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Turkish Translation and Cultural Adaptation, Validity and Reliability of the CALCULATE Pressure Injury Risk Scale in Intensive Care Unit Patients

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ABSTRACT

Background: Pressure injuries are largely preventable adverse events that compromise patients' quality of life and impose a substantial financial burden on healthcare systems.

Aim: To assess the validity and reliability of the Turkish version of the Critical Care Pressure Ulcer Assessment Tool Made Easy (CALCULATE) for evaluating pressure injury (PI) risk among intensive care unit (ICU) patients.

Study Design: A methodological validation study employing an observational, prospective cohort design.

Methods: This study was conducted in a level III Anaesthesia and Resuscitation ICU at a teaching and research hospital in Türkiye, between October 1, 2024, and January 31, 2025. Adult patients (≥18 years) who were hospitalized in the ICU for ≥24 h and had no PI at admission were eligible for inclusion. PI risk was independently evaluated by the researcher and an ICU nurse using CALCULATE and the Braden Scale. Predictive validity was analysed through receiver operating characteristic (ROC) curve analysis by calculating the area under the curve (AUC) on days 1 and 7. Inter-rater reliability was determined using the intraclass correlation coefficient (ICC).

Results: A total of 76 patients were enrolled, of whom 15 (19.7%) developed PIs. The content validity index (CVI) was 1.00, indicating full expert agreement. CALCULATE demonstrated strong inter-rater reliability (ICC = 0.933; 95% CI, 0.922–0.943; $F = 15.007$; $p < 0.001$). Furthermore, CALCULATE exhibited strong discriminative performance in predicting PI occurrence (AUC = 0.82 on day 1; AUC = 0.84 on day 7; $p < 0.0001$). For the CALCULATE scale, the Youden index values were 0.4874 on Day 1 and 0.6525 on Day 7, with an optimal cutoff value of > 3 at both time points. At this threshold, sensitivity was 73.33% on Day 1 and 80.00% on Day 7, while specificity was 75.41% and 85.25%, respectively. For the Braden Scale, the AUC was 0.752 on Day 1 and 0.857 on Day 7. The Braden Scale Youden index was 0.4918 on Day 1 and 0.6230 on Day 7, with an optimal cutoff value of ≤ 14 at both time points. Sensitivity was 100% on both days, whereas specificity was 49.18% on Day 1 and 62.30% on Day 7, indicating higher specificity on Day 7 while maintaining full sensitivity for pressure injury occurrence.

Conclusion: The Turkish version of the CALCULATE Scale showed evidence of content validity, inter-rater reliability, and predictive performance for assessing pressure injury risk in intensive care unit patients.

Implications for the Profession and/or Patient Care: The Turkish version of the CALCULATE scale may provide ICU nurses with a brief and structured approach to identifying patients at increased risk of pressure injury during the early stages of critical care. Its use may support individualized prevention planning, including more frequent skin assessment, appropriate repositioning, support-surface selection, moisture management, nutritional evaluation, and medical device surveillance.

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CALCULATE should be used as a complement to comprehensive nursing assessment and clinical judgement rather than as a replacement for them. Further studies are needed to determine whether its implementation influences pressure injury incidence, patient safety outcomes, or resource utilization. The psychometric findings of this study align with existing literature and support the clinical interpretability of the Turkish CALCULATE scale. Future studies could examine additional time points to confirm performance over time. Multicenter studies with larger samples across different ICU levels are recommended to further validate the Turkish CALCULATE scale and to assess its impact on clinical outcomes.

Patient or Public Contribution: There was no patient or public contribution.

Trial Registration: The study was registered at ClinicalTrials.gov (NCT07454746) because the study implementation phase involved the prospective enrollment of patients and the collection of clinical data.

1 | Introduction

Pressure injuries (PI) are largely preventable adverse events that compromise patients' quality of life and impose a substantial financial burden on healthcare systems (Demarré et al. 2015; Li et al. 2020). A PI is defined as a localized injury to the skin and/or underlying tissue, typically occurring over a bony prominence or associated with a medical device, resulting from pressure and/or shear forces (EPUAP/NPIAP/PPPIA 2025). Patients in the intensive care unit (ICU) represent one of the most vulnerable populations because they are concurrently exposed to multiple risk factors such as immobility, sedation, mechanical ventilation, hemodynamic instability, and the use of medical devices (Hyunand and Park 2025; Jacq et al. 2021; Labeau et al. 2021). Consequently, the likelihood of developing PI in the ICU has been reported to be approximately four times higher than in other patient groups, with ~75% of cases occurring between 5 and 25 days of hospitalization (Coyer et al. 2022; Caner et al. 2022).

