Aims and objectives. To assess and compare the predictive validity of the modified Braden and Braden scales and to identify which of the modified Braden subscales are predictive in assessing pressure ulcer risk among orthopaedic patients in an acute care setting.

Background. Although the Braden scale has better predictive validity, literature has suggested that it can be used in conjunction with other pressure ulcer risk calculators or that some other subscales be added. To increase the predictive power of the Braden scale, a modified Braden scale by adding body build for height and skin type and excluding nutrition was developed.


Method. A total of 197 subjects in a 106-bed orthopaedic department of an acute care hospital in Hong Kong were assessed for their risk for pressure ulcer development by the modified Braden and Braden scales. Subsequently, daily skin assessment was performed to detect pressure ulcers. Cases were closed when pressure ulcers were detected.

Results. Out of 197 subjects, 18 patients (9.1%) developed pressure ulcers. The area under the receiver operating characteristic curve for the modified Braden scale was 0.736 and for the Braden scale was 0.648. The modified Braden cut-off score of 19 showed the best balance of sensitivity (89%) and specificity (62%). Sensory perception (Beta = −1.544, OR=0.214, p = 0.016), body build for height (Beta = −0.755, OR = 0.470, p = 0.030) and skin type (Beta = −1.527, OR = 0.217, p = 0.002) were significantly predictive of pressure ulcer development.

Conclusion. The modified Braden scale is more predictive of pressure ulcer development than the Braden scale.

Relevance to clinical practice. The modified Braden scale can be adopted for predicting pressure ulcer development among orthopaedic patients in an acute care setting. Specific nursing interventions should be provided, with special attention paid to orthopaedic patients with impaired sensory perception, poor skin type and abnormal body build for height.

Key words: acute care setting, Braden scale, modified Braden scale, orthopaedic patient, predictive validity, pressure ulcer

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Introduction

Pressure ulcer is defined 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 and/or friction’ (National Pressure Ulcer Advisory Panel 2007). It not only reduces patients’ quality of life, but also carries underlying connotations of lowered efficiency in nursing care (Seongsook et al. 2004) and constitutes a significant financial burden on healthcare systems (Fogerty et al. 2008). The incidence of pressure ulcers ranges from 0.4–38% in acute care hospitals (Bolton 2007) and 66% of older patients with
hip fracture have been found to develop pressure ulcers (Maclean 2003). Many patients admitted to orthopaedic units are older people, as ageing is a global health issue which will result in older people comprising 17% of the global population in 2050 compared with 7% in 2002 (Romanelli & Michael 2006). Most of them are limited in their ability of activity and mobility due to trauma injury, degeneration of the skeletal system or chronic pain. Fortunately, it is estimated that 95% of pressure ulcers may be prevented (Gunningberg et al. 1999) and nursing care is believed to be a first step of preventing pressure ulcer development (David et al. 1983, Flanagan 1993, Davis 1994, Pang & Wong 1998). Therefore, accurate identification of at-risk patient by a reliable and valid pressure ulcer risk calculator is the first step to pressure ulcer prevention. Correct allocation of resources, then, will achieve the goal of cost-effectiveness, a key issue in health care (Frank 2001, Franks & Collier 2001).

Commonly used pressure ulcer risk calculators include the Braden, Norton and Waterloo scales. Even though the Braden scale has found to be the most predictive (Pang & Wong 1998, Bergquist & Frantz 2001, Seongsook et al. 2004), most studies (Halfens et al. 2000, Defloor & Grypdonck 2005 & Kring 2007) have suggested that it can be enhanced and that some subscales be added to strengthen its predictive validity in pressure ulcer management. A modified Braden scale (Pang & Wong 1998, Kwong et al. 2005) for more accurate identification of at-risk patients has thus been developed. The modified Braden scale has been found to be more predictive of pressure ulcers than the Braden scale (Xue et al. 2004 & Kwong et al. 2005) in hospitalised adult patients. It is worth further assessing the predictive validity of the modified Braden scale in different specialties to ascertain its power in pressure ulcer prediction, so that it can be applied in different units and settings. This study aimed to evaluate the predictive validity of the modified Braden scale and compare the predictive power of the Braden and modified Braden scales. Further, it attempted to identify the modified Braden subscales that are predictive of pressure ulcer development among orthopaedic patients in an acute hospital in Hong Kong. The study would provide valid information for selection of a more powerful pressure ulcer prediction scale in the O&T unit and knowledge of which subscales would significantly contribute to pressure ulcer risk among orthopaedic patients to design specific nursing interventions to eliminate and/or reduce them.

