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Dry skin and pressure ulcer risk: A multi-center cross-sectional prevalence study in German hospitals and nursing homes

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ABSTRACT

Background: Pressure ulcers are a serious health problem in medical and nursing care. Therefore, effective prevention is crucial. Major pressure ulcer risk factors have been identified but the particular role of dry skin (xerosis cutis) is unclear.
Objectives: To investigate possible associations between dry skin and pressure ulcers focusing on the sacrum/trochanter and at heel/ankle skin areas.
Design: Two multicenter cross-sectional studies.
Settings/participants: In 2014 and 2015 thirty nursing homes and thirteen hospitals in Germany participated. In total 3837 participants were included. Mean age was 76.1 (SD 15.5) years.
Methods: Skin assessments and data collection were performed by trained nurses based on a standardized data collection form. Descriptive comparisons and multilevel logistic regressions predicting pressure ulcers at sacrum/trochanter and ankle/heel were conducted.
Results: The prevalence of skin dryness at the trunk was significantly higher for subjects with pressure ulcers category 2+ at the sacral area compared to without (39.0% vs. 24.4%, $p = 0.010$). Adjusted to demographic variables, mobility and type of institution dry skin at the trunk was no longer associated with pressure ulceration (OR 1.11 (95% CI 0.62–2.00)). 71.9% of patients with heel/ankle pressure ulcers category 2+ were affected by dry skin at legs or feet, compared to 42.8% of subjects without pressure ulcers ($p < 0.001$). In the adjusted analysis the OR was 1.85 (95% CI 0.83–4.14).
Conclusions: Study results indicate that dry skin at the feet may be considered as a risk factor for heel pressure ulcer development. Skin dryness may be less important for sacral pressure ulcers. Therefore, the variable skin status should be better defined in future studies and pressure ulcer risk models. Results further support differences in pressure ulcer aetiologies between anatomical locations.

What is already known about the topic?

- Skin status is regarded as an important risk factor in pressure ulcer development.
- The particular impact of dry skin on pressure ulcer development at pressure ulcer predilection areas has not been investigated so far.

What this paper adds

- Dry skin at feet seems to be a relevant risk factor for pressure ulcer development at heel/ankle
- Skin dryness at the sacral skin does not seem to increase pressure ulcer risk.
- There seem to be differences in sacral and heel pressure ulcer development.

1. Introduction

Worldwide, pressure ulcers are a serious health problem in all healthcare settings. The reported prevalence of category 1 to 4 pressure ulcers ranges from 1.6% in China (Jiang et al., 2014) to 18.2% in Norway (Bredesen et al., 2015). Individuals with impaired mobility are at particular high risk for developing pressure ulcers due to prolonged loading and mechanical deformation of soft tissues at pressure ulcer

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predilection areas (Coleman et al., 2014). The process of tissue breakdown is not yet completely understood, but empirical evidence supports two main pathological pathways: (1) Prolonged mechanical loading leads to direct deformation damage in soft vulnerable tissues (e.g. muscle tissue); (2) Prolonged loading causes occlusion of blood and lymph vessels leading to ischemia and triggering inflammation, which results in cellular necrosis (National Pressure Ulcer Advisory Panel et al., 2014; Berlowitz and Brienza, 2007; Kottner et al., 2009a).

Pressure ulcers are painful and therapy is expensive (Demarré et al., 2015). Thus, effective prevention of pressure ulcers is crucial. It includes an accurate individual risk assessment and the application of preventive measures based on the assumed pressure ulcer risk level. For this purpose it is essential to consider and to assess all relevant risk factors (Kottner et al., 2011; National Pressure Ulcer Advisory Panel et al., 2014).

In 2014 an updated pressure ulcer conceptual framework was introduced (Coleman et al., 2014). It was based on the results of a systematic review (Coleman et al., 2013) and the discussions of an expert panel. In this framework direct and indirect causal factors for developing pressure ulcers and the interrelationships between these are proposed (Coleman et al., 2014). Beside immobility, poor perfusion and skin/pressure ulcer status are also listed as direct causal factors (Coleman et al., 2014). The concept of skin status is considered to affect tissue tolerance (Coleman et al., 2013). Skin status emerges in several multivariable models as a significant risk factor (National Pressure Ulcer Advisory Panel et al., 2014). However, the concept of skin status is broad and it covers a wide range of meanings from increased skin surface moisture to dry skin (Kottner and Surber, 2016).