International evidence demonstrates that both the prevalence and incidence of PI in ICUs are substantially higher than those observed in general wards (Labeau et al. 2021; Chaboyer et al. 2018). Economic analyses further indicate that PI, particularly in advanced stages, are associated with significantly increased treatment costs, underscoring their global clinical and financial impact (Cortésand and Vásquez 2024; Zarei et al. 2019). Similarly, research conducted in Türkiye shows that although rates vary across institutions, the occurrence of PI in ICUs remains clinically significant, and medical device-related PI (MDRPI) accounts for a considerable proportion of cases (Baykara et al. 2023; Karacabay et al. 2023).

The prevention of hospital-acquired PI is widely recognized as a key indicator of healthcare quality and continues to be a major priority in clinical practice (Tayyiband and Coyer 2016). The 2025 EPUAP guideline emphasizes that risk assessment should not be regarded merely as a screening procedure but rather as a comprehensive clinical decision-making process that guides the development of individualized preventive care plans (EPUAP/NPIAP/PPPIA 2025). Although more than 40 instruments have been developed to assess PI risk, tools designed for general patient populations may not adequately reflect the unique risk profile of critically ill patients in the ICU (Adıbelliand and Korkmaz 2018; Mooreand and Patton 2019; European Pressure Ulcer Advısory Panel 2019; Richardsonand and Straughan 2015; *Design and Study of Validity and Reliability of a New Rating Scale to Estimate the Risk of Pressure Ulcer in Patients Attended in Critical Care Units COMHON [Internet]* 2013; Norton et al. 1962; Waterlow 1985; National Pressure Injury Advisory Panel (NPIAP) 2019; Wåhlin et al. 2021; González-Ruiz et al. 2008; Richardsonand and Barrow 2015; Akmanand and Alpar 2014; Suriadi et al. 2008).

Among the available PI risk assessment instruments, the Braden Scale is widely used in clinical practice (Bradenand and Bergstrom 1989); however, it was developed for general patient populations and may not fully capture ICU-specific risk factors such as hemodynamic instability, mechanical ventilation, sedation, impaired tissue perfusion, and medical device exposure (Zhang et al. 2021). ICU-specific risk assessment instruments have therefore been developed to address these limitations, with evidence supporting their validity and reliability across different clinical and cultural contexts (Adıbelliand and Korkmaz 2018; Richardsonand and Straughan 2015; González-Ruiz et al. 2008; Akmanand and Alpar 2014; Grupo de desarrollo del Índice COMHON 2013). CALCULATE, on the other hand, was developed to provide a rapid and practical assessment of pressure injury risk in critical care settings and is sensitive to ICU-specific risk factors (Alderden et al. 2017; Picoito et al. 2023). The availability of these tools indicates that general risk assessment scales alone may not be sufficient for ICU patients and highlights the need for valid, reliable, and clinically feasible risk assessment instruments specific to this patient population. Therefore, evaluating CALCULATE in Turkish ICU patients is important to support accurate risk assessment and individualized prevention strategies.

This study aimed to translate and culturally adapt the Critical Care Pressure Ulcer Assessment Tool Made Easy (CALCULATE) into Turkish and to evaluate its validity and reliability for use in ICU patients.

2 | Methods

2.1 | Design

This methodological, observational, prospective cohort study was conducted to ensure a systematic and transparent Turkish adaptation of the instrument. The translation and cultural adaptation process was designed and implemented in accordance with the International Test Commission (ITC) Guidelines for Translating and Adapting Tests (International Test Commission 2019) and the International Society for Pharmacoeconomics and Outcomes Research (ISPOR)

Principles of Good Practice for Translation and Cultural Adaptation (Beaton et al. 2000).

The ITC guideline includes 29 criteria encompassing pre-adaptation decisions; translation and adaptation procedures; the generation of evidence for measurement equivalence, reliability, and validity; as well as considerations related to administration, scoring, interpretation, and documentation. Applying this framework enhances the instrument's suitability for the target population, improves the traceability of psychometric outcomes, and strengthens the overall quality of reporting (International Test Commission 2019; Beaton et al. 2000; Hernández et al. 2020). The procedures followed for validity and reliability testing are summarized in Figure 1.

2.2 | Setting and Sample

The study population consisted of patients admitted to a Level III Anesthesiology and Reanimation ICU of a training and research hospital between October 2024 and January 2025. A power analysis was conducted to determine the number of participants required for the study. The test power was calculated using Medcalc 18.11.3 software. A Type I error of 0.05, a Type II error of (1—Power), and an AUC of 0.8 were assumed. To ensure the study's power exceeded 90%, a total of 39 participants, 13 diagnosed and 26 undiagnosed, were required at a 5% significance level. Since the study was conducted using a prospective method, a total of 76 patients, 15 diagnosed and 61 undiagnosed, were ultimately required.

Eligible participants were adults (≥18 years) with an ICU length of stay of ≥24 h and no PI at admission. During the study period, 253 patients were admitted to the unit. Of these, 138 patients did not meet the inclusion criteria, and 39 declined participation. Consequently, the final study sample included 76 patients.

2.3 | Data Collection Tools

Data were collected using the Patient Identification Form and the Braden and CALCULATE scales. Assessments performed by the researcher and an ICU nurse were recorded independently to ensure objectivity.

