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ORIGINAL PAPER

Development of pressure ulcers depending on age, body mass index, body fat, mobility and diabetes mellitus in overweight or obese patients older than 65 years hospitalised in an internal department: a longitudinal study

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Abstract

Aim: A longitudinal study aimed at evaluating the influences of age, body mass index, percentage of body fat, mobility and Type 2 diabetes mellitus on the development and progression of pressure ulcers in hospitalized overweight and obese patients older than 65 years. *Design:* A longitudinal cohort study. *Methods:* The study involved 86 men and 64 women. Patients were examined in three phases: upon admission to hospital, upon discharge, and 10–12 weeks after hospitalization. In each phase of the survey, the patients underwent anthropometry, and the occurrence and stage of pressure ulcers, mobility and the presence of diabetes mellitus were evaluated. *Results:* In phase 1 of measurement, there were 39.33% overweight patients and 60.67% obese patients; in phase 3, there were 34.67% overweight patients and 65.33% obese patients. The prevalence of pressure ulcers was 36.7%. Immobility was the strongest predictor of pressure ulcer development. Age significantly increased the risk of pressure ulcer development, especially in women. The presence of diabetes was not connected with a higher occurrence of pressure ulcers, but diabetics had more severe stages of pressure ulcers. The body mass index, percentage of body fat, and length of hospitalization were not significant predictors. *Conclusion:* Limited mobility and higher age are key risk factors for the formation of pressure ulcers in overweight and obese older adults. Diabetes mellitus does not influence the frequency of formation but is associated with progression and worse healing of pressure ulcers. Preventive care should emphasize mobilization and an individualized approach to repositioning at-risk patients.

Keywords: body mass index, diabetes mellitus, mobility, older adults, pressure ulcers.

Introduction

Pressure ulcers (PU) are defined as localized damage to the skin and underlying tissue which develops mainly in areas over bony prominences as a result of the action of pressure and shear and other risk factors (National Pressure Ulcer Advisory Panel et al., 2019). They may form within several hours, and even within several minutes in the case of high-risk patients (Bereded et al., 2018). In spite of heightening awareness of the prevention of pressure ulcers and the introduction of preventive measures, their prevalence continues to rise, and their occurrence has not significantly decreased for several decades (Gould et al., 2024). The increasing age of the population contributes to this trend as confirmed by the studies of Chung et al. (2022) and Khan et al. (2020). The global prevalence of pressure ulcers in acute inpatient care settings is as high as 14.8%. (Ghaderi et al., 2023; Pokorná et al., 2023).

The presence of pressure ulcers negatively affects recovery, increases pain, prolongs hospitalization, and significantly increases healthcare costs (Borghardt et al., 2016). The main risk factors of pressure ulcer development include pressure and shearing forces, immobility, higher age, and chronic diseases such as diabetes mellitus, cardiovascular and renal diseases (Bhattacharya & Mishra, 2015; Jaul et al., 2018). Osuagwu et al. (2023) identify immobility as the highest-risk factor, whereas the National Pressure Ulcer Advisory Panel et al. (2019) emphasize the critical role of mechanical forces acting on tissue.

The prevention of pressure ulcers begins with the identification of at-risk patients by means

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of screening tools such as the Braden Scale (Braden & Bergstrom, 1987) or classification according to Norton (Hajhosseini et al., 2020; Norton, 1996). Active preventive approaches include regular patient repositioning, the use of pressure-relieving mattresses, and timely identification of risk factors (Institute for Quality and Efficiency in Health Care, 2022; Lovegrove et al., 2022). Ghaderi et al. (2023) identify pressure ulcers as the most frequent complication in long-term immobile patients, which can often be prevented through timely mobilization (Caggiari et al., 2024). Similarly, Hilšerová (2010) emphasizes the importance of restoring mobility as a key element of prevention.

The Ministry of Health (MH) of the Czech Republic recommends that patients should be repositioned every two to three hours and points out the need for an individual approach according to the needs of a particular patient (MH, 2020). Nevertheless, there is no clear evidence as to the optimum frequency of repositioning, and a routine frequency often tends to be observed in healthcare facilities regardless of the individual risk (Caggiari et al., 2024).

