected immediately. Within one day, the same group of nurses reassessed the same patients using the Chinese version of the Braden Scale. After a one-week interval, approximately ten pairs were selected from the same participants for retesting with the graphical Braden Scale to measure test-retest reliability.

Fifteen experts reviewed the Braden assessment results of all included patients. Assessment results that clearly did not meet the standard were screened out to ensure the accuracy of all results. Patients whose Braden scores showed no significant fluctuation within one week were selected for retesting.

## 1.2.4 Reliability Analysis

Cronbach's α coefficient, split-half reliability, and test-retest reliability were used to assess the scale's reliability. Cronbach's α coefficient measures the degree of consistency among internal items, reflecting the scale's homogeneity reliability. A Cronbach's α ≥ 0.7 is acceptable, and ≥ 0.8 is good. Split-half reliability involves randomly dividing the scale into two parts and calculating the correlation between the scores of the two parts, reflecting item equivalence. A split-half reliability ≥ 0.7 is acceptable, and ≥ 0.8 is good. Test-retest reliability involves administering the same scale to the same participants at different

times to assess score stability. A test-retest reliability ≥ 0.6 is acceptable, and ≥ 0.8 indicates excellent stability.

### 1.2.5 Validity Analysis

Content validity and criterion-related validity were used to assess the scale's validity. Fifteen relevant experts were invited to evaluate the relevance of each item in the graphical Braden Scale to the Chinese version, provide modification suggestions, and score each item based on the degree of relevance, thereby calculating the content validity index (CVI). Criterion-related validity of the graphical Braden Scale was examined from multiple perspectives using the Chinese Braden Scale as the criterion.

## 1.3 Statistical Analysis

Data were entered by two individuals using Excel software. After verification, the data were imported into SPSS 25.0 for statistical analysis. Measurement data are expressed as mean ± standard deviation ($\bar{x} \pm s$), and count data are expressed as number (%). A two-sided $\alpha = 0.05$ was set as the significance level, with $P < 0.05$ considered statistically significant.

# RESULTS

## 2.1 Delphi Expert Consultation Results

### 2.1.1 General Characteristics of Experts

Fifteen experts from the fields of clinical nursing, nursing management, research, and wound/ostomy care in China were included. Twelve were female, three were male; average age was (46.53 ± 7.74) years; five held bachelor's degrees, five held master's degrees, and five held doctoral degrees; average years of relevant work experience was (25.60 ± 8.81) years; six held senior professional titles, seven held associate senior titles, and three held intermediate titles; four were doctoral supervisors, three were master's supervisors.

### 2.1.2 Experts' Enthusiasm and Authority

Expert enthusiasm was indicated by the effective questionnaire return rate. Fifteen questionnaires were distributed for each of the two rounds, all were returned, resulting in a 100% effective return rate. The coefficient of expert familiarity (Cs) was 0.91, the coefficient of judgment basis (Ca) was 0.92, and the authority coefficient (Cr) was 0.915, indicating reliable consultation results (Tables 2–3).

Table 2
Expert familiarity

| Degree of familiarity | Number (scores) | | | | |
|---|---|---|---|---|---|
| | Very familiar | More familiar | Generally familiar | Not very familiar | Not familiar |
| | 8(□) | 7(0.8) | 0(0.6) | 0(0.4) | 0(0.2) |

Table 3
Expert judgment basis

| **Judgment criteria** | **Number (scores)** | | |
|---|---|---|---|
| | **Great degree** | **Moderate degree** | **Small degree** |
| Practical experience | 11(0.5) | 3(0.4) | 1(0.3) |
| Theory evidence | 8(0.3) | 7(0.2) | 0(0.1) |
| Literature support | 6(0.1) | 8(0.1) | 1(0.1) |
| Subjective feeling | 8(0.1) | 2(0.1) | 5(0.1) |

# 2.1.3 Expert Suggestions

Kendall's W coefficients for the two consultation rounds were 0.211 and 0.786 ($P < 0.001$), respectively. The second round showed good consistency, so consultation was terminated. Suggestions from the 15 experts included:

1) For the Sensory Perception dimension, depict patient pain stimulus expressions, verbal responses, pain stimulus methods, and areas of bodily sensory impairment in a hierarchical manner.

