

ORIGINAL PAPER

PREDICTIVE VALIDITY OF THE BRADEN SCALE, NORTON SCALE AND WATERLOW SCALE IN SLOVAK REPUBLIC

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Abstract

Aim: To determine the levels of predictive validity of scales for assessing the risk of pressure ulcers (Braden, Norton and Waterlow scales) in the Slovak clinical setting. *Design:* A prospective study. *Methods:* One hundred patients staying in a long-term care department of a hospital from April to August 2014 were investigated using the Braden, Norton and Waterlow scales. The inclusion criteria were age over 18 years and having no pressure ulcers on admission to the department. The predictive validity of the pressure ulcer risk assessment scales was evaluated based on sensitivity, specificity, positive and negative predictive values and the area under the ROC curve. *Results:* The incidence of pressure ulcers in the study was 14%. The sensitivity, specificity, positive predictive value and negative predictive value were 85.71%, 53.48%, 23.07% and 95.83%, respectively, for the Braden Scale (a cut-off point of 15); 85.71%, 48.83%, 21.42% and 95.45%, respectively, for the Norton Scale (a cut-off of 12); and 85.71%, 30.23%, 16.66% and 92.85%, respectively, for the Waterlow Scale (a cut-off of 13). The areas under the ROC curve were 0.696 (Braden), 0.672 (Norton) and 0.579 (Waterlow). *Conclusion:* In the present study, the best predictive validity values, with little differences, were observed for the Braden Scale, followed by the Norton Scale and the Waterlow Scale, in that order.

Keywords: Braden Scale, Norton Scale, Waterlow Scale, pressure ulcer, risk assessment, validity.

Introduction

In clinical practice, pressure ulcers represent a high priority nursing and social problem. They are of great concern to patients, health professionals as well as health care facility managers. They lower patients' quality of life (Hopkins et al., 2006) and cause discomfort, suffering and frustration (Moore, Price, 2004). Pressure ulcers are associated with health professionals' feelings of guilt and failure (Claire et al., 2011). They may lead to legal cases concerning medical malpractice (Verdú et al., 2004). They impose a considerable financial burden on health care systems (Graves et al., 2005). The annual costs of pressure ulcer treatment reach 11 billion dollars in the USA (Hyun et al., 2013) and between 1.4 and 2.1 billion euros in the United Kingdom (Bennett et al., 2004).

The European Pressure Ulcer Advisory Panel (EPUAP) and American National Pressure Ulcer Advisory Panel (NPUAP) (2009) define pressure ulcers as "localized injury to the skin and/or underlying tissue, usually over a bony prominence, as a result of pressure, or pressure in combination with shear".

In the Slovak Republic, pressure ulcers are monitored as one of nursing care indicators based on several legislative documents (Zákon 581/2004, Nariadenie vlády 51/2009, Nariadenie vlády 663/2005, Vestník MZSR 15–26, 2013). Health insurance companies in Slovakia are required to examine the quality of care delivered by health care providers. Each health insurance company performs its own analysis of nursing care indicators (Všeobecná zdravotná poisťovňa, 2010). The results of individual nursing care indicators may be found but no nationwide data are available on the incidence and prevalence of pressure ulcers in the Slovak Republic. In the Czech Republic, the prevalence of pressure ulcers ranges from 3.49% to 5.46%. The incidence varies, depending on hospital departments, ranging from 1.86% in surgical departments and 4.53% in internal medicine departments to 10.89% in intensive care

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departments and 12.87% in the long-term care setting (Ministerstvo zdravotníctví České republiky, 2009).

Predicting the risk for developing pressure ulcers is a priority issue in nursing. A targeted, high-quality preventive approach is cheaper than the treatment of pressure ulcers (Lyder, 2003). According to Bóriková (2006), prevention of pressure ulcers is the oldest preventive method in nurses' work, dating back to the time of Florence Nightingale. The EPUAP and NPUAP consider pressure ulcer prevention the best and effective method. They classified pressure ulcer prevention recommendations into five key areas: risk assessment, skin assessment, nutrition, repositioning and support surfaces (NPUAP, 2009).