A significant risk factor for pressure ulcer development is diabetes mellitus (DM). Dryden et al. (2015) state that the prevalence of pressure ulcers is higher in diabetes patients (8.1%) than in non-diabetic patients (0.9%) owing to reduced mobility which is more frequent in diabetics (Jaul et al., 2018). Furthermore, Zambonato et al. (2013) point out that DM reduces the ability of tissues to withstand pressure and affects the healing process negatively (Becker et al., 2017). Kang and Zhai (2015) identify diabetes as a significant predictor of pressure ulcer development, whereas Lin et al. (2017) did not find a significant association between diabetes and pressure ulcer development.

Diabetes mellitus is a chronic disease that affects more than half a billion people around the world, with the greatest increase being recorded in low- and medium-income countries (Saeedi et al., 2019; World Health Organization [WHO], 2024). The main risk factors for diabetes development include higher age and obesity, which are also connected with an increased risk of pressure ulcer development.

Globally, a further increase in the prevalence of diabetes and pressure ulcers is expected, which is connected with the aging of the population and increasing rate of obesity (Harding et al., 2019; Menke et al., 2015). Institute of Health Information and Statistics (IHIS) of the Czech Republic predictions state that there will be up to 1.3 million people with DM in the Czech Republic by 2030 (IHIS, 2019).

Pelikánová et al. (2023) report that diabetes is most prevalent among individuals aged 70–79 years, with more than 30% of this population affected, and Kvapil (2022) add that approximately one in three individuals older than 65 years has diabetes.

Data of IHIS CR (2022) show that there were more than one million diabetics registered in the Czech Republic in 2021, and this number has continued to rise over time. In 2010, there were approximately 864,000 patients with DM in the Czech Republic, whereas the figure was more than one million in 2017, reaching 1,038,000 in 2022 (Pelikánová et al., 2023). Diabetes mellitus is also associated with increased mortality and numerous complications. In 2021, more than 50,000 individuals with diabetes mellitus died, including 5,261 deaths directly attributable to diabetes (IHIS, 2022). Compared with 2010, when 33,085 deaths were recorded, this represents a substantial increase (IHIS, 2019). The World Health Organization (2024) further reports a 3% increase in diabetes-related mortality between 2000 and 2019.

The most frequent complications of diabetes include cardiovascular and kidney diseases and diabetic neuropathy. The latter significantly increases the risk of pressure ulcers and other chronic wounds forming as it reduces sensory perception and the ability to perceive pain (Deshpande et al., 2008; Rogers et al., 2011; Tesfaye et al., 2010). According to The Wound Pros (2024), diabetes also impairs tissue perfusion and delays wound healing.

Given the inconsistent findings regarding the relationship between pressure ulcer development and various risk factors, we conducted this study to evaluate individual factors as potential ancillary predictors of pressure ulcer development. The results might provide a deeper understanding of the association between pressure ulcer occurrence and risk factors, thereby supporting the optimization of preventive strategies for at-risk patient populations.

Aim

The longitudinal study aimed at evaluating the relation between the development and progression of pressure ulcers and selected risk factors: age, gender, BMI category, the presence of Type 2 diabetes mellitus, percentage of body fat, and the level of mobility in overweight and obese patients older than 65 years hospitalized in an internal department. The study monitored the occurrence and progression of pressure ulcers both during hospitalization and after its end, and aimed to identify significant predictors of their development.

Methods

Design

The study was designed as a longitudinal observational survey conducted in accordance with the recommendations of the international methodological guidelines STROBE (Strengthening the Reporting of Observational Studies in Epidemiology), which provides for transparent and quality processing of observational data.

Sample

A total of 150 patients (86 men and 64 women) hospitalized in an internal medicine department in the Ústí nad Labem Region were included in the study. Participants were selected based on predefined inclusion criteria: age ≥ 65 years, BMI ≥ 25 kg/m², absence of language barriers, and provision of informed consent. Only patients without diabetes or with a confirmed diagnosis of Type 2 diabetes mellitus were included; individuals with other forms of diabetes were excluded. Patients who did not meet the inclusion criteria or declined participation were also excluded.