Braden scale

The Braden scale was first introduced by Braden and Bergstrom 1987b and is one of the best-known and most widely used tools for evaluating pressure ulcer risk. With proven validity and reliability, it now used widely in acute and long-term care settings. This tool has been tested and translated into Japanese, Korean, Italian, Dutch, French, Portuguese (Bergstrom et al. 1998) and Chinese (Xue et al. 2004, Kwong et al. 2005). It reflects a particular conceptualisation of aetiological factors in pressure ulcer formation, including the intensity and duration of pressure and the tolerance of the skin and supporting structures for pressure. The intensity and duration of pressure are related to sensory perception, mobility and activity. Tissue tolerance for pressure is influenced by both extrinsic and intrinsic factors. Extrinsic factors impinging on the outer layers of the surface of the skin are related to skin moisture, friction and shear. Intrinsic factors such as nutritional status, age and low arteriolar pressure influence the architectures and integrity of the skin and supporting structures, particularly collagen and elastin and diminish the ability of soft tissues to absorb and tolerate mechanical load (Bergstrom et al. 1987a). These factors constitute the six Braden subscales: sensory perception, activity, mobility, moisture, nutritional status and friction and shear. Five of the six subscales are rated from 1 (most impaired) – 4 (least impaired) and the subscale of friction/shear is rated from 1 (problem) – 3 (no problem). The total scores range from 6–23. Lower total scores indicate a higher risk of developing pressure ulcers (Bergstrom et al. 1987a).

The subscales of sensory perception, activity and mobility are the primary factors affecting intense and prolonged pressure. Sensory perception is an individual’s ability to perceive pain or discomfort and to respond purposefully by changing position or seeking assistance in changing position. Mobility refers to an individual’s ability to change and maintain or sustain body positions. Activity is the ability of an individual to remove all pressure from skin areas not adapted to weight bearing, which also enhances circulation and influences metabolism. The subscales of moisture, friction and shear are primary extrinsic factors influencing tissue tolerance. Moisture is the exposure of an individual’s skin to moisture, leading to maceration and rashes and thus weakening the natural barrier of the epidermis. Friction likewise weakens this barrier as a result of movement over a rough surface and shearing results when outer layers of the skin slide on rough or sticky surfaces, pulling and potentially tearing underlying tissues. Nutrition reflects the usual food and fluid intake of an individual (Bergstrom et al. 1987a).

The scale has much strength in that it is a user-friendly instrument with detailed explanations of the factors comprising the scale (Bergstrom et al. 1987a) and it is demonstrated to be both valid and reliable in existing studies. Early studies found that a cut-off score of 16 or less on the Braden scale identified
83–100% of general medical, surgical and intensive care patients in whom pressure ulcers developed. The percentage of patients without pressure ulcers who were identified by the Braden scale as being risk-free (specificity) was 64–90% (Bergstrom et al. 1987a, Bergquist & Frantz 2001, Bergquist 2001). Research conducted in medical, surgical and orthopaedic units in acute care institutions reported that the Braden scale had 60–81% sensitivity and 54–100% specificity for stage I–IV pressure ulcers when using a cut-off score of 18. It further demonstrated a high degree of inter-rater reliability coefficients from 0·83–0·99 and agreement of 88–100% for registered nurses (Braden & Maklebusht 2005, Kring 2007).