2.3.1 | Patient Identification Form

The Patient Identification Form was developed by the researcher and includes eight items addressing patients' demographic and clinical characteristics, as well as variables related to PI (Richardsonand and Straughan 2015; Richardsonand and Barrow 2015; Theeranut et al. 2021; Günesand and Efteli 2015).

2.3.2 | Braden Scale

The Braden Scale was developed by Braden and Bergstrom (Bradenand and Bergstrom 1989), and its Turkish validity and reliability were established by Oğuz (Oğuz 1997). The instrument assesses PI risk across six domains: sensory perception, moisture, activity, mobility, nutrition, and friction/shear. It is widely used in clinical settings and generates a total score ranging from 6 to 23, with lower scores indicating a higher risk of PI development. In the Turkish validation study, Cronbach's alpha coefficient was reported as 0.95.

2.3.3 | CALCULATE Scale

The Critical Care Pressure Ulcer Assessment Tool made Easy (CALCULATE) is a PI risk assessment tool developed for critically ill patients by Richardson and Straughan (Richardsonand and Straughan 2015). The instrument consists of eight dichotomous risk factors: inability to reposition, low protein levels, dialysis, faecal incontinence, mechanical ventilation, prolonged

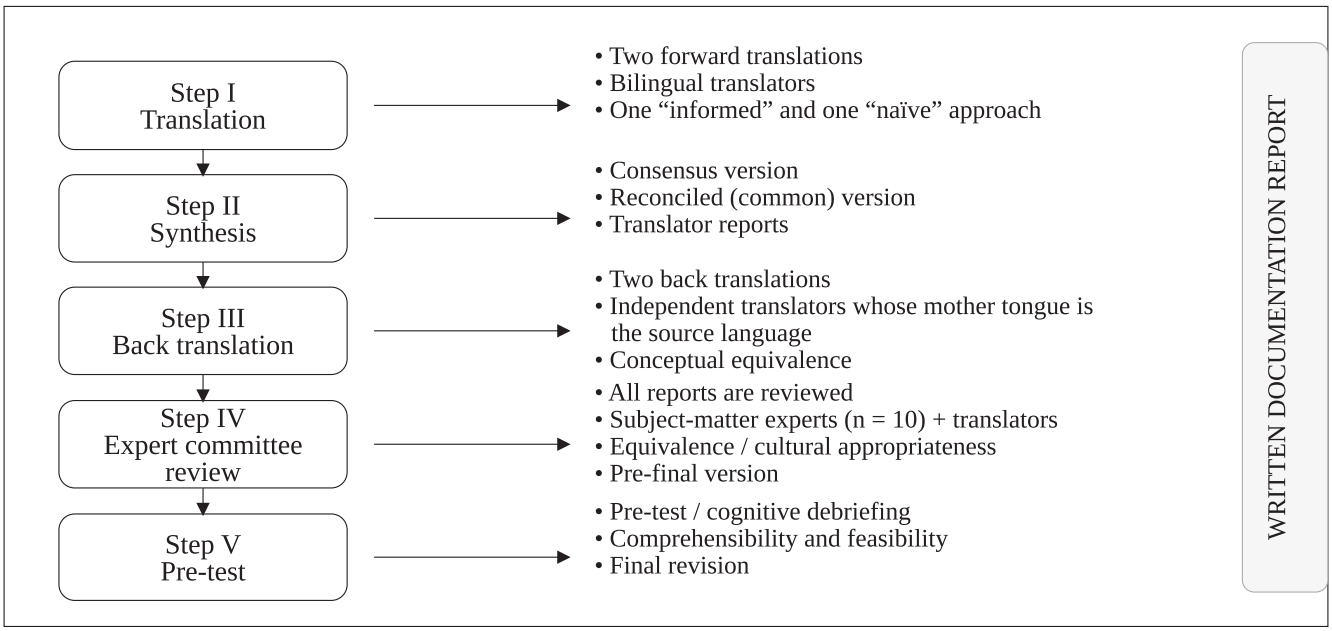


FIGURE 1 | Steps of the translation, cultural adaptation, and pretesting process.

surgery or cardiac arrest, immobility, and impaired circulation. Each item is scored as 1 if present (0 if absent), yielding a total score ranging from 0 to 8; higher scores reflect a greater risk of PI development (Richardsonand and Straughan 2015).

In intensive care settings, the use of CALCULATE for PI risk assessment is recommended within 8 h of admission, followed by reassessment every 12 h. Scoring involves identifying the presence of each risk factor and summing the item scores. According to the total score, patients with ≥4 risk factors are categorized as "very high risk," whereas those with ≤3 risk factors are classified as "high risk" (Richardsonand and Straughan 2015; De Souza et al. 2023).

2.4 | Translation and Cultural Adaptation of the CALCULATE Scale

2.4.1 | Linguistic Equivalence

A forward–back-translation procedure was employed to ensure linguistic equivalence. The scale was independently translated into Turkish by two bilingual experts. The two versions were compared, reconciled, and merged into a single consensus draft (Politand and Beck 2010).