At the start of the study, 186 patients were approached and provided informed consent. Of these, 36 patients were subsequently excluded due to health deterioration, inability to attend follow-up examinations, death, or other reasons. Consequently, 150 patients completed all examinations and measurements throughout all phases of this longitudinal study.

Before being included in the survey, the patients were informed in detail about the purpose and course of the study. All participants signed an informed consent that had been approved by the Ethical Committee of the Faculty of Health Sciences of Palacký University, Olomouc (UPOL – 18731/FZV-2023).

Data collection

The study took place in the period from 10 February 2023 to 2 January 2024 in an internal department of a hospital in the Ústí nad Labem Region, Czech Republic. Follow-up measurements were conducted either in an internal outpatient department or in an aftercare department of the same hospital. As part of the longitudinal study, patients were assessed in three phases: at admission (initial measurement), at discharge (exit measurement), and approximately 10–12 weeks after discharge (follow-up measurement). The average duration of patient monitoring was 10–12 weeks.

The initial assessment was performed within 24 hours of admission. Patients were examined individually and measured in their underwear or hospital attire at the hospital outpatient clinic. The assessment included evaluation of self-sufficiency using a 4-point scale (1 = not self-sufficient, 4 = completely immobile), based on the Braden scale (Braden & Bergstrom, 1987) and the extended Norton scale (Norton, 1996). In addition, each patient's body height was measured using an A-226 anthropometer, body weight using a diagnostic scale (InBody, 2023), and skinfold thickness and girth dimensions were measured according to standardized anthropometric methods (Kopecký et al., 2019). The thickness of skinfolds (biceps, triceps, subcapsular) was measured using a BEST II K-501 Caliper, and the relaxed arm circumference was measured with a soft metric tape (Kopecký et al., 2019). Body height, arm circumference, and skinfold thickness were measured to an accuracy of 0.1 cm, and body weight was measured to an accuracy of 0.1 kg.

From the measured body height and weight, the body mass index [BMI kg/m^2 = body weight (kg) / body height (m^2)] was calculated and categorized according to WHO criteria (Hainer, 2021). The percentage of body fat was subsequently calculated using the equation described by Dodd et al. (2015) and Kannieappan et al. (2013): Body fat % = 12.7 + (0.457 × triceps skinfold) + (0.352 × subscapular skinfold) + (0.103 × biceps skinfold) – (0.057 × body height) + (0.265 × arm circumference).

The condition of the skin was assessed with a special focus on the occurrence of pressure ulcers, and their area (in mm^2) and classification according to the International Pressure Ulcer Classification (MH, 2020). The initial assessment also included a structured medical-history interview focusing on the presence of Type 2 diabetes mellitus and the currently established treatment.

The exit assessment was conducted on the day of patient discharge (M = 6.67, Me = 6, range: 5–9 days) and followed the same procedures as the initial assessment. During this visit, patients were also informed of the scheduled date for the follow-up assessment.

The follow-up assessment was conducted 10–12 weeks after discharge, either in the internal outpatient department or in aftercare facilities.

The same methodology was used to assess somatometric indicators and skin condition.

All measurements were conducted by the study author in collaboration with a specialist from the internal department. Comparative checks were performed at the start of data collection to minimize errors during assessments in the different phases of the study.

Data analysis

The basic statistical characteristics – arithmetic mean (M) and standard deviation (SD) – were calculated for each age category in males and females. Data normality was assessed using the Shapiro-Wilk test.

Differences between mean values of somatic parameters (body height, body weight, BMI, percentage of body fat, and arm circumference) were calculated and evaluated separately for each gender using repeated-measures analysis of variance (ANOVA) followed by a post-hoc Scheffé test. Nonparametric tests – including Cochran's Q test and the chi-squared test with Bonferroni correction – were used to compare changes in the number of patients across the three measurement phases (1, 2, 3).

Logistic regression was used to identify independent predictors of pressure ulcer development (Enter method). All the statistical tests were conducted at the level of significance $^*p < 0.05$ and $^{**}p < 0.01$ (Hendl, 2023). Data were analyzed using the Czech STATISTICA 14 program.