The Braden cut-off score of 18 produced the best balance between sensitivity (72–81%) and specificity (60–73%) in various settings (Bergstrom et al. 1998, Pang & Wong 1998, Schue & Langemo 1998, Lyder et al. 1999). Although sensitivity and specificity varied slightly between studies, the collective evidence indicated that a cut-off score of 18 for older patients is more appropriate in long-term care and tertiary care settings (Braden & Bergstrom 1987b, Pang & Wong 1998). The Braden scale also demonstrated higher predictive power than the Norton and Waterloo scales, indicated by sensitivity, specificity, positive predictive values and percentage of correct classification (Pang & Wong 1998, Lyder et al. 1999, Bergquist & Frantz 2001). Recently, Pancorbo-Hidalgo et al.’s (2006) systematic bibliographical review and Kring’s (2007) meta-analysis found that the Braden scale is the best at predicting pressure ulcer risk when compared with the Norton, Waterloo and Gosnell scales. In a recent review, health professionals in more than 11 published studies supported the Braden scale as a reliable measurement of pressure ulcer risk (Kring 2007). However, Schoonhoven et al. (2005) criticised the Braden scale as not satisfactorily predicting pressure ulcer development in patients admitted to hospital, due to being based on clinical observation and pathophysiological insights rather than adequate prospective or prognostic research. Defloor and Grypdonck (2005) found that 80% of patients were over-predicted to be at risk of pressure ulcer development and that only 20% of them needed to receive preventive treatment, which means that much needless work is done and expensive material is wrongly allocated. Brown’s (2004) review likewise found that 58–91% of patients were over-predicted to be at risk of developing pressure ulcers by the Braden scale, representing a waste of healthcare resources. In addition, only the most recent studies provide the value of the area under the ROC curve (AUC), which gauges the predictive usefulness of the Braden scale finding ranges from a very low value 0·55–0·74 (Pancorbo-Hidalgo et al. 2006).

Halfens et al. (2000) emphasised that the predictive validity of the Braden scale could be enhanced; Defloor and Grypdonck (2005) also find that it had lower effectiveness and suggest that it could better be used in conjunction with other pressure ulcer calculators which should be based on the causal and associated factors of pressure ulcer development. Kring (2007) also suggests adding other items with potential for further strengthening the scale’s predictive validity.

Modified Braden scale

Pang and Wong (1998) conducted a study to compare the Braden, Norton and Waterloo scales (Waterloo 1985) in a Hong Kong rehabilitation hospital. The Braden scale was found to have higher predictive power than the other two scales. Further analysis revealed that the moisture/incontinence, mobility, activity and friction and shear subscales from the Braden scale and the skin type and body build for height subscales from the Waterloo scale were most strongly related to pressure ulcer formation. Based on these findings, the Braden scale was initially modified to include skin type and body build for height subscales. In one study, the initial Braden scale was translated to Chinese and further modified by excluding the nutrition subscale because it was found to be the least distinct factor for pressure ulcer development and was not easy to measure subjects’ oral intake of protein based on the brief description reported by the nurse assessors (Kwong et al. 2005). The final modified Braden scale comprises seven subscales of sensory perception, moisture, mobility, activity, friction and shear, skin type and body build. As on the Braden scale, all the subscales are rated from 1 (most impaired) to 4 (least impaired), except the friction and shear subscale, which is rated from 1 (problem) to 3 (no problem). The total scores range from 7–27. The higher scores indicate lower pressure ulcer risk. Several previous studies have reported that the scale demonstrates the best balance of sensitivity and specificity at the cut-off points of 19 and 22 (sensitivity: 89%; specificity: 75–68%) among adult patients in acute care (Xue et al. 2004, Kwong et al. 2005). It obtained 100% agreement among raters in Kwong et al. study (2005). In these studies, the modified scale was found to be more predictive of pressure ulcer development than the Braden scale. Despite this, more studies need to be conducted in various healthcare settings to determine its predictive validity and confirm its comparatively higher predictive power.

Method

Design and sample

This is a prospective cohort study of 197 patients from two orthopaedic wards of an acute care hospital in Hong Kong.
They were Chinese, aged 18 or above, expected to stay in the ward for five days or more following admission, not ambulant and had no pressure ulcers detected on admission.

Measures
A patient characteristic form was used to record subjects’ age, gender, length of hospital stay, other medical problems, whether or not they had undergone surgery and smoking habits. The Braden and modified Braden scales with good reliability and validity were used to assess subjects’ risk of pressure ulcer development. The skin assessment form was used to record subjects’ skin condition including the site and stage of pressure ulcer development, categorising the lesions according to National Pressure Ulcer Advisory Panel (2007) criteria for staging pressure ulcers. A Stage I ulcer is intact skin with non-blanchable redness of a localised area, usually over a bony prominence. Darkly pigmented skin may not have visible blanching and the area may be painful, firm, soft and warmer or cooler compared with the adjacent tissue. It is also considered reversible in that no irreparable tissue damage has occurred. A Stage II ulcer is a partial thickness loss of dermis presenting as a shallow open ulcer with a red or pink wound bed, without slough. A Stage III ulcer is full thickness skin loss. Subcutaneous fat may be visible but bone, tendon or muscle are not exposed and slough may be present but does not obscure the depth of tissue loss; it may include undermining and tunneling. A Stage IV ulcer is full thickness skin loss with exposed bone, tendon or muscle; slough or eschar may be present on some parts of the wound bed, often including undermining and tunneling (Black et al. 2007).