2) For the Moisture dimension, clarify the area and color of moisture and the interval for changing bed linens.

3) For the Activity and Mobility dimensions, pay attention to detail depiction, such as adding bed rails, distinguishing indoor/outdoor with windows and colors, and specifying assistance actions for repositioning.

4) For the Nutritional Status dimension, consult nutritionists to define specific foods and portions for "one serving" of protein and clarify the representation of enteral and parenteral nutrition.

5) For the Friction/Shear dimension, pay attention to illustrating the magnitude of friction and clearly define actions.

After two rounds of consultation, expert opinions converged. The consultation was concluded, resulting in a revised questionnaire containing 40 pictures.

## 2.2 Pilot Survey Results

Twenty clinical nurses trialed the revised scale. Cognitive interviews indicated that the items were reasonable, clearly expressed, with no comprehension deviations or suggested modifications. Completion time was around 5 minutes.

## 2.3 Psychometric Test Results of the Graphical Braden Scale

### 2.3.1 General Characteristics of Survey Participants

The 102 clinical nurses surveyed were aged 21–61 (32.54 ± 7.05) years; 19 (18.6%) were male, 83 (81.4%) were female; 25 (24.5%) worked in general wards, 77 (75.5%) in intensive care units; 16 (15.7%) had associate degrees, 78 (76.5%) had bachelor's degrees, 8 (7.8%) had postgraduate degrees; 17 (16.7%) were Nurses, 16 (15.7%) were Senior Nurses, and 69 (67.6%) were Nurse-in-Charge.

Among the 88 patients surveyed, PI risk ratings were: very high risk (≤ 9 points): 5; high risk (10–12 points): 45; moderate risk (13–14 points): 12; mild risk (15–18 points): 13; no risk (> 18 points): 13.

### 2.3.2 Reliability Test Results

Cronbach's α coefficient for the final graphical Braden Scale was 0.849. The Cronbach's α coefficients for the dimensions of Sensory Perception, Moisture, Activity, Mobility, Nutritional Status, and Friction/Shear were 0.804, 0.873, 0.798, 0.785, 0.835, and 0.823, respectively, indicating good internal consistency within each dimension. Split-half reliability was 0.892, indicating good structural stability of the scale. The test-retest reliability coefficient was 0.875 ($P < 0.001$), indicating good test-retest reliability and temporal stability of the scale.

### 2.3.3 Validity Test Results

#### 2.3.3.1 Content Validity

First-round consultation results showed that the I-CVIs for the four items of Sensory Perception and the second item of Mobility ranged from 0.67 to 0.73, below 0.78. Second-round results showed I-CVIs for all items ranging from 0.93 to 1.00, all above 0.78. The average S-CVIs for each dimension were 1.00, 1.00, 0.98, 1.00, 0.93, and 0.98, respectively. The average S-CVI/ave for the total scale was 0.98, all exceeding 0.80. This indicates good content validity of the scale.

#### 2.3.3.2 Factor Analysis

Principal component analysis was used. Results showed: Kaiser-Meyer-Olkin (KMO) measure was 0.776 (≥ 0.5), Bartlett's test of sphericity approximate $\chi^2$ was 328.775 ($P < 0.001$), indicating suitability for principal component analysis. Only one component was extracted, explaining 58.448% of the total variance.

## 2.3.3.3 Criterion-Related Validity

Correlation analysis showed a significant correlation between the graphical Braden Scale and the Chinese version ($r = 0.938$, $P < 0.001$).