Results

A total of 150 patients hospitalized in two internal departments were included in the study. The sample comprised 86 males (57.3%) and 64 females (42.7%), with a mean age of 75.86 years for males (SD ± 7.31) and 79.33 years for females (SD ± 7.68). The composition of males and females remained consistent across all three monitoring phases.

Table 1 shows that, among males, none of the somatic parameters – body height, body weight, or BMI – changed over the study period (repeated-measures ANOVA with post-hoc Scheffé test). Regarding females, body height did not change, but both BMI (kg/m^2) and body weight showed statistically significant differences between individual phases of monitoring ($p \leq 0.05$). Due to sexual dimorphism, males had significantly greater body height and body weight than females ($p \leq 0.05$), but no statistically significant difference was found in BMI (kg/m^2) values in any phase ($p \geq 0.05$, unpaired two-sample t-test). The highest measured values of BMI amounted to 55.82 kg/m^2 for a male and to 47.87 kg/m^2 for a female.

The results of Cochran's Q test (Table 1) indicated a slight decrease in the number of males in the overweight category and a corresponding increase in the proportion of obese patients over the study period; however, these changes were not statistically significant ($Q = 4.667$, $p = 0.096$). A similar trend was observed in females, with a more pronounced increase in obesity, which also did not reach statistical significance. ($Q = 5.333$, $p = 0.069$). No statistically significant differences in percentage of body fat were observed across any of the phases for both men and women. Although women exhibited a change in BMI, no corresponding change in percentage of body fat was detected in either men or women.

Type 2 diabetes mellitus (Table 1) was diagnosed in 76 patients (50.7%), with a nearly even distribution between genders – 42.1% in females and 57.9% in males – but no statistically significant difference was observed. Among the diabetic patients, 36.9% were treated with oral antidiabetic agents, 23.7% followed a diabetic diet, and 19.7% received insulin therapy, either alone or in combination with oral antidiabetic agents. An analysis of diabetes occurrence by BMI revealed that approximately half of the overweight or obese patients suffered from this disease. However, statistical tests (chi-squared) did not demonstrate a significant correlation between the occurrence of diabetes and BMI ($p > 0.05$).

Upon admission, 55 patients (36.7%) had already been affected by a pressure ulcer, and two pressure ulcers were recorded in 17 (30.9%) patients. During hospitalization, a new pressure ulcer developed in another 18 patients. No cases of three or more pressure ulcers were recorded in all phases of monitoring. The average area of pressure ulcers was 39.4 cm^2 in the first phase, 41.4 cm^2 in the second phase, and 32.1 cm^2 in the third phase of monitoring. The most frequent locations were the area of the sacral bone, heel, buttocks, and hips. In total, a pressure ulcer was recorded in 26 diabetes patients (34.2%).

Additionally, the occurrence of pressure ulcers was analyzed in relation to BMI and gender. For overweight males, the occurrence of pressure ulcers ranged from 32.3 to 54.8%, whereas for obese males it was between 36.4% and 44.8%. The occurrence of pressure ulcers was higher in females, ranging from 28.6% to 45.8% in overweight individuals and 42.5% to 52.8%

in obese individuals. Although the data suggest a higher prevalence in obese females, statistical analysis did not confirm this trend. The values of chi-squared tests and the corresponding p-values (0.07–0.82) showed that the differences ascertained were not statistically significant.

Table 1 Characteristics of patients in individual phases of measurement (n = 150)