Data collection procedure
The data collection period was 13 months from May–August 2005 and from October 2007–June 2008. The researcher, an experienced nurse trained to use the modified Braden scale, screened all newly admitted patients who met the selection criteria of our study. Having obtained informed verbal consent from the subjects and written consent from the next-of-kin of unconscious or cognitively impaired patients were obtained before commencement of the study. They were assured that there would be no penalties if they withdrew from the study at any time and that their rights to anonymity and confidentiality would be protected.

Data analysis
The data were analysed using the Statistical Package for Social Science – SPSS 15.0 (SPSS INC., Chicago, IL, USA). The skew value of ±3 and kurtosis value of ±3 (Garson 2008) support the use of parametric tests in this study. The modified Braden scale score has a skew value of −0.025 and a kurtosis +0.426. All modified Braden subscale scores, except those of sensory perception (skew value: −2.621 and kurtosis value +6.451) and activity (skew value: +2.017 and kurtosis value +3.181) have skew values of −1.245 − +0.358 and kurtosis values of −0.456–+2.143. Therefore, the independent t-test and logistic regression analysis were used to identify the modified Braden subscales that were predictive of pressure ulcer development. The independent t-test (age, length of hospital stay) and Chi-square test (gender, medical problems, surgery, smoking habit) were used to examine the differences in patient characteristics between the subjects with and without pressure ulcers. The receiver operating characteristic (ROC) curve determined the predictive validity of the Braden and modified Braden scales. The significance value was set at \( p < 0.05 \).

Ethical consideration
Ethical approval was granted from the Joint Chinese University of Hong Kong and New Territories East Cluster Clinical Research Ethics Committee. Verbal informed consent from the subjects and written consent from the next-of-kin of unconscious or cognitively impaired patients were obtained before commencement of the study. They were assured that there would be no penalties if they withdrew from the study at any time and that their rights to anonymity and confidentiality would be protected.

Results
Subject characteristics
Of 197 subjects with a mean age of 79.4, 30 (15.2%) were male and 167 (84.8%) were female. Twenty-three (11.7%) subjects were current smokers. Apart from orthopaedic diseases, 167 (84.8%) patients had at least one medical problem. All subjects stayed an average of 10.8 days in the wards (Table 1).
Eighteen patients (9.1%) developed pressure ulcers after an average of 8.1 days of observation (range 1–9 days, SD: 4.873). Stage II pressure ulcers (n = 14, 77.8%) on the buttock (n = 8, 44.5%) were the dominant stage and site of pressure ulcers (Table 2).

Table 2 Site and stage of pressure ulcer

<table>
<thead>
<tr>
<th>Site</th>
<th>Total (n = 18, 100%)</th>
<th>Stage I (n = 4, 22.2%)</th>
<th>Stage II (n = 14, 77.8%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buttock</td>
<td>9 (50.1%)</td>
<td>1 (5.6%)</td>
<td>8 (44.5%)</td>
</tr>
<tr>
<td>Sacrum</td>
<td>6 (33.3%)</td>
<td>2 (11.2%)</td>
<td>4 (22.3%)</td>
</tr>
<tr>
<td>Hip</td>
<td>1 (5.6%)</td>
<td>1 (5.6%)</td>
<td>0</td>
</tr>
<tr>
<td>Inner thigh</td>
<td>1 (5.6%)</td>
<td>0</td>
<td>1 (5.6%)</td>
</tr>
<tr>
<td>Ankle</td>
<td>1 (5.6%)</td>
<td>0</td>
<td>1 (5.6%)</td>
</tr>
</tbody>
</table>

Table 3 Predictive validity of Braden and modified Braden scales

<table>
<thead>
<tr>
<th>Cut-off point</th>
<th>AUC</th>
<th>p</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>95% CI (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Braden scale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>0.684</td>
<td>0.39</td>
<td>67</td>
<td>64</td>
<td>0.509–0.786</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified Braden scale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td>39</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td>56</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>0.736</td>
<td>0.01</td>
<td>89</td>
<td>62</td>
<td>0.632–0.841</td>
</tr>
</tbody>
</table>

*differs significantly from the control group (p < 0.05).