Risk assessment is the first step in pressure ulcer prevention. Nurses play a key role in assessing and identifying patients at risk for developing pressure ulcers and allocating adequate preventive interventions (Pancorbo-Hidalgo et al., 2006). According to the Slovak Ministry of Health Decree No. 364/2005, a nurse has to identify the nursing care needs of a person, family or community and ensures that needs related to health, illness or dying are met. A nurse's competencies comprise providing nursing care including prevention and management of compromised skin and mucosal integrity such as pressure ulcers (Ministerstvo zdravotníctva Slovenskej republiky, 2005). Worldwide, more than 40 scales are available for assessing the risk for pressure ulcers (Thompson, 2005). Most of these scales have not been validated until now. Many of the scales are just modifications of original scales, have not been tested for their reliability and validity, and are of poor quality in respect of methodological rigor, samples sizes and populations (Pressure Ulcer Risk Assessment and Prevention, 2001). The most frequently used and tested scales are those by Braden, Norton and Waterlow. In Slovakia, there are no guidelines concerning the use of scales for assessing the risk for pressure ulcers. Numerous research studies on the validity of scales for predicting the risk of pressure ulcers have been performed abroad (Araújo, 2011; Feuchtinger et al., Gonzales-Ruiz et al., 2008; 2009; Hyun, 2013; Kwong et al., 2005; Serpa et al., 2011; Suriadi et al., 2008; Tannen et al., 2010). In the Slovak clinical setting, however, no such scale has been validated. Therefore, the present study aimed at evaluating the levels of predictive validity of the three scales that have been most frequently tested globally (Braden, Norton and Waterlow scales) in the Slovak clinical setting. The objectives were to compare the three scales for assessing the risk of pressure ulcers and to determine which of them had the highest levels of predictive validity (high sensitivity, negative predictive value,

specificity, positive predictive value and the area under the ROC curve), using a cut-off point that was set for the group of respondents based on statistical analysis.

Aim

To determine the levels of predictive validity of scales for assessing the risk of pressure ulcers (Braden, Norton and Waterlow scales) in the Slovak clinical setting. To determine the incidence of pressure ulcers depending on preventive measures used.

Methods

Design

A prospective study.

Sample

The sample comprised 100 patients staying in a long-term care department of a hospital. The inclusion criteria were age over 18 years and having no pressure ulcers on admission to the department. The mean age was 73.89 years (Table 1). The mean scores were 15.78 (SD = 4.71) for the Waterlow Scale, 12.83 (SD = 3.51) for the Norton Scale and 16.29 (SD = 3.65) for the Braden Scale (Table 2).

Table 1 Sample characteristics (n = 100)

	n	mean	SD	min	max
Age	100	73.89	10.12	52	96

n – number, SD – standard deviation, min – minimum value, max – maximum value

Table 2 Scale scores (n = 100)

	n	mean	SD	min	max
Waterlow Scale score	100	15.78	4.71	7	27
Norton Scale score	100	12.83	3.51	7	20
Braden Scale score	100	16.29	3.65	10	23

n – number, SD – standard deviation, min – minimum value, max – maximum value

Data collection

The data were collected over a period of 5 months, from April to August 2014. Within 24 hours from admission to the department, newly admitted patients who met the inclusion criteria were assessed by an investigator or by a nurse working at the department, using the Braden, Norton and Waterlow scales. In addition to the scales for predicting the risk of pressure ulcers, a special recording sheet developed by the study authors was completed, which included the following information: (a) patient identification, (b) preventive interventions initiated after the

patient's assessment (the interventions were based on the 2009 NPUAP and EPUAP clinical recommendations; only interventions initiated in the particular patient were recorded by a nurse working in the department), (c) information on the incidence (the site of pressure ulcer development) and description of the patient's pressure ulcer according to the Torrance grading system (Torrance, 1983). Every two weeks, the patients were assessed to determine whether they developed pressure ulcers or not, and the effectiveness of preventive measures was evaluated.

The **Braden Scale** was first introduced by its authors Braden and Bergstrom in 1987 (Bergstrom et al., 1987). It is one of the best known and most widely used scales for assessing the risk of pressure ulcers. With confirmed validity and reliability, it has been widely used in both acute clinical and long-term nursing care settings. It is one of the most frequently used pressure ulcer risk assessment scales in the USA (Hyun et al., 2013). The scale was developed for all patients in general wards (Kim et al., 2013). The Braden Scale contains six items: sensory perception, moisture, activity, mobility, nutrition, and friction and shear. Five of the six items are rated on a scale from 1 (most impaired) to 4 (least impaired). The remaining item, friction and shear, is rated on a scale from 1 (problem) to 3 (no problem). The total score ranges from 6 to 23 points. Lower total scores indicate a higher risk for the development of pressure ulcers.