More than 20 years ago dry skin was reported to be a risk factor for pressure ulcer development (Guralnik et al., 1988; Allman et al., 1995). A more recent study by Baumgarten et al. (2006) also showed that pressure ulcer incidence was associated with dry skin in aged hospital patients (odds ratio of 1.53, $p = 0.035$) in a multivariable model. These seem to be the only studies investigating this possible relationship. However, precise definitions and operationalizations of dry skin are lacking in these studies. Dry skin does not usually affect the whole body. Skin dryness is a local phenomenon that may be present at certain parts of the body (Lichterfeld et al., 2016; Kottner and Surber, 2016). The nature of skin dryness must be taken into account when considering its possible relationship to pressure ulcer development. Therefore, the aim of this study was to investigate the association between dry skin and pressure ulcers paying particular attention to the two most vulnerable body areas for pressure ulcer development sacrum/trochanter and heel/ankle.

2. Methods

2.1. Study design and setting

The data used in this study is based on two multicenter descriptive cross-sectional prevalence studies in 2014 and 2015, which have been performed annually by the Department of Nursing Science at the Charité – Universitätsmedizin Berlin (Lahmann et al., 2005) since 2001. The study design is based on a similar study conducted in The Netherlands since 1999 (Bours et al., 1999) and methods have been previously described (Kottner et al., 2009b; Lahmann et al., 2005). In brief, all hospitals and nursing homes in Germany were invited to participate. In participating sites data collection was performed by nurses using standardized data collection forms.

2.2. Participants

For participation a minimum age of 16 years was determined. Only patients and residents who gave their informed consent, personally or by a legal representative, were included. Approval by the ethics commission of the Medical Association of Berlin has been obtained.

2.3. Measures

For this study the following variables were relevant: demographic data including gender, age, weight, height, body mass index (BMI) and main medical diagnoses. Residents and patients with a BMI below 18.5 kg/m^2 were regarded as having 'underweight' (WHO, 1999).

The occurrence and severity of dry skin was assessed for four separate skin areas face, trunk, hands and arms, and feet and legs. The severity of dry skin was measured using the Overall Dry Skin Score according to the European Group on Efficacy Measurement of Cosmetics and other Topical Products for dry skin assessment (Serup, 1995), which was recently validated (Kang et al., 2014). The Overall Dry Skin Score categorizes clinical signs of dryness from 0 (=absent) to 4 (=large scales, roughness, redness, cracks/fissures). In this study the variable "dry skin overall" was defined as having dry skin (category 1+) at the trunk and/or hands and arms and/or feet and legs.

The presence of pressure ulcers was assessed in two localizations sacrum/trochanter and heel/ankle. Pressure ulcers were classified according to the NPUAP/EPUAP system (National Pressure Ulcer Advisory Panel et al., 2014) into following categories: category 1 was non-blanchable redness of a localized area, category 2 was partial thickness loss of epidermis, dermis or both. In the case of full thickness skin loss the pressure ulcer was referred to category 3. Subcutaneous fat may be visible here but bone, tendon or muscle are not exposed. Category 4 was extensive tissue destruction with exposed bone, tendon or muscle. Deep Tissue Injury (DTI) refers to purple or maroon discolored localized area with intact skin or blood-filled blister. This discoloring is due to damage of underlying soft tissue (National Pressure Ulcer Advisory Panel et al., 2014). Due to reliability and validity problems category 1 pressure ulcers were excluded from the main analyses (Kottner et al., 2009a).

The variable mobility was classified from 0 (=complete dependent) to 5 (=complete independent) according to the Care Dependency Scale (Dijkstra et al., 2000). Skin care independency was defined as the subject's ability to wash, shower, bath or cream the own body independently. Taking four or more drugs orally was determined as multi-medication (Patterson et al., 2012). The support surfaces were classified into alternating pressure, soft positioning, and no special support surface.

2.4. Data collection

Participating nursing homes and hospitals had a named a qualified study coordinator, who was responsible for data collection and who trained the involved nurse raters. The nurses were given detailed instructions and explanations about completion of the forms and the performance of assessments. The data collection manual included images of different pressure ulcers classes and explanations of diagnostic scores. On a specific day the data was collected by two trained nurses, who examined, interviewed and assessed the participating residents and patients. The completed data forms were sent to the Department for Nursing Science where they were analysed (Kottner et al., 2009b).

2.5. Bias

A high degree of standardization and the appropriate training of the data collectors were regarded as important measures to support internal validity. To enhance external validity a high number of institutions was invited to participate. Previous empirical evidence suggests that the sample characteristics seem to be generalizable to the German hospital and nursing home populations, and that pressure ulcer diagnoses, pressure ulcer classifications and assessment of mobility are accurate (Kottner et al., 2009b; Lahmann et al., 2015). These variables are relevant for the current study as well.