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Table 4 Modified Braden subscales in relation to presence and absence of pressure ulcer

<table>
<thead>
<tr>
<th>Subscales</th>
<th>All subjects mean (SD)</th>
<th>Subjects with pressure ulcer mean (SD)</th>
<th>Subjects without pressure ulcer mean (SD)</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory perception</td>
<td>3.86 (0.378)</td>
<td>3.67 (0.594)</td>
<td>3.88 (0.346)</td>
<td>2.275</td>
<td>0.024</td>
</tr>
<tr>
<td>Moisture</td>
<td>3.28 (1.151)</td>
<td>2.83 (1.425)</td>
<td>3.32 (1.115)</td>
<td>1.733</td>
<td>0.085</td>
</tr>
<tr>
<td>Activity</td>
<td>1.45 (0.854)</td>
<td>1.39 (0.850)</td>
<td>1.46 (0.856)</td>
<td>0.327</td>
<td>0.744</td>
</tr>
<tr>
<td>Mobility</td>
<td>2.88 (0.517)</td>
<td>2.61 (0.778)</td>
<td>2.91 (0.477)</td>
<td>2.372</td>
<td>0.019</td>
</tr>
<tr>
<td>Friction and shear</td>
<td>2.25 (2.180)</td>
<td>1.89 (0.471)</td>
<td>2.29 (2.279)</td>
<td>0.744</td>
<td>0.458</td>
</tr>
<tr>
<td>Body build for height</td>
<td>3.25 (0.752)</td>
<td>2.83 (0.857)</td>
<td>3.29 (0.730)</td>
<td>2.491</td>
<td>0.014</td>
</tr>
<tr>
<td>Skin type</td>
<td>2.91 (0.664)</td>
<td>2.39 (0.698)</td>
<td>2.96 (0.639)</td>
<td>3.589</td>
<td>0.000</td>
</tr>
<tr>
<td>Nutrition</td>
<td>3.22 (0.768)</td>
<td>2.94 (0.802)</td>
<td>3.25 (0.761)</td>
<td>1.593</td>
<td>0.113</td>
</tr>
</tbody>
</table>

*p < 0.05, p ≤ 0.001.

Table 5 Logistic regression analysis of the subscale items in the modified Braden and Braden scales

<table>
<thead>
<tr>
<th>Subscales</th>
<th>B</th>
<th>Wald X²</th>
<th>Degree of freedom</th>
<th>p</th>
<th>Odd ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory perception</td>
<td>-1.544</td>
<td>5.852</td>
<td>1</td>
<td>0.016*</td>
<td>0.214</td>
<td>0.061-0.746</td>
</tr>
<tr>
<td>Mobility</td>
<td>-0.518</td>
<td>0.943</td>
<td>1</td>
<td>0.332</td>
<td>0.596</td>
<td>0.210-1.694</td>
</tr>
<tr>
<td>Body build for height</td>
<td>-0.755</td>
<td>4.712</td>
<td>1</td>
<td>0.030*</td>
<td>0.470</td>
<td>0.238-0.929</td>
</tr>
<tr>
<td>Skin type</td>
<td>-1.527</td>
<td>9.930</td>
<td>1</td>
<td>0.002*</td>
<td>0.217</td>
<td>0.084-0.561</td>
</tr>
</tbody>
</table>

*p ≤ 0.05, p ≤ 0.001.

Modified Braden and Braden subscales in relation to presence and absence of pressure ulcers

Among the modified Braden and Braden subscales, sensory perception (t = 2.28, p = 0.024), mobility (t = 2.37, p = 0.019), body build for height (t = 2.49, p = 0.014) and skin type (t = 3.59, p = 0.000) were significantly different in term of the presence and absence of pressure ulcers among the subjects (Table 4).

Risk factors affecting pressure ulcer development

The significant subscales were included for the logistic regression analysis. Sensory perception (Beta = -1.544, OR = 0.214, p = 0.016), body build for height (Beta = -0.755, OR = 0.471, p = 0.030) and skin type (Beta = -1.527, OR = 0.217, p = 0.002) affected pressure ulcer development. The subjects with poorer sensory perception and abnormal body build/height and skin type were more likely to develop pressure ulcers (Table 5).