Parameter	Phase 1	Phase 2	Phase 3
Body height (cm)	**M (SD)**	**M (SD)**	**M (SD)**
males	173.43 (4.22) n.s.	173.55 (4.17) n.s.	173.56 (7.24) n.s.
females	161.52 (4.33) n.s.	161.57 (4.37) n.s.	161.54 (4.33) n.s.
Body weight (kg)	**M (SD)**	**M (SD)**	**M (SD)**
males	96.88 (18.77) n.s.	97.17 (18.73) n.s.	97.33 (17.11) n.s.
females	84.11 (18.36) n.s.	84.23 (18.21) n.s.	85.13 (17.80) **
BMI (kg/m^2)	**M (SD)**	**M (SD)**	**M (SD)**
males	32.15 (5.32) n.s.	32.19 (5.27) n.s.	32.28 (4.94) n.s.
females	32.22 (5.48) n.s.	32.25 (5.47) n.s.	32.61 (5.44) **
Body fat (%)	**M (SD)**	**M (SD)**	**M (SD)**
males	33.46 (7.08) n.s.	33.65 (6.85) n.s.	32.77 (6.43) n.s.
females	34.69 (6.74) n.s.	34.87 (6.82) n.s.	34.79 (6.86) n.s.
BMI category	**N (%)**	**N (%)**	**N (%)**
overweight males	31 (36.1)	30 (34.9)	28 (32.7)
obesity males	55 (64.0)	56 (65.1)	58 (67.4)
overweight females	28 (43.8)	28 (43.8)	24 (37.5)
obesity females	36 (56.3)	36 (56.3)	40 (62.5)
Diabetes mellitus	**N (%)**	**N (%)**	**N (%)**
overweight males	16 (51.6)	16 (54.6)	14 (50.0)
obesity males	28 (50.9)	28 (50.9)	30 (51.7)
overweight females	13 (46.4)	13 (46.4)	11 (45.8)
obesity females	19 (52.8)	20 (55.6)	25 (62.5)
Pressure ulcer	**N (%)**	**N (%)**	**N (%)**
overweight males	10 (32.3)	17 (54.8)	14 (50.0)
obesity males	20 (36.4)	25 (45.5)	26 (44.8)
overweight females	8 (28.6)	10 (35.7)	11 (45.8)
obesity females	17 (47.2)	19 (52.8)	17 (42.5)

*M – mean; SD – standard deviation; N (%) – absolute number and relative frequency in per cent; n.s. – statistically insignificant; ** – statistically significant difference ($p < 0.01$)*

Analysis of pressure ulcer classification by diabetes status (Table 2) indicated that overall prevalence was similar in both groups, with pressure ulcers recorded in 50.2% of patients with diabetes and 49.3% of patients without diabetes. During the monitoring period, a slight increase in pressure ulcer occurrence was observed among patients with diabetes, whereas a gradual decrease was noted in non-diabetic patients.

A Stage 2 pressure ulcer was most frequently diagnosed in all the phases of measurement, both in patients with and without diabetes. In the case of diabetics, its occurrence ranged between 41.7% and 44.4%, whereas it reached up to 55.6% in non-diabetics in the second phase of measurement. Thus, this stage represented the most frequent form of pressure ulcer throughout the period under consideration.

More severe pressure ulcers (Stages 3 and 4) were more frequently observed in patients with diabetes (18.7%) compared with those without diabetes (11%). Stage 3 ulcers in diabetic patients were most prevalent in the third phase of measurement (29.2%), compared with 26.2% in non-diabetic patients during the same phase. Stage 4 pressure ulcers were rare, occurring in only two patients with diabetes (4.2%) and two patients without diabetes (4.8%) in the third phase.

By contrast, the mildest form of pressure ulcer (Stage 1) was more frequently found in patients without diabetes, especially in the first phase of measurement (39.5% compared to 26.5% for diabetics). In the third phase, the occurrence of Stage 1 pressure ulcers dropped markedly in non-diabetics to 14.3%, whereas it was recorded in 25% of patients with diabetes. This finding supports the trend of a higher prevalence of milder pressure ulcers in non-diabetic patients, with an overall difference of 3.4% in favor of this group.

The results show that although the overall occurrence of pressure ulcers among patients with and without diabetes was similar, more severe forms of pressure ulcer affected diabetic patients more frequently. This trend may be connected with a diabetes-induced deterioration of perfusion of tissues, decelerated healing of wounds, and other complications due to this disease.

In the next phase of the analysis, we concentrated on identifying variables that affected the formation of pressure ulcers. Independent variables included: age, gender, BMI category, relative amount of body fat, mobility, and presence of diabetes mellitus.

The logistic regression model using the Enter method did not include the variable "mobility," as no pressure ulcers were recorded in the group of mobile patients (n = 30) at admission. Nonetheless, mobility was analyzed separately using the chi-squared test and Fisher's exact test. The results demonstrated that mobility was a significant factor influencing pressure ulcer development in all three monitoring phases ($p < 0.001$), for both genders. The results of logistic regression summarized in Table 3 show that in the first phase of monitoring, age was a statistically significant predictor of pressure ulcer development, both in males and females ($p < 0.05$). The OR value (1.063) indicated that the risk of pressure ulcer development increased approximately by 6% with every further year of age. The effect of age was more pronounced in females, suggesting that elderly female patients may be more vulnerable to pressure ulcer development than males in the same age group.