The **Norton Scale** was proposed in 1962 as the first scale for assessing the risk of pressure ulcers (Norton et al., 1962). Its author, Doreen Norton, created the scale for elderly patients (Lindgren et al., 2002). The scale was developed based upon clinical experience. Following discussions with her colleagues, Norton identified five main risk factors to be included in the instrument: physical condition, mental condition, activity, mobility and incontinence (Bell, 2005). All items are rated on a scale from 1 (most impaired) to 4 (least impaired). The maximum total score is 20 points. Lower total scores indicate a higher risk for the development of pressure ulcers.

The **Waterlow Scale** is commonly used for assessing the risk of pressure ulcers in the United Kingdom and Ireland despite the fact that its validity is not high (O'Tuathail, Taqi, 2011). The scale, developed in 1985 (Waterlow, 1985), contains the following categories: build/weight for height, skin type / visual risk areas, sex / age, Malnutrition Screening Tool, continence, mobility and special risks (tissue malnutrition, neurological deficit, major surgery or trauma, medication). Each category has its own

scores. The total score 10–14 points suggests that the patient is at risk for pressure ulcers, 15–19 points mean a high risk and 20+ points indicate a very high risk of pressure ulcer development.

Data analysis

The data were analyzed using descriptive statistics. The incidence of pressure ulcers depending on preventive measures used was calculated with the chi-squared test and Fisher's exact test. Cut-off points for individual scales were determined using the decision tree algorithms QUEST (Quick, Unbiased and Efficient Statistical Tree) a CART (Classification and Regression Trees). The algorithm divides the sample into two equal subgroups of patients either with or without the risk using a selected value. Then, the value is used as a cut-off point. The calculations were made with SPSS AnswerTree v. 3.1. The predictive validity of the pressure ulcer risk assessment scales was evaluated based on sensitivity, specificity, positive and negative predictive values and the area under the ROC curve. The statistical tests were performed at a significance level of 5%. The data were processed using Stata v. 13 software.

Evaluating predictive validity

Predictive validity is the extent to which a tool may predict future events. For instance, is an instrument for assessing the risk of developing pressure ulcers in hospital actually capable of identifying patients at risk? (Twycroos, Shields, 2004) In foreign studies, the validity of pressure ulcer risk assessment scales is determined based on sensitivity, specificity, positive and negative predictive values and the area under the ROC curve. Sensitivity is the ability of an instrument to give a positive result if the risk does exist. It is expressed as the percentage of patients in whom pressure ulcers are predicted and actually develop. For example, 80% sensitivity of an instrument means that the risk is found in 80 out of 100 patients. Specificity is expressed as the percentage of patients in whom pressure ulcers neither develop nor are predicted (Bóriková, Žiaková, Gurková, 2009). Positive predictive value is the proportion of patients classified as being at risk who actually develop pressure ulcers; negative predictive value is the proportion of patients classified as having no risk who do not develop pressure ulcers. An ROC curve is a measure of how well a scale can distinguish between two groups such as patients with and without pressure ulcers in the present study. A greater area under the ROC curve means a better discrimination power. An area under the ROC curve equal to 1 represents perfect classification whereas an

area under the ROC curve of 0.5 means that the test is no better than tossing a coin (Hyun et al., 2013).

Results

Incidence of pressure ulcers

Fourteen patients (14%) developed pressure ulcers. Grade III (n = 6; 42.86%) and the sacral area (n = 6; 42.86%) were the most frequent grade and site of development of pressure ulcers (Table 3).

Predictive validity of the Braden Scale, Norton Scale and Waterlow Scale

The values for the Braden Scale were as follows: sensitivity 85.71%, specificity 53.48%, positive predictive value 23.07%, and negative predictive value 95.83%, with a cut-off point of 15. For the Norton Scale, the values were: sensitivity 85.71%, specificity 48.83%, positive predictive value 21.42%, and negative predictive value 95.45%, with a cut-off of 12. The values for the Waterlow Scale were: sensitivity 85.71%, specificity 30.23%, positive predictive value 16.66%, and negative predictive value 92.85%, with a cut-off of 13.