For content validity, a panel of 10 experts comprising nursing academics, physicians, and ICU nurses evaluated the clarity and relevance of each item. Items were rated on a 4-point Likert scale (Politand and Beck 2010). The content validity index (CVI) was calculated as 1.00, indicating full expert agreement. The Turkish consensus version was subsequently back translated into English by a bilingual nurse academic. The original and back-translated versions were compared, and a final consensus form was established. The back translation demonstrated strong consistency with the original instrument. All documentation was submitted to the scale developer for review and approval. Data collection commenced following formal approval (Politand and Beck 2010; Karaçam 2019) (Figure 1).

2.5 | Data Collection

Demographic and clinical data were obtained from patients' medical records and, when necessary, from family members. ICU nurses received training on the administration of the CALCULATE scale. Within the first 12 h of ICU admission, the researcher conducted a comprehensive skin assessment in collaboration with ICU nurses to verify the absence of PI at baseline and documented the initial risk assessment on the data collection form. Because the researcher was constant across assessments whereas the ICU nurse rater varied according to clinical assignment, a one-way random-effects model with absolute agreement for single measurements (ICC1.1) was used (Kooand and Li 2016).

Each patient was subsequently evaluated once daily throughout their ICU stay using both the Braden and CALCULATE scales. At each observation point, the researcher and the ICU nurse independently completed both Braden and CALCULATE assessments. The assessors recorded their scores separately, did not discuss their evaluations, and were blinded to each other's scoring during data collection. The evaluators were blinded to each other's evaluations and to previously assigned scores. Assessments were performed independently by the researcher and an ICU nurse to ensure objectivity. A total of 580 Braden and 580 CALCULATE assessment forms were analysed; the ICU nurse completed an equivalent number of independent evaluations.

2.6 | Psychometric Testing

2.6.1 | Validity Criteria

2.6.1.1 | Content Validity. Construct validity was examined by administering the routinely used Braden Scale concurrently with the CALCULATE scale. Data collected on days 1 and 7 following the admission assessment were analysed using IBM SPSS Statistics v22.0 and MedCalc v18.11.3.

2.6.1.2 | Convergent Construct Validity. Convergent construct validity was evaluated by assessing the correlation between CALCULATE and Braden scores using Pearson's correlation analysis. The influence of CALCULATE scores on PI development was further examined through logistic regression analysis.

2.6.1.3 | Predictive Validity. Predictive validity for both the Braden and CALCULATE scales was assessed using receiver operating characteristic (ROC) curve analysis. Diagnostic performance was evaluated by calculating sensitivity and specificity values, and optimal cutoff points were determined using the Youden index.

2.6.2 | Reliability Criteria

2.6.2.1 | Inter-Rater Reliability. Inter-rater reliability was assessed using the intraclass correlation coefficient (ICC). Furthermore, item-level and scale-level content validity indices (CVI) were calculated (https://internationalguideline.com/2019, 2019).

2.7 | Data Analysis

Statistical analyses were performed using IBM SPSS Statistics v22.0 and MedCalc v18.11.3. Patients' demographic and clinical characteristics were summarized using descriptive statistics, including frequencies, percentages, and mean values, as appropriate.

For the assessment of linguistic equivalence and expert evaluation of item clarity and relevance, the CVI was calculated. Predictive validity was examined using ROC curve analysis, with sensitivity and specificity values computed to determine diagnostic accuracy. Optimal cutoff values were identified using the Youden index. Statistical significance was defined as $p < 0.05$, with 95% confidence intervals (CIs) applied throughout.

The CALCULATE scores on day 1 and day 7 were compared between patients who developed pressure injuries and those who did not. Intergroup comparisons were performed using the Mann–Whitney *U* test.

The authors adhered to the Consensus-based Standards for the Selection of Health Measurement Instruments (COSMIN) guidelines throughout the study, ensuring a rigorous and systematic approach to the validation process.

2.8 | Ethical and Institutional Approvals

Ethical approval was obtained from the Clinical Research Ethics Committee of Acıbadem Mehmet Ali Aydınlar University Medical Research Ethics Committee (2023-15/520). Written permission to conduct the validity and reliability study was obtained via email from the developer of the CALCULATE scale, and from the researcher who conducted the Turkish validity and reliability study of the Braden Scale Institutional approval was also secured from the study site.

Written informed consent was obtained from patients who were capable of providing consent. For patients who were unconscious, consent was obtained from their legal representatives. The study was conducted in accordance with the principles of the Declaration of Helsinki.

3 | Results

3.1 | Characteristics of the Participants

A total of 76 patients were included in the study; 39 (51.3%) were female and 37 (48.7%) were male. The majority had at least one chronic condition ($n = 54$, 71.1%). The most prevalent comorbidities were hypertension (64.8%), diabetes mellitus (31.5%), and heart failure (22.2%). Less common conditions included asthma/chronic obstructive pulmonary disease (COPD) (14.8%), cancer (13.0%), chronic kidney disease (9.3%), and cerebrovascular events (9.3%) (Table 1).