In phases 2 and 3 of monitoring, no statistically significant predictor of pressure ulcer development was identified either in males or in females (Table 3).

Table 2 Classification of pressure ulcers by diabetes in individual phase of measurement (N = 150)

Pressure ulcer stage	**With diabetes**			**Without diabetes**		
	Phase 1 (N = 76) N (%)	**Phase 2 (N = 76) N (%)**	**Phase 3 (N = 80) N (%)**	**Phase 1 (N = 74) N (%)**	**Phase 2 (N = 74) N (%)**	**Phase 3 (N = 70) N (%)**
Stage 1	9 (26.5)	16 (35.6)	12 (25)	15 (39.5)	14 (31.1)	6 (14.3)
Stage 2	15 (44.1)	20 (44.4)	20 (41.7)	17 (44.7)	25 (55.6)	22 (52.4)
Stage 3	8 (23.5)	8 (17.8)	14 (29.2)	4 (10.5)	5 (11.1)	11 (26.2)
Stage 4	0 (0.0)	0 (0.0)	2 (4.2)	0 (0.0)	1 (2.2)	2 (4.8)
Not determined	2 (5.9)	1 (2.2)	0 (0.0)	2 (5.3)	0 (0.0)	1 (2.4)
Total	34 (47.2)	45 (50.0)	48 (53.3)	38 (52.8)	45 (50.0)	42 (46.7)

N – absolute frequency; % – relative frequency

Table 3 Logistic regression (Enter method) between pressure ulcer development and independent predictors (n = 150)

	Phase 1			**Phase 2**			**Phase 3**		
Predictor	**p**	**OR**	**95% CI**	**p**	**OR**	**95% CI**	**P**	**OR**	**95% CI**
Age	0.013*	1.063	(1.013; 1.116)	-	-	-	-	-	-
Gender	0.961	1.018	(0.501; 2.069)	0.445	0.767	(0.389; 1.515)	0.633	0.848	(0.432; 1.667)
Hospitalization	-	-	-	0.818	1.035	(0.774; 1.384)	0.682	1.062	(0.796; 1.417)
BMI category	0.126	1.754	(0.853; 3.608)	0.801	1.090	(0.557; 2.133)	0.657	0.857	(0.434; 1.693)
Body fat (%)	0.129	1.263	(0.934; 1,707)	0.300	0.720	(0.386; 1,344)	0.607	1.079	(0.806; 1,446)
DM	0.892	0.953	(0.473; 1.918)	0.662	0.861	(0.441; 1.682)	0.861	0.942	(0.484; 1.834)

*p – value of statistical significance; OR – odds ratio; CI – confidence interval; DM – Diabetes mellitus; "-"– the data has not changed; * – statistically significant (*p < 0.05)*

Discussion

The overall prevalence of pressure ulcers in the cohort monitored was 36.7%, recorded more often in men, but the differences were not statistically significant. Of the total number of patients with pressure ulcers, diabetics comprised 50.2% and patients without diabetes accounted for 49.3%. Although the occurrence of pressure ulcers appeared to be comparable in both groups, the analysis of severity of the individual stages revealed a higher share of more progressive forms in diabetic patients.

In their meta-analysis of 15 studies examining risk factors for pressure ulcers in patients hospitalized in intensive care units, Gou et al. (2023) identified diabetes mellitus as a risk factor, although only two of the included studies (13.3%) demonstrated statistical significance. Similar conclusions were also drawn by Wang et al. (2024) and Luo and Huang (2024), who confirmed a significant relation between Type 2 diabetes and a heightened risk of pressure ulcers ($p < 0.001$). Our study, however, did not find a statistically significant association between diabetes and pressure ulcer development in patients hospitalized in an internal medicine department (Table 3).