The areas under the ROC curve for the Braden, Norton and Waterlow scales were 0.696, 0.672 and 0.579, respectively (Table 4).

Effects of preventive interventions

In 2009, a clinical practice guideline called Pressure Ulcer Prevention was published by the NPUAP and EPUAP. From the guideline, eighteen preventive interventions were selected for the present study. Significant differences between two patient groups (with and without pressure ulcers) were noted for the following interventions: checking the predilection sites ($\chi^2 = 8.01$, F-test = 0.004, p = 0.005), the question “How often are the predilection sites checked?” ($\chi^2 = 8.01$, F-test = 0.004, p = 0.005), repositioning the patient ($\chi^2 = 6.22$, F-test = 0.015, p = 0.013), repositioning during the day ($\chi^2 = 6.22$, F-test = 0.015, p = 0.013), repositioning during the

night ($\chi^2 = 6.22$, F-test = 0.015, p = 0.013) and using a cushion to relieve pressure over the predilection sites ($\chi^2 = 8.76$, F-test = 0.002, p = 0.003) (Table 5).

Discussion

In the present study, the incidence of pressure ulcers was 14%. In the Slovak Republic, pressure ulcers are monitored as quality of care indicators by both health insurance companies and individual health care facilities. However, the results are difficult to obtain. Missing are nationwide data on the incidence and prevalence of pressure ulcers. Therefore, the incidence rates in this study cannot be compared to other results.

The study aimed at evaluating the levels of predictive validity of three pressure ulcer risk assessment scales (Braden, Norton and Waterlow) in the Slovak clinical setting. In Slovakia, no such scale has been validated until now. Moreover, no guidelines on the use of scales for assessing the risk for pressure ulcers are available in the country. Those were the main reasons for performing the study. Three pressure ulcer risk assessment scales most frequently evaluated in foreign studies were selected to be tested for their validity in the Slovak clinical setting.

Braden Scale

The Braden Scale, one of the most frequently tested pressure ulcer risk assessment scales, has shown optimum levels of validity in various clinical studies (Pancorbo-Hidalgo et al., 2006). The analysis of data in the present study showed the following values for the Braden Scale: sensitivity 85.71%, specificity 53.48%, positive predictive value 23.07%, and negative predictive value 95.83%, with a cut-off point of 15. The sensitivity value is consistent with that in a study by Tannen et al. (2010) investigating the validity of the Braden Scale in a university hospital using a cut off point of 18.

Table 3 Sites and grades of pressure ulcers

Site	Total (n = 14; 100%)	Grade I (n = 1; 7.14%)	Grade II (n = 7; 50.00%)	Grade III (n = 6; 42.86%)
Sacral area	11 (78.57%)	1 (7.14%)	4 (28.57%)	6 (42.86%)
Heel	3 (21.43%)	0 (0%)	3 (21.43%)	0 (0%)

Table 4 Predictive validity of the Braden Scale, Norton Scale and Waterlow Scale

	Cut-off point	Sensitivity	Specificity	PPV	NPV	ROC
Braden Scale	15	85.71	53.48	23.07	95.83	0.696
Norton Scale	12	85.71	48.83	21.42	95.45	0.672
Waterlow Scale	13	85.71	30.23	16.66	92.85	0.579

PPV – positive predictive value, NPV – negative predictive value, ROC – area under the ROC curve