The mean ICU length of stay was 7.6 days (range, 1–74), and 27 patients were monitored for ≥ 7 days. The mean age was 63.36 ± 17.24 years (range, 22–92). The average serum albumin level was 33.65 ± 5.81 g/L (range, 19.4–46.1 g/L). At ICU discharge, 73.7% of patients were transferred to inpatient wards, whereas 6.6% died.

PI developed in 15 of the 76 patients (19.7%). Pressure injuries developed in 14 people on the 7th day and thereafter. MDRPI were identified in seven patients and were associated with compression stockings ($n = 4$), urinary catheters ($n = 2$), and a continuous positive airway pressure (CPAP) mask ($n = 1$).

PI occurred most frequently on days 3 and 8, with time to onset ranging from 2 to 76 days (mean, 5.2 days). No surgery-related PI was observed among the 48 postoperative patients included in the study. Within the first 72 h of ICU admission, three PI were detected in patients diagnosed with dyspnea, epilepsy, and cerebrovascular events.

The most commonly affected anatomical sites were the heel, sacrum, and gluteal region (Table 2). Comparisons of demographic and clinical characteristics according to PI development revealed no statistically significant differences ($p > 0.05$).

TABLE 1 | Demographic and clinical characteristics ($n = 76$).

Characteristics	*n*	%
Sex		
Female	39	51.3
Male	37	48.7
	M	**SD**
Age	63.36	17.242
Albumin (g/L)	33.651	5.817
Chronic diseases	***n***	**%**
Yes	54	71.1
No	22	28.9
Disease ($n = 54$)[a]	***n***	**%**
Hypertension	35	64.8
Diabetes mellitus	17	31.5
Cardiac failure	12	22.2
Asthma/COPD	8	14.8
Cancer	7	13.0
Cerebrovascular accident	5	9.3
Kidney disease	5	9.3
Other	2	3.8

Note: Values are presented as *n* (%) unless otherwise indicated.
Abbreviations: COPD: chronic obstructive pulmonary disease; *M*, Mean; *n*, number; SD, standard deviation.
[a]More than one chronic disease could be reported for each patient.

3.2 | Psychometric Properties

3.2.1 | Inter-Rater Agreement

Inter-rater reliability for the CALCULATE scale was excellent, with an ICC of 0.933 (95% CI, 0.922–0.943), which was statistically significant ($F = 15.007$, $p < 0.001$). For the Braden Scale, inter-rater agreement was also high, with an ICC of 0.875 (95% CI, 0.853–0.894) and statistically significant ($F = 7.999$, $p < 0.001$) (Table 3) (National Pressure Injury Advisory Panel (NPIAP) 2019).

For concurrent validity, a moderate negative correlation was observed between the mean Braden and CALCULATE scores on day 1 ($r = -0.56$), which strengthened to a stronger negative correlation on day 7 ($r = -0.69$). Both correlations were statistically highly significant.

3.3 | Predictive Validity of the CALCULATE and Braden Scales

3.3.1 | ROC Analysis for CALCULATE

In the ROC analysis assessing the discriminative ability of the scales, the CALCULATE scale demonstrated good predictive performance for PI development. The AUC was 0.825 on day 1

(95% CI: 0.721–0.903) and 0.849 on day 7 (95% CI: 0.74–0.92). At both time points, the discrimination was highly statistically significant ($p < 0.0001$).

The predictive performance of the Braden Scale for PI risk was assessed using ROC analysis on days 1 and 7. The AUC was 0.752 on day 1 and 0.857 on day 7, indicating statistically significant discrimination at both points (day 1: $z = 4.685$; day 7: $z = 8.405$; $p < 0.0001$ for both) (Figure 2).

CALCULATE scores effectively predicted PI development on both days 1 and 7. The day 1 model demonstrated slightly greater explanatory power (Nagelkerke $R^2 = 0.340$), indicating a stronger contribution to early risk estimation. The day 7 model also provided significant predictive value. Overall, these results suggest that CALCULATE is a reliable tool for identifying PI risk during both the early and later stages of ICU stay (Table 4).

TABLE 2 | Incidence and clinical characteristics of pressure injuries observed during ICU follow-up ($n = 76$).

	n	%
PI		
Yes	15	19.7
No	61	80.3
MDRPI[a]		
Yes	7	46.7
Medical device type ($n = 7$)		
Compression stockings	4	57.1
Urinary catheter	2	28.6
CPAP face mask	1	14.3
Pressure injury sites[b]		
Heel	4	26.7
Sacrum	3	20.0
Gluteal region	2	13.4
Foot	2	13.3
Ear	1	6.7
Scapula	1	6.7
Malleolus	1	6.7
Leg	1	6.7

Note: Values are presented as *n* (%) unless otherwise indicated; *n*, Frequency.
Abbreviations: CPAP, continuous positive airway pressure; ICU, intensive care unit; MDRPI, medical device-related pressure injury; PI, pressure injury.
[a]Percentages for pressure injury sites were calculated among patients who developed pressure injuries.
[b]Percentages were calculated among patients who developed pressure injuries.