2.6. Data analysis

Due to the exploratory nature of this study a formal sample size calculation was not performed. However, the expected number of participants (at least n = 1500 per year) was considered sufficient for the following statistical analyses.

First, demographic and other characteristics were described using proportions, means and spread parameters for nursing home residents, hospital patients and for the whole sample. Afterwards, the characteristics were compared between subjects with and without pressure ulcers. In the next step, only subjects with pressure ulcers at sacrum/trochanter or at heel/ankle were selected and compared to subjects without pressure ulcers at these areas. For these comparisons skin dryness at these skin areas was considered only. Independent *t*-tests were applied for comparisons of continuous variables (e.g. age, BMI) and Chi-square-tests were used for comparing dichotomous or ordinal variables like gender or mobility. For the main analyses only pressure ulcers category 2, 3, 4 or DTI were considered. An additional analysis was run for all pressure ulcer categories including 1.

All variables emerging as statistically significant in bivariate analyses were entered in a multiple logistic regression model with random intercept. This variable selection algorithm was applied for sacral and trochanter areas separately. In order to take the clustered nature of the data into account a random intercept was included in the logistic model. Each institution was regarded as one cluster. Because of having too few pressure ulcers (category 2 to 4+ DTI) at the heel/ankle areas the mixed effects logistic model did not converge and it was replaced by a logistic model without random effects. In order to take missing data into account the method of multiple imputation with five imputation samples was applied. The results for the imputation samples were combined by Rubin's rule. Data analyses were done using SPSS (Version 22.0. Armonk, NY: IBM Corp.) and SAS 9.4. The level of significance was set at a = 0.05 (two-tailed).

3. Results

3.1. Participants

In total, 13 hospitals and 30 nursing homes participated in both years, which resulted in 3837 hospital patients and nursing home residents participating in this study. On average, 89 participants per institution were recruited. The smallest number of participants per institution was 10, the highest 396. In the hospitals the response rate was 68% and 87% in the nursing homes (Fig. 1).

Sample characteristics are shown in Table 1. The mean age was 81.4 (SD 12.1) years in nursing homes versus 69.7 (SD 16.5) years in the hospitals. Residents in nursing homes were on average more immobile than patients in hospitals (38.9% vs. 18.0% completely or mainly dependent). A diagnosed dementia was identified in 50.9% and mental diseases in 24.4% of all residents compared to 6.8% and 11.6% of hospital patients. The prevalence of oncological diseases in hospitals was twice as high as in nursing homes (15.2% vs 7.6%). The prevalence of pressure ulcers category 1–4 and DTI as well as of pressure ulcers category 2–4 and DTI was higher in hospitals compared to nursing homes. The overall prevalence of dry skin was 46.9% and comparable in both institution types.

3.2. Main results

In Table 2, the characteristics of subjects with and without pressure ulcers category 2–4 and DTI are shown. In total 94 residents and patients (2.4%) had at least one pressure ulcer. Of those, 70.2% were affected by dry skin overall compared to 46.3% without pressure ulcers ($p < 0.001$). In addition, subjects with pressure ulcers were statistically significantly older, had a lower BMI, were less mobile and less skin care independent as well as were more often lying on alternating pressure or soft mattresses.

In Table 3a, the results for the prevalence of dry skin and pressure ulcers for the sacral and trochanter areas are presented. The prevalence of skin dryness at the trunk was significantly higher for subjects with pressure ulcers at sacrum/trochanter compared to subjects without (39.0% vs. 24.4%, p = 0.010). Regarding the heel and ankle region (Table 3b) the difference was higher: 71.9% of patients with pressure ulcers showed dry skin compared 42.8% of subjects without pressure ulcers (p = 0.001). The severity of skin dryness was also higher in subjects with pressure ulcers. Approximately half of the subjects with dry skin but without pressure ulcers showed mild forms of dryness at feet. The majority of subjects with heel/ankle pressure ulcers and dry skin showed moderate dryness.

All variables which showed statistically significant differences in the bivariate analyses in Tables 3a and 3b as well as the type of institution were entered into logistic regression models. Results of the multilevel logistic regression analysis for the sacrum/trochanter region are shown in Table 4a. According to this model strongest predictors for sacral pressure ulcer development were mobility (completely dependent vs. completely independent OR 27.1, 95% CI 3.0–247.1), type of institution (OR 4.5, 95% CI 2.2–9.1) and alternating pressure/soft mattress (OR 4.2, 95% CI 2.2–8.1). There was no association between skin dryness at the trunk and sacral/trochanter pressure ulcers (OR 1.11, 95% CI 0.62–2.00). The adjusted intra-cluster correlation was 0.022.