Table 5 Effects of preventive interventions

Preventive measures	Pressure ulcers		χ^2	F-test	p-value
	No (n = 86)	Yes (n = 14)			
Assessing the risk for developing pressure ulcers with a scale			ND	ND	ND
No scale used	86 (86.00)	14 (14.00)			
Norton Scale	0 (0)	0 (0)			
Modified Norton Scale	0 (0)	0 (0)			
Waterlow Scale	0 (0)	0 (0)			
Skin assessment using a scale			ND	ND	ND
No	86 (100.00)	14 (14.00)			
Yes	0 (0)	0 (0)			
Checking the predilection sites			8.01	0.004	0.005
No	33 (38.37)	0 (0)			
Yes	53 (61.63)	14 (100.00)			
How often the predilection sites are checked			8.01	0.004	0.005
No time specification	33 (38.37)	0 (0)			
Twice a day	53 (61.63)	14 (100.00)			
Every two hours	0 (0)	0 (0)			
Three times a day	0 (0)	0 (0)			
Using emollients to hydrate dry skin			ND	ND	ND
No	86 (86.00)	14 (14.00)			
Yes	0 (0)	0 (0)			
Using ointments to dry moist skin			ND	ND	ND
No	86 (86.00)	14 (14.00)			
Yes	0 (0)	0 (0)			
Massage of the predilection sites			ND	ND	ND
No	86 (86.00)	14 (14.00)			
Yes	0 (0)	0 (0)			
Assessing the nutritional status with a scale			ND	ND	ND
No	86 (86.00)	14 (14.00)			
Yes	0 (0)	0 (0)			
Nutritional supplements (in case of undernutrition)			ND	ND	ND
No	86 (86.00)	14 (14.00)			
Yes	0 (0)	0 (0)			
Repositioning the patient			6.22	0.015	0.013
No	36 (41.86)	1 (7.14)			
Yes	50 (58.14)	13 (92.86)			
Repositioning during the day			6.22	0.015	0.013
No repositioning	36 (41.86)	1 (7.14)			
Every 2 hours	50 (58.14)	13 (92.86)			
Every 3 hours	0 (0)	0 (0)			
Repositioning during the night			6.22	0.015	0.013
No repositioning	36 (41.86)	1 (7.14)			
Every 2 hours	50 (58.14)	13 (92.86)			
Every 3 hours	0 (0)	0 (0)			
Using a pressure ulcer mattress			0.08	1.000	0.771
No	71 (82.56)	12 (85.71)			
Yes	15 (17.44)	2 (14.29)			
Using a cushion to relieve pressure over the predilection sites			8.76	0.002	0.003
No	35 (40.70)	0 (0)			
Yes	51 (59.30)	14 (100.00)			
Using heel-protection devices (rings, etc.)			1.51	0.222	0.218
No	63 (73.26)	8 (57.14)			
Yes	23 (26.74)	6 (42.86)			
Using pressure-redistributing devices for the patient sitting in an armchair or chair (cushions, support surfaces, etc.)			1.03	0.591	0.308
No	80 (93.02)	14 (100.00)			
Yes	6 (6.98)	0 (0)			
Using alternative materials (sheepskin, water mattresses, gel pads, etc.)			ND	ND	ND
No	86 (100.00)	14 (100.00)			
Yes	0 (0)	0 (0)			
Keeping bed linen clean and dry			ND	ND	ND
Yes	86 (100.00)	14 (100.00)			

ND – No data

The reported sensitivity was 84.8%. The negative predictive value in the present study is consistent with results published by Costa and Caliri (2011, 94%) and Serpa et al. (2011, 96.4%). Although the two studies were carried out in intensive care units, the samples were smaller than in the present study (23 and 72 patients, respectively). The cut-off points were 14 and 13, respectively. All these variables have to be taken into consideration when comparing the results. The area under the ROC curve was consistent with that in a study by Chan et al. (2009, 0.684), performed in an orthopedic department on a sample of 197 patients and using a cut-off of 16. In the present study, the Braden Scale has shown optimum levels of validity.

Norton Scale

The Norton Scale was proposed as the first scale for assessing the risk of pressure ulcer development. The present study showed the following values of validity: sensitivity 85.71%, specificity 48.83%, positive predictive value 21.42%, and negative predictive value 95.45%, with a cut-off of 12. Despite the fact that it is the oldest pressure ulcer risk assessment scale, it has been little tested and investigated. Only few foreign studies evaluating its validity are available (Pancorbo-Hidalgo et al., 2006; Šáteková, Žiaková, 2014). A systematic review by Pancorbo-Hidalgo et al. (2006) recommends that more tests of the Norton Scale are performed. Further investigation and testing in various clinical settings would help to compare the results with those in other studies.