3.3.2 | Hypothesis Testing for Construct Validity

According to additional hypothesis tests conducted within the construct validity framework, CALCULATE scores were higher in patients who developed pressure ulcers on Day 1 compared to those who did not develop pressure ulcers. This difference was statistically significant in both the researcher and ICU nurse assessments (researcher assessment: $U = 709.00$, $p < 0.001$; ICU nurse assessment: $U = 733.00$, $p < 0.001$). In the analysis on Day 7, CALCULATE scores were also higher in the pressure injury group; however, the difference between groups was not statistically significant (researcher assessment: $U = 78.00$, $p = 0.652$; ICU nurse assessment: $U = 93.50$, $p = 0.166$). These findings suggest that higher CALCULATE scores in the early period are associated with pressure injuries that develop later during the ICU stay.

4 | Discussion

In this study, we translated and culturally adapted the CALCULATE scale into Turkish and evaluated its validity and reliability for assessing PI risk among critically ill patients. The results indicate that the Turkish version of CALCULATE is both valid and highly reliable for use in Turkish ICU patients.

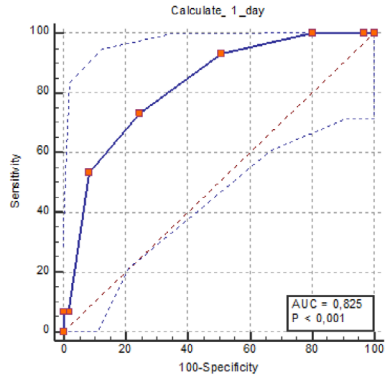
Although numerous instruments exist for PI risk assessment in general patient populations, only a few have been specifically developed for critically ill patients (Richardsonand and Straughan 2015; Wåhlin et al. 2021; González-Ruiz et al. 2008; Fulbrookand and Anderson 2016). Following permission to use CALCULATE, the linguistic adaptation and subsequent evaluation demonstrated excellent content validity, suggesting that the Turkish version is clear, relevant, and culturally appropriate for this population.

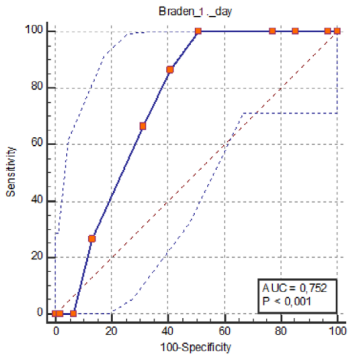
In this study, data were collected through independent observations by the researcher and ICU nurse, and inter-rater agreement was evaluated. The findings showed a high level of agreement between the two raters for both CALCULATE and the Braden Scale (Table 3). Although the Braden Scale has been widely used in clinical practice for many years, the strong inter-rater agreement observed for CALCULATE suggests that the scale can be applied consistently in ICU settings.

TABLE 3 | Inter-rater reliability of the CALCULATE and Braden Scale scores.

		95% confidence interval			
Questionnaire	**ICC**	**Lower bound**	**Upper bound**	***F* test**	***p***
CALCULATE	0.933	0.922	0.943	15.007	0.000
Braden	0.875	0.853	0.894	7.999	0.000

Abbreviations: CALCULATE, Critical Care Pressure Ulcer Assessment Tool Made Easy; CI, confidence interval; *F*, *F* statistic; ICC, intraclass correlation coefficient; *p*, probability value.





AUC : 0.825
Standard error: 0.05
95% CI : 0,721-0,903
Z : 5.824
P : <0.0001
Youden index J: 0.49

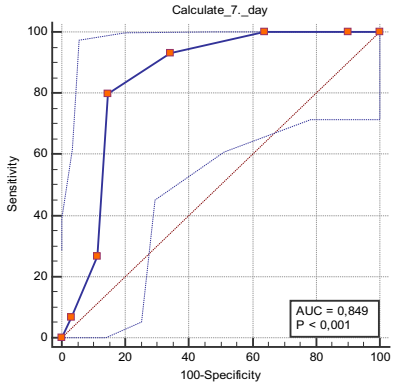
Cut off point : >3

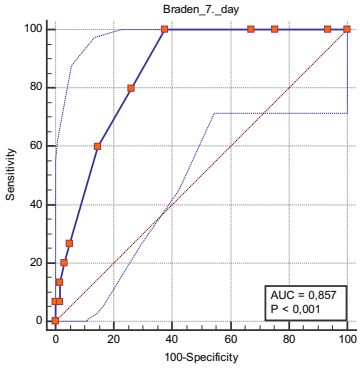
Sensitivity : 73.33
Specificity : 75.41

AUC : 0.752
Standard error : 0.0538
95% CI: 0.640–0.844
Z : 4.685
P : <0.0001
Youden index J : 0.4918