Results of the logistic regression for the heel pressure ulcers are shown in Table 4b. In this model, the strongest and statistically significant predictors were mobility (mainly dependent vs. completely independent OR 16.5, 95% CI 1.3–206.2) and type of institution (OR 3.3, 95% CI 1.5–7.7). The OR for having a heel pressure ulcer category 2–4 + DTI was 1.9 (95% CI 0.8–4.1) when having dry skin, but this association was not statistically significant (p = 0.133).

Results including category 1–4 and DTI are shown in the Online appendices. The prevalence of dry skin was higher for subjects having a sacral/trochanter pressure ulcer (46.2%) compared to subjects without pressure ulcers (24.1%) (Online Appendix C). A similar observation was made for dryness at the distal extremities and heel/ankle pressure

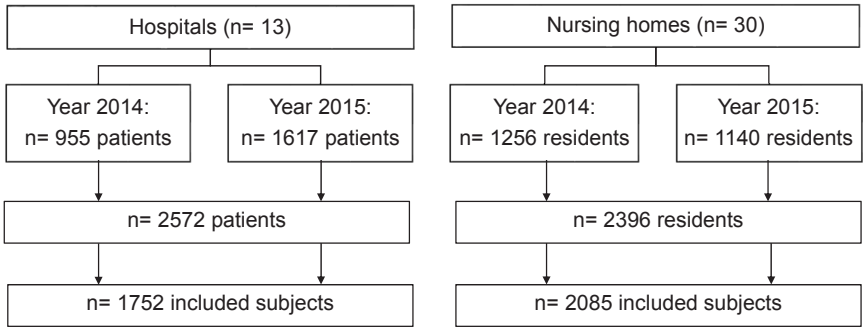

Fig. 1. Flow chart of participating institutions and subjects.

Table 1
Characteristics of participants in nursing homes and hospitals.

	Nursing homes (n = 2085)	Hospitals (n = 1752)	Total (n = 3837)
Age, years [a]			
Mean (SD)	81.4 (12.1)	69.7 (16.5)	76.1 (15.5)
Median (IQR)	84.0 (77–89)	74.0 (60–81)	80.0 (69–87)
Females (n, %) [b]	1418 (68.0)	891 (50.9)	2309 (60.2)
Body mass index, kg/m^2 [c]			
Mean (SD)	26.1 (5.4)	27.1 (5.6)	26.5 (5.5)
Median (IQR)	25.5 (22.5–28.7)	26.3 (23.3–30.1)	25.9 (22.8–29.4)
Underweight BMI < 18.5 kg/m^2 (n, %)	117 (5.6)	51 (2.9)	168 (4.4)
Mobility [d]			
Completely dependent (n, %)	492 (23.6)	149 (8.5)	641 (16.7)
Mainly dependent (n, %)	320 (15.3)	166 (9.5)	486 (12.7)
Partially dependent (n, %)	397 (19.0)	297 (17.0)	694 (18.1)
Mainly independent (n, %)	481 (23.1)	280 (16.0)	761 (19.8)
Completely independent (n, %)	383 (18.4)	850 (48.5)	1233 (32.1)
Pressure ulcer prevalence			
Category 1–4 + DTI (n, %)	71 (3.4)	84 (4.8)	155 (4.0)
Category 2–4 + DTI (n, %)	43 (2.1)	51 (2.9)	94 (2.4)
Category 2–4 + DTI sacrum/trochanter (n, %)	28 (1.3)	31 (1.8)	59 (1.5)
Category 2 to 4 + DTI heel/ankle (n, %)	15 (0.7)	17 (1.0)	32 (0.8)
Dry skin overall (n, %)	955 (45.8)	844 (48.2)	1799 (46.9)
Skin care independency (n, %)[e]	130 (6.2)	1044 (59.6)	1174 (30.6)
Alternating pressure/soft mattress (n, %)	568 (27.2)	179 (10.2)	747 (19.5)
Diabetes mellitus (n, %)	523 (25.1)	395 (22.5)	918 (23.9)
Dementia (n, %)	1062 (50.9)	119 (6.8)	1181 (30.8)
Stroke (n, %)	320 (15.3)	236 (13.5)	556 (14.5)
Oncological diseases (n, %)	158 (7.6)	267 (15.2)	425 (11.1)
Mental diseases (n, %)	509 (24.4)	204 (11.6)	713 (18.6)
Cardiovascular diseases (n, %)	1309 (62.8)	1018 (58.1)	2327 (60.6)
Musculoskeletal diseases (n, %)	976 (46.8)	824 (47.0)	1800 (46.9)
Multi-medication (n, %)	385 (18.5)	433 (24.7)	818 (21.3)

[a] n = 23 missing values.
[b] n = 170 missing values.
[c] n = 100 missing values.
[d] n = 22 missing values.
[e] n = 161 missing values.