Nevertheless, more severe stages of pressure ulcer were more often present in diabetics, which may point to a correlation between diabetes and progression of pressure ulcer lesions, but not necessarily with their formation. Muhammad et al. (2024) add that the risk rises in the case of diabetics that are immobile longer than seven days.

Length of hospitalization is another risk factor discussed in the literature. Some studies (Wang et al., 2024) identify a length of hospitalization exceeding three days as a risk. Statistical significance ($p = 0.067$) for this variable was not proven in our study, however. The difference in results may be attributed to the shorter average length of hospitalization in our cohort (6.68 ± 1.22 days) compared with other studies. In this context, Veverková et al. (2018) reported an average hospital stay of 23.4 days and demonstrated a significant relationship between length of hospitalization and patient age ($p < 0.05$). In contrast, Gou et al. (2023) did not find a correlation between length of hospitalization and pressure ulcer development in their meta-analysis. However, similar to Veverková et al. (2018), they confirmed a significant association between patient age and pressure ulcer occurrence ($p = 0.013$).

The results concerning BMI as a risk factor also vary in specialist literature (Chung et al., 2022; Labeau et al., 2021; Veverková et al., 2018). BMI was not statistically significant in our study ($p = 0.171$), which is in line with the conclusions of Veverková et al. (2018) and Labeau et al. (2021). By contrast, Chung et al. (2022) identified a high BMI as a risk factor in three studies analyzed. These differences may be owing to the specifics of the populations monitored and diverse methodologies used.

Similar to BMI, body fat percentage was not a statistically significant predictor of pressure ulcer development. On average, men across all measurement phases were classified as obese, whereas women were on the borderline of overweight. The body fat percentages observed in our study (mean across three measurement phases: 34.04 ± 6.80%) were higher than those reported by Montalcini et al. (2015), who found an average of 27 ± 11% in their cohort. Nonetheless, consistent with our findings, Montalcini et al. did not demonstrate a significant effect of body fat on the risk of pressure ulcer development.

In addition, gender as a predictor of pressure ulcer development shows differing results in various studies. Whereas Chung et al. (2022) and Muhammad et al. (2024) refer to male sex as a risk factor, in our study we identified a greater risk in females. Differences in the age structure, comorbidities, and physical fitness of the monitored patients may serve as a possible explanation.

Mobility was identified as the most significant predictor of pressure ulcer development in our cohort. A significant association between limited mobility and pressure ulcer occurrence was observed across all three monitoring phases ($p < 0.001$), and this factor was significant in both genders. These findings support those of Zhetmekova et al. (2024), who reported a strong association between reduced mobility and pressure ulcers in long-term care residents, as well as Tervo-Heikkinen et al. (2022), who analyzed 5,902 patients in acute care. Similarly, Luo and Huang (2024) confirmed the significance of mobility, age, and underweight status, whereas BMI was not a significant factor ($p = 0.026$). Our results confirm the statements of Osuagwu et al. (2023) and Chung et al. (2022) who highlight level of mobility as a key predictor in the occurrence of pressure ulcers, and almost half the studies analyzed refer to this variable as decisive (Luo & Huang, 2024; Tervo-Heikkinen et al., 2022; Zhetmekova et al., 2024).

Consistent with the findings of Labeau et al. (2021), the sacral area (37%) and heels (19.5%) were the most frequently affected sites in our cohort.

Regarding severity, Stage 1 and Stage 2 pressure ulcers were the most common, similar to the study by Pérez-Juan et al. (2023), in which Stage 1 accounted for 33.8% and Stage 2 for 66.2% of cases. The average BMI of the patients in their study was 30.7 kg/m^2, whereas in our cohort it was 32.2 ± 5.4. While Pérez-Juan et al. (2023) identified statistically significant differences between genders and BMI, a relation between age and pressure ulcer development was not proven, which is probably associated with the lower average age of their respondents.

Limitation of study

The study presented has several limitations that need to be taken into account. First, the survey was conducted in an internal department of a hospital in the Ústí nad Labem Region, which restricted the generalizability of the results to other types of departments.