Cut off point : ≤14

Sensitivity :100
Specificity : 49.18





AUC :0.849
Standard error :0.0457
95% CI : 0.748–0.921
Z :7.634
P : < 0.0001
Youden index J : 0.6525

Cutoff point : >3

Sensitivity : 80.00
Specificity : 85.25

AUC : 0.857
Standard error : 0.0425
95% CI : 0.758–0.927
Z : 8.405
P : < 0.0001
Youden index J : 0.6230

Cutoff point : ≤14

Sensitivity : 100
Specificity : 62.30

FIGURE 2 | Receiver operating characteristic curves comparing the CALCULATE and Braden Scale scores for predicting pressure injury development: (A) day 1 and (B) day 7. AUC, area under the curve; CALCULATE, Critical Care Pressure Ulcer Assessment Tool Made Easy; J, Youden index; *p*, probability value; PI, pressure injury; ROC, receiver operating characteristic; *z*, *z* statistic.

To assess early risk prediction for PI in the ICU, ROC analysis showed that CALCULATE had higher discriminative ability on day 1 than the Braden Scale. By day 7, AUC values were comparable between the two scales. These findings indicate that CALCULATE is more sensitive for early risk assessment, while both instruments perform similarly during longer follow-up. By incorporating ICU-specific risk factors, CALCULATE may support timely and clinically relevant PI risk assessment in critically ill patients. Overall, CALCULATE scores appear to serve as a robust predictive tool for PI risk.

Based on the Youden index, the optimal cutoff point for CALCULATE was consistent across both assessment days. At this threshold, the scale demonstrated acceptable sensitivity and

TABLE 4 | Logistic regression analysis of CALCULATE scores for predicting pressure injury development.

	B	SE	Sig.	Exp(*B*)	95% CI lower	95% CI upper	Cox & Snell R^2	Nagelkerke R^2
Day 1	1.015	0.290	0.000	2.760	1.565	4.867	0.214	0.340
Day 7	0.868	0.242	0.000	2.383	1.484	3.826	0.209	0.332

Note: p-values <0.001 indicate statistical significance. Cox, Cox & Snell R^2; Nagelkerke R^2.
Abbreviations: *B*, regression coefficient; CALCULATE, Critical Care Pressure Ulcer Assessment Tool Made Easy; CI, confidence interval; Exp(*B*), odds ratio; SE, standard error; Sig, significance.

specificity for predicting PI development (Figure 2). These findings support the potential utility of CALCULATE for identifying ICU patients at risk of PI during both early assessment and follow-up.

For the Braden Scale, the optimal cutoff point was ≤14 on both days 1 and 7. At this threshold, sensitivity indicated that all at-risk patients were correctly identified, while specificity improved on day 7, suggesting better overall accuracy at later assessment points (Figure 2). The higher specificity of CALCULATE compared with the Braden Scale on both days suggests that CALCULATE is a more suitable risk assessment tool for ICU populations.

Although previous studies on CALCULATE have primarily focused on risk prediction, variations in sample size and study design limit direct numerical comparisons. In this study, the Braden Scale was used to assess convergent validity. Because lower Braden scores indicate higher risk, whereas higher CALCULATE scores indicate higher risk, a negative correlation between the two measures was expected. The correlation was moderately negative on day 1 and stronger on day 7, suggesting that agreement between the scales increases with longer ICU stays.

In a multicenter cohort study evaluating the Braden Scale in critically ill patients, discriminative ability was reported as good, though the authors noted that it may be insufficient for risk identification in this population (Ranzani et al. 2016).

When the effect of CALCULATE scores on PI development was examined, each one-point increase in the day 1 score was associated with a ~2.76-fold increase in the odds of developing a PI, whereas on day 7, each one-point increase was associated with a ~2.38-fold increase. Although predictive performance was stronger on day 1, these findings indicate that CALCULATE reliably identifies PI risk during both early and later phases of ICU stay (Table 4).

The additional hypothesis-testing analysis also provided support for the construct validity of CALCULATE. Patients in whom pressure injuries subsequently occurred had higher early CALCULATE scores than those in whom pressure injuries did not occur, which is consistent with the theoretical expectation that higher ICU-specific risk scores indicate greater vulnerability to pressure injury occurrence. Although Day 7 scores were also descriptively higher in the pressure injury group, this difference was not statistically significant. Therefore, the findings particularly support the usefulness of CALCULATE in early ICU risk assessment.

In similar adaptation studies, De Souza et al. (2023) compared CALCULATE with the Braden Scale at two time points and concluded that CALCULATE outperformed Braden in predictive performance, discriminative ability, sensitivity, and specificity (De Souza et al. 2023). Other studies also reported that CALCULATE was more discriminative than Braden for PI risk prediction, with both instruments showing reproducibility but favouring CALCULATE (Saranholi 2018). Picoito et al. further suggested that, compared with another risk assessment tool (EVARUCI), CALCULATE is descriptively higher in terms of relevance, appropriateness, simplicity, and ease of use (Picoito et al. 2023). Collectively, these findings indicate that CALCULATE's clinically relevant risk factor-based structure and feasibility make it a practical tool for rapid risk stratification in the ICU.