Discussion

The pressure ulcer incidence of 9.1% in our sample is lower than in other studies of orthopaedic patients in acute care settings, in which 30% of patients with hip fractures developed pressure ulcers postoperatively (Rademakers et al. 2007). The findings in this study showed no significant relationship between subjects’ characteristics and pressure ulcer development except the length of hospital stay, which supports Defloor and Grypdonck’s (2005) finding of no relationship between pressure ulcer and age. The HCUP (2005) study also found no difference in the patients according to gender, age and medical diagnosis. Although Gunningberg et al. (1999) suggested that smoking, age and medical problem are causative factors for pressure ulcer development and Russell et al. (2003) also reported that age is a major contributor to pressure ulcer risk, these contention are not supported in this study. However, length of hospital stay showed a significant relationship in that the longer the hospital stay, the higher the risk of pressure ulcer development found in this study. This is supported by Fogerty et al. (2008). The risk of developing postoperation complications was higher if the operation was delayed and the length of hospital stay longer. Rademakers et al. (2007) also showed that the development of pressure ulcers is significantly related to prolonged length of hospital stay.

The average age of our subjects with pressure ulcers was 82.2 and 14 (77.8%) of them had had surgery. These are the possible reasons for the stage II pressure ulcers being much more developed than the stage I pressure ulcers in our study. Perneger et al. (1998) found that patient age and having had surgery were the strongest risk factors for stage II or greater ulcers. Stage II pressure ulcers are usually caused by friction or shearing of the tissues, which appear more readily during
Wound care and pressure ulcers

the turning or transferring of subjects. Orthopaedic patients, particularly those in old age, tend to be immobile after an operation, which may put them at high risk of friction and shearing of the tissues, particularly when care providers perform turning and transferring inappropriately.

The area under the ROC curve of the modified Braden scale is 0.736, with 89% sensitivity and 62% specificity using a cut-off score of 19. With respect to the predictive validity, the modified Braden scale had the high sensitivity of 89%. Kring (2007) says that a perfect measurement tool would yield 100% sensitivity and 100% specificity, but no real-world clinical instrument is able to achieve this level of precision. Instead, those that achieve a sensitivity of 75% or higher are considered reasonably robust in terms of their predictive validity. The modified Braden scale in the study by Kwong et al. (2005) demonstrated a higher specificity of 75% and a positive predictive value of 7% among hospitalised patients, which was higher than the Braden scale; therefore, it is more effective in minimising unnecessary nursing interventions. Xue et al.’s study (2004) also found that the modified Braden scale was more effective in pressure ulcer risk prediction and more suitable for use in clinical settings, particularly where the incidence of pressure ulcer is high. The area under the ROC curve of the modified Braden scale is 0.736 (95% CI, 0.632–0.841) and that of the Braden scale is 0.684 (95% CI, 0.509–0.786), indicating that the modified Braden scale is more accurate at identifying patients who are and those who are not at risk of developing pressure ulcers.

The sensitivity (67%) and specificity (64%) of the Braden scale with a cut-off score of 16 had a better balance between sensitivity and specificity compared with using cut-off scores of 17 and 18 where the sensitivity was 72 and 89% and the specificity 41 and 21% respectively. The cut-off score of 19 in the modified Braden scale demonstrated higher predictive validity, sensitivity (89%) and specificity (62%) than the Braden scale whether the cut-off score was 16, 17 or 18.

Thus, in terms of sensitivity and specificity, the modified Braden scale showed greater accuracy in identifying patients who are and those who are not at risk of developing pressure ulcers, supporting Kwong et al.’s study (2005) reporting that the modified Braden scale with a cut-off score 19 is more effective and can minimise unnecessary nursing interventions. The sensitivity was of greater value than the specificity in correctly identifying all patients really at risk of developing pressure ulcers, as this is more desirable than wrongly identifying patients as at risk and needlessly giving preventive care (Defloor 2004). Higher specificity nevertheless helps to cost-effectively and correctly allocate resources to patients at risk of pressure ulcer development. Therefore, adopting the modified Braden scale as a predictor of pressure ulcer development may help in the cost containment and allocation of resources to patients at risk. Therefore, a modified Braden scale with a cut-off score of 19 is suggested for use in orthopaedic departments in an acute care setting.