Table 4
Matrix of components of Pictorial Braden scale

| Item | Factor loading |
|---|---|
| Incomotivity | 0.887 |
| Motility | 0.848 |
| Perception | 0.833 |
| Frictional/Shearing Force | 0.789 |
| Nutriture | 0.729 |
| Humidity | 0.393 |

# DISCUSSION

## 3.1 The Graphical Braden Scale Exhibits Good Reliability and Measurement Stability

This study systematically tested the reliability and validity of the graphical Braden Scale, and the results indicate good psychometric properties. Regarding reliability, the scale demonstrated excellent internal consistency (Cronbach's α = 0.849) and split-half reliability (0.892) in the sample of clinical nurses, both exceeding the recommended threshold of 0.80, indicating high measurement stability. The test-retest reliability coefficient after a one-week interval was 0.875 ($P < 0.001$), further confirming good temporal stability of the scale.[8]

## 3.2 Validity Test Results Support Its Unidimensionality Hypothesis and Theoretical Framework

In terms of validity, the scale passed rigorous content validity assessment. The second-round Delphi consultation results showed that all items' I-CVIs were greater than 0.78, the total scale's S-CVI/ave reached 0.98, and Kendall's W coefficient was 0.786 ($P < 0.001$), indicating high consensus among experts regarding scale content.[9] Exploratory factor analysis extracted one common factor, explaining 58.448% of the total variance. The KMO value was 0.776. Factor loadings for all dimensions except Moisture (0.393) were greater than 0.7. These indicators meet standards[10], supporting the scale's unidimensionality hypothesis. The criterion-related validity was 0.938, consistent with the theoretical framework of the original Braden Scale[11].

## 3.3 Graphical Improvement Enhances Clinical Applicability, but Limitations Remain

Compared to the original Braden Scale, the pictorial version, while maintaining the original measurement properties, significantly improves ease of use and clinical applicability through visual presentation. This improvement not only increases assessment efficiency but may also reduce inter-rater variability, consistent with findings by Zhang et al. on visual assessment tools.[12] However, this study has several limitations. First, the relatively limited sample size may affect the generalizability of the results. Second, the lack of a unified criterion validity analysis aligns with common scale validation issues noted in related research.[7] Third, patients' conditions may change during a week of hospitalization, consequently altering PI risk.[13] Although we proactively selected patients with minimal score fluctuation for retesting, whether test-retest reliability in this study accurately reflects the scale's temporal stability remains debatable. Finally, qualitative feedback from third-party users was not included.

## 3.4 Future Research Directions

Based on the above limitations, future research is recommended to:  Expand the sample size to include different levels of healthcare institutions.  Employ standardized criterion tools for parallel validation.  Enhance inter-rater consistency to compensate for limitations of test-retest reliability.  Conduct qualitative research on user experience.

In summary, the pictorial Braden Scale demonstrates good reliability and validity indicators, meeting psychometric standards[14], and can effectively assess patients' pressure injury risk. The development of this scale not only provides reliable tool support for clinical nursing practice but also offers a new methodological reference for pressure injury risk assessment, holding significant clinical application value.

## Abbreviations

PI
Pressure Injury
ET
Enterostomal Therapist
CVI
Content Validity Index
S-CVI
Scale-level Content Validity Index
S-CVI/Ave
Scale-level Content Validity Index/Average
I-CVI
Item-level Content Validity Index

KMO
Kaiser-Meyer-Olkin
SPSS
Statistical Package for the Social Sciences
UI
User Interface

## Declarations

# Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and the Ethical Review Methods for Life Science and Medical Research Involving Humans (2023). The study protocol was approved by the Medical Ethics Review Committee of Xiangya Hospital Central South University (Approval No. 2025122351). Written informed consent was obtained from all participants, including nurses and patients.

**Consent for publication**

Not applicable.

# Competing Interests

All authors declare no conflicts of interest.