In Türkiye, various risk assessment scales specifically designed for intensive care and proven to be valid and reliable are in use. When compared to scales used to assess critically ill patients in previous studies (Akmanand and Alpar 2014; Günesand and Efteli 2015; Oğuz 1997; Göncüand and Kir Bicer 2025; Adibelliand and Korkmaz 2019; Uslu et al. 2024), our findings indicate that the CALCULATE scale strikes a balance between predictive performance and clinical applicability. Although several existing ICU-specific tools have demonstrated acceptable validity, some require more extensive assessment or include items with limited contribution to pressure injury prediction In contrast, CALCULATE offers a concise ICU-focused assessment while maintaining significant predictive ability on both Day 1 and Day 7. Furthermore, previous studies have reported acceptable to high predictive accuracy for CALCULATE in different ICU populations, supporting its clinical utility (Picoito et al. 2023; Theeranut et al. 2021; De Souza et al. 2023; Saranholi 2018). Although the Braden Scale is widely used in clinical practice, its predictive validity in critically ill patients has been reported to be moderate, and its performance may vary according to cutoff values and clinical settings (Huang et al. 2021). ICU-specific instruments offer important alternatives by incorporating physiological and critical care-related risk factors (Fulbrookand and Anderson 2016; Ahtiala et al. 2016; Kim et al. 2013; Wåhlin et al. 2021). In contrast, CALCULATE has been described as a recent, appropriate, simple, and easy-to-use ICU-specific tool, which may support its feasibility in routine critical care practice (Richardsonand and Straughan 2015; Richardsonand and Barrow 2015). Therefore, CALCULATE does not replace existing instruments or clinical judgement; rather, it may serve as a brief, ICU-oriented, and clinically feasible tool that supports early risk identification and timely preventive interventions in critically ill patients.

This study reinforces the clinical importance of accurate and systematic PI risk assessment in critically ill patients. Consistent with the 2025 EPUAP guideline, it emphasizes that the mere use of risk assessment tools alone is insufficient; demonstrating

their validity and reliability in the target population is essential (EPUAP/NPIAP/PPPIA 2025). Due to factors such as sedation, mechanical ventilation, vasopressor therapy, low albumin levels, and limited mobility or consciousness, ICU patients are at high risk of developing PI (Manzano et al. 2010). Demonstrating the Turkish validity and reliability of CALCULATE may therefore support more context-sensitive risk assessment in intensive care settings.

These findings suggest that CALCULATE may support nurses in performing consistent and clinically relevant PI risk assessments in ICU settings. This supports the early identification of at-risk patients and the timely implementation of preventive nursing interventions, potentially standardizing care and reducing PI incidence.

4.1 | Limitations

Several limitations of this study should be considered when interpreting the findings. The study was conducted in a single Level III ICU, which may limit the generalizability of findings to other institutions or ICU patient populations. Additionally, the relatively small number of patients who developed PI may have reduced the precision of some estimates. Although pressure injury risk assessments were performed daily throughout ICU follow-up, predictive performance analyses were conducted only for Day 1 and Day 7 assessment points. This may limit the interpretation of how CALCULATE performs across the entire ICU stay, particularly among patients with shorter or longer hospitalization periods.

4.2 | Strengths

Key strengths include independent daily assessments by two raters throughout the ICU stay and the implementation of a standardized preventive care protocol for all patients, which minimized variability in routine care and enhanced internal validity.

5 | Conclusion

This study demonstrates that the Turkish version of the CALCULATE scale is a valid and reliable tool for assessing PI risk in critically ill patients. Its strong discriminative ability (ROC) and high inter-rater reliability (ICC) support its use in clinical practice for guiding risk stratification and planning preventive care. Early and accurate identification of patients at risk may support timely, targeted clinical decision-making and individualized pressure injury prevention planning, thereby contributing to patient safety.

Author Contributions

Ayper Önal Alkan: conceptualization, investigation, funding acquisition, writing – original draft, methodology, validation, visualization, writing – review and editing, software, formal analysis, project administration, data curation, supervision, resources. **Ükke Karabacak:** conceptualization, methodology, software, data curation, investigation, validation, formal analysis, supervision, funding acquisition, visualization, project administration, resources, writing – original draft, writing – review and editing.

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Ethics Statement

This study was approved by the Acıbadem Mehmet Ali Aydınlar University Medical Research Ethics Committee (2023-15/520). Written permission to conduct the validity and reliability study was obtained via email from Annette Richardson, the tool developer. Approval was secured from the institution where the study was conducted. Written informed consent was obtained from the patients or the legal representatives of the unconscious patients.

Consent

Informed consent was received from all participants.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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