In this study, the modified Braden subscale items of sensory perception, body build for height and skin type were the risk factors affecting pressure ulcer development, supporting Halfens et al.’s (2000) contention that sensory perception was the most important risk factor for pressure ulcer development. Sensory perception is the ability to notice and respond to discomfort caused by exposure to increased pressure on the skin. Patients who lack sensory awareness are more likely to remain in one position for a prolonged period and therefore to sustain a pressure injury (Kring 2007). This also supports the findings of Defloor and Grypdonck (2005) that the subscale of sensory perception of the Braden scale and skin condition were significant predictors of pressure ulcer lesions; diminished sensory perception will increase the duration of pressure and shearing force, which cause pressure ulcers. In addition, Kwong et al. (2005) showed that skin type and body build for height were very distinct in positive and negative pressure ulcer groups. Low body weight has been shown to be a statistically significant indicator of pressure ulcer development; it acts as an extrinsic tissue factor as bony prominences become more pronounced in the underweight person (Kring 2007). In addition, obesity is also one of the causes of pressure ulcer development because extra weight increases pressure on the skin over the bone and joints (Wood 2005). With respect to unhealthy skin, dehydrated skin that loses elasticity and oedematous skin that has a poorer supply of oxygen are also risk factors of pressure ulcer development (Potter & Perry 2001).

The findings show that the subscale of nutrition is not significant in relation to pressure ulcer development ($p = 0.113$), supporting Pang and Wong (1998), who found it to be the least distinct subscale. Halfens et al. (2000) tested and found that all factors of the original Braden scale were related to the risk of developing pressure ulcer, with the exception of nutrition. The measure of nutrition in the Braden scale is of the intake of meals and not the nutritional content, leading Halfens et al. (2000) to suggest reformulating the risk factor of nutrition in the Braden scale to enhance its sensitivity and specificity. Body weight may also be considered a proxy for nutritional condition and is included in the prediction rule (Schoonhoven et al. 2005) that low body mass index typically indicate poor nutrition (Kring 2007). Kwong et al. (2005) also suggested deleting the subscale of nutrition in the modified Braden scale due to the finding that it is the least distinct subscale for predicting pressure ulcer development.
development and the difficulty of assessing this in Chinese communities. As ‘one serving’ may have a well known meaning or be an amount that is easily understood in western countries, it is different in Chinese or Asian societies, such that it may not be effective for nurses in clinical application. By contrast, the subscales of body build for height and skin type are comparatively easy to assess. The modified Braden scale was found to have better predictive validity than the Braden scale because of adding the distinct subscale items of skin type and body build for height and deleting the subscale of nutrition. In view of these findings, the modified Braden scale with a cut-off score 19 seems to be more capable of assessing pressure ulcer risk than the Braden scale in the orthopaedic department in an acute care setting.

**Conclusion**

The modified Braden scale with a cut-off score of 19 showed better predictive validity than the Braden scale in predicting patients at risk and those not at risk of pressure ulcer development in orthopaedic departments in an acute care setting. Therefore, health care providers are recommended to adopt the modified Braden scale with a cut-off point of 19 in orthopaedic units for better prediction of pressure ulcer development and more cost-effective pressure ulcer management. In fact, various departments/units are encouraged to conduct their own studies to determine the optimal cut-off score based on their patient population and care settings, because the recommended cut-off scores vary based on different patient groups and different care settings (Kring 2007). Further, when determining the appropriate cut-off scores, agencies must balance their need to accurately identify those patients at risk with avoiding the over-identification of risk for ulceration and instituting costly but unnecessary prevention programmes (Kring 2007). Furthermore, among the seven modified Braden subscales, sensory perception, skin type and body build for height were identified as being predictive of pressure ulcer development. Nurses should thus design specific nursing interventions to reduce and/or eliminate these three risk factors among patients in orthopaedic units for better pressure ulcer prevention. This study was limited to older patients in an acute setting in a Chinese community; as such, it applies only in this setting and further studies need to be conducted in various healthcare settings and units to confirm its predictive power. Therefore, it is highly recommended that the predictive validity testing of the modified Braden scale can be continued in different settings and that the distinct subscales be identified and modified to further strengthen the validity of the scale.

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**Contributions**

Study design: SMCP, WSC; data collection and analysis: WSC, SMCP, E W Y K; manuscript preparation: WSC, SMCP, EWYK.

**References**


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