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# Author Contribution

First Author Tian Hanzhang's contributions: Conceptualization and design of the study, drafting of the graphical scale, data collection and organization, and manuscript writing.Corresponding Author Zhang Qijian's contributions: Overall conception and supervision of the study, provision of key methodological guidance, and final review and approval of the manuscript.Third Author Dai Weiwei's contributions: Organization and implementation of the Delphi expert consultation, statistical analysis and interpretation

of data.Fourth Author Tang Qiongfang's contributions: Participation in data collection for the pilot and formal surveys, quality control and logistical support for the study.All authors reviewed the manuscript.

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# Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to patient privacy and institutional data protection policies, but are available from the corresponding author on reasonable request.

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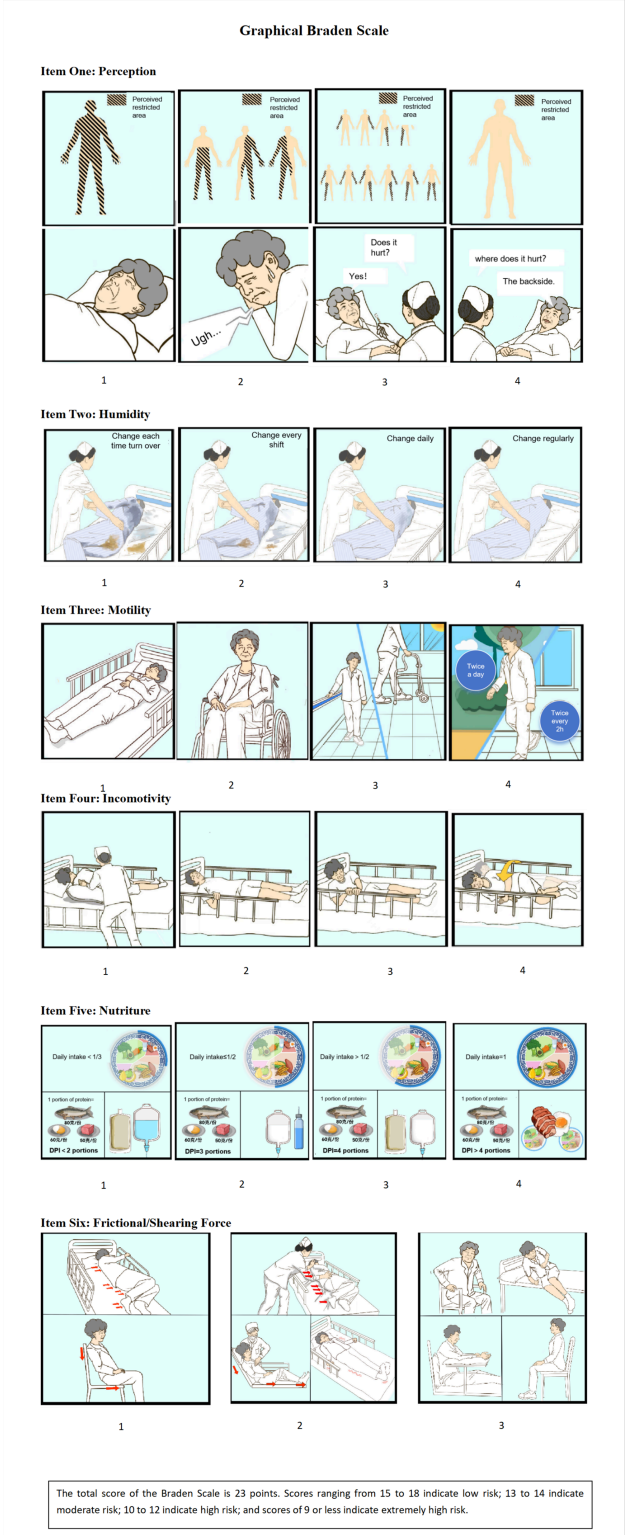
## Figures




## Figure 1

The final version of the graphical Braden Scale