One of the objectives of the study was to assess body composition (e.g., evaluation of sarcopenia) using bioelectrical impedance analysis (BIA) with the diagnostic scale InBody 120. However, the majority of patients were unable to undergo this examination due to postural instability, contraindications to BIA measurement, or inability to maintain a firm grip on the hand electrodes, which were connected to the scale by a cable rather than mounted on a stable stand. As a result, repeated BIA-based body composition analysis could be performed in only 20 patients. For this reason, it was not possible to analyze body composition using BIA in all study participants. The InBody 120 composition analyzer was therefore used solely for body weight measurement to maintain consistency of the measuring device and standardized conditions throughout the study period. Anticipating potential limitations at the outset of the research, we also performed concurrent skinfold thickness measurements, which are reported in this study for the assessment of relative body fat. The assessment of pressure ulcers was carried out by a single observer due to organizational constraints and the need to maintain a consistent and standardized evaluation procedure. Although longitudinal data collection in a hospital setting is time-consuming, organizationally demanding, and financially intensive, it provides valuable insights for clinical practice. Additional potentially relevant comorbidities (e.g., cardiovascular disease, renal failure) were not statistically controlled for, as the primary focus of this study was to identify key risk factors. The study also did not evaluate the effectiveness of preventive interventions; therefore, we did not report findings on the efficacy of specific preventive measures. Other clinical parameters (e.g., urea, creatinine, C-reactive protein) were monitored but were not included in this publication due to scope and space limitations.

In terms of generalizability, the results can be applied mainly to a similar population of elderly overweight and obese patients in internal departments in countries having a similar healthcare system.

Based on our experience, implementing longitudinal research in routine hospital settings is demanding in terms of organization, resources, and time; however, it provides highly valuable results with potential applications in clinical nursing practice.

For these reasons, future research should consider multicenter studies involving larger patient cohorts and a broader range of factors. Such studies would enable a more comprehensive understanding of the mechanisms underlying pressure ulcer development and support the design of effective preventive strategies.

Based on the results of this study, a follow-up research project is currently underway to examine the effect of individualized repositioning frequency on pressure injury prevention in immobile patients. Multiple assessors are involved in this ongoing study to enhance the reliability of pressure injury evaluations.

Conclusion

The longitudinal study presented confirmed that the formation of pressure ulcers in hospitalized overweight and obese patients older than 65 years is influenced by the complex interaction of several risk factors. The strongest predictor was limited mobility, which showed statistical significance through all phases of monitoring. In addition, age had a significant impact, with a higher prevalence in females than in males, in the monitored age bracket of 65 years and older.

Although the presence of Type 2 diabetes mellitus in our study was not significantly associated with a higher overall occurrence of pressure ulcers, more advanced stages were more frequent in diabetic patients, suggesting a possible link between diabetes and poorer healing prognosis. These findings support the hypothesis that diabetes may not play a primary role in the initial formation of pressure ulcers but contributes to their progression and worsening of the clinical course.

By contrast, BMI, body fat percentage, and length of hospitalization were not significant predictors of pressure ulcer development in our sample. Although pressure ulcers were observed more frequently in females with higher body weight, this difference did not reach statistical significance. This finding may reflect the characteristics of our sample and the relatively short duration of hospitalization. It follows from the results that the priority of preventive strategies should be early detection and active control of risk factors. In addition, the findings highlight the need for individualized prevention and careful monitoring of at-risk patients, chiefly in the context of population aging and the increasing prevalence of obesity and diabetes. Emphasis should be placed on the timely identification of at-risk individuals, regular repositioning, education of personnel and patients, and interdisciplinary cooperation. These steps may contribute to reducing the incidence of pressure ulcers, improving patients' quality of life and reducing the costs of health care. Preventive nursing care should include regular repositioning of immobile patients (ideally based on individualized risk scores), optimization of skin care, and continuous monitoring of glycemic levels in patients with diabetes.

Ethical aspects and conflict of interest

The research was approved by the Ethics Committee of the Faculty of Health Sciences on 10 January 2023 No. UPOL-18731/FZV-2023. The authors of the article agreed to participate in the manuscript.

The authors declare that they have no competing interests in this research.

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Author contributions

Conception and design (MK, AH), data analysis and interpretation (MK, AH), manuscript draft (AH, MK), critical revision of the manuscript (AH, MK), final approval of the manuscript (AH, MK).

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