Waterlow Scale

The last tested instrument was the Waterlow Scale. In the present study, the scale achieved high sensitivity (85.71%) and negative predictive value (92.85%), but low specificity (30.23%) and positive predictive value (16.66%). As a result, preventive measures may be initiated also in patients who actually do not need them, leading to increased costs in the areas of prevention and nurses' work. Additionally, the area under the ROC curve was also low (0.579). This is an insufficient value. Therefore, we recommend further testing of the Waterlow Scale to confirm or refute the predictive validity. The same conclusion was made by Webster et al. (2010).

When testing the validity of a pressure ulcer risk assessment scale, all its criteria must be taken into consideration, that is, sensitivity, negative predictive value, specificity, positive predictive value and the area under the ROC curve. If only sensitivity and positive predictive value were considered, nurses might miss patients in need of preventive nursing care. Therefore, scales with high sensitivity and

negative predictive value have to be selected (Kim et al., 2013). When evaluating the validity of pressure ulcer risk assessment scales, the area under the ROC curve is of particular importance. In conclusion, the above data suggested the following results. The best values of validity in the Slovak clinical setting were observed in the Braden Scale, showing the highest values of all validity testing criteria. This was followed by the Norton Scale and the Waterlow Scale, in that order. The sensitivity values were the same for all pressure ulcer risk assessment scales included in the study. The results were influenced by low numbers of pressure ulcers in the sample.

Defloor, Grypdonck (2005) performed a critical analysis of methods for testing the validity of prediction scales. They do not consider sensitivity and specificity as the most suitable diagnostic parameters for prediction scale testing. The scales should be evaluated in combination with preventive measures used. Therefore, a recording sheet containing 18 preventive interventions was compiled for the present study (see Table 5) to determine their impact on the development of pressure ulcers. The preventive interventions were selected based on clinical recommendations published by the NPUAP and EPUAP. That is why some of them were not applied in the department included in the study. The examples are the interventions assessing the risk for developing pressure ulcers with a scale and „skin assessment using a scale. At the department, no scale for pressure ulcer risk assessment had been used. The preventive interventions that were used are listed in Table 5. The data analysis led to the following conclusions. The most significant preventive interventions were checking the predilection sites, the question “*How often are the predilection sites checked?*”, repositioning the patient, repositioning during the day, repositioning during the night, and using a cushion to relieve pressure over the predilection sites. When testing the predictive validity of pressure ulcer risk assessment scales, foreign authors have increasingly included preventive interventions in their studies. Defloor and Grypdonck (2005) included in their study the following preventive interventions: pressure-reducing mattresses, water mattresses, sheepskins and gel cushions. Kwong et al. (2005) reported the following preventive measures: turning every 2 hours, use of material to reduce pressure (cushion, air ring, etc.), keeping bed linen clean, dry and smooth, keeping skin clean and dry, or massage of pressure points. Costa, Caliri (2011) reported the following preventive interventions: air mattress and position changes. A study by Liu et al. (2013) included the following preventive measures: gel cushions,

massage and repositioning every two hours. Several other articles, however, do not state which preventive measures were used in the study or the authors only mention standard nursing care. The lack of specification of such care makes comparison of the studies impossible.

Conclusion

In the present study, the best predictive validity values, with little differences, were observed for the Braden Scale, followed by the Norton Scale and the Waterlow Scale, in that order. Based on the study results, we recommend that in long-term care departments, the Braden Scale with a cut-off point of 15 is used. The results may serve as an incentive for systematic and evidence-based introduction of pressure ulcer risk assessment scales into the Slovak clinical setting.

Since the study is limited by a small sample of respondents, the results cannot be generalized to the entire clinical setting in Slovakia.

In other countries, an increasing number of studies testing the validity of pressure ulcer risk assessment scales with effects on the nursing practice have been performed. Therefore, we recommend that the above three scales continue to be evaluated in the Slovak clinical setting.

Ethical aspects and conflict of interest

Prior to the study, approval was obtained from the Ethics Committee of the Faculty of Medicine, University of Ostrava. At the same time, the study was approved by the health care facility where it was performed. All references are cited. The authors declare no conflict of interest relating to the study.

Author contribution

Conception and design (LŠ, KŽ, RZ), draft of the manuscript (LŠ, KŽ), critical revision of the manuscript (KŽ), final version of the manuscript (LŠ, KŽ, RZ).

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