Table 2
Comparison of subjects with and without pressure ulcers (category 2 to 4 + DTI).

	No pressure ulcers n = 3743	Pressure ulcers n = 94	*p* value
Mean age, years (SD)	75.9 (15.5)	81.4 (11.3)	< 0.001
Female (n, %)	2247 (60.0)	62 (66.0)	0.246
Body mass index, kg/m^2 mean (SD) [a]	26.6 (5.5)	24.9 (5.5)	0.006
Underweight BMI < 18.5 kg/m^2 (n, %) [a]	161 (4.3)	7 (7.4)	0.128
Mobility [b]			
Completely dependent (n, %)	597 (15.9)	44 (46.8)	< 0.001
Mainly dependent (n, %)	463 (12.4)	23 (24.5)	
Partially dependent (n, %)	679 (18.1)	15 (16.0)	
Mainly independent (n, %)	754 (20.1)	7 (7.4)	
Completely independent (n, %)	1229 (32.8)	4 (4.3)	
Dry skin overall (n, %)	1733 (46.3)	66 (70.2)	< 0.001
Skin care independent (n, %) [c]	1167 (31.2)	7 (7.4)	< 0.001
Alternating pressure/soft mattress (n, %)	697 (18.6)	50 (53.2)	< 0.001
Diabetes mellitus (n, %)	884 (23.6)	34 (36.2)	0.005
Dementia (n, %)	1150 (30.7)	31 (33.0)	0.640
Stroke (n, %)	545 (14.6)	11 (11.7)	0.437
Oncological (n, %)	414 (11.1)	11 (11.7)	0.845
Mental (n, %)	704 (18.8)	9 (9.6)	0.023
Cardiovascular diseases (n, %)	2257 (60.3)	70 (74.5)	0.005
Musculoskeletal diseases (n, %)	1746 (46.6)	54 (57.4)	0.038
Multi-medication (n, %)	797 (21.3)	21 (22.3)	0.807
Hospital (n, %)	1701 (45.4)	51 (54.3)	0.090

[a] n = 4 missing values in pressure ulcers group.
[b] n = 1 missing value in pressure ulcers group.
[c] n = 2 missing values in pressure ulcers group.

ulcers (Online Appendix C).

4. Discussion

4.1. Key results and interpretation

Using data from two German wide prevalence studies, which were performed in 2014 and 2015 by the Department of Nursing Science at the Charité – Universitätsmedizin Berlin (Lahmann et al., 2005), this study aimed to investigate possible associations between dry skin and pressure ulcers. Overall 2.4% of the study population was affected by at least one pressure ulcer category 2–4 and DTI. The bivariate comparisons showed that the prevalence of dry skin was significantly higher in the group affected by pressure ulcers. This association applies to the sacral and trochanteric skin as well as to the heels/ankles. In the multivariable model an association between skin dryness and pressure ulcers at the sacral region could not be shown. At the feet however the probability of having a pressure ulcer when having skin dryness is almost twice as high.

The different results at the sacral and heel areas are probably linked to particular skin and tissue properties. Skin at the heels has a much thicker stratum corneum layer (Cichowitz et al., 2009) compared to the sacrum and its mechanical properties are different. Heel skin is stiffer (Dobos et al., 2015) and dryness further increases the stiffness. Higher stratum corneum hydration is associated with higher pliability of the skin (Baalham et al., 2011; Korponyai et al., 2017). Dry skin, in turn, results in an impaired skin barrier function and leads to a reduction of elastic properties (Proksch and Lachapelle, 2005). These skin properties due to dryness may cause enhanced susceptibility for pressure ulcers development especially at the heels.

Table 3a
Comparison of subjects with and without pressure ulcers at sacrum or trochanter (category 2 to 4 + DTI)

	No pressure ulcers at sacrum or trochanter n = 3778	Pressure ulcers at sacrum or trochanter n = 59	*p* value
Mean age, years (SD)	76.0 (15.5)	81.9 (10.1)	< 0.001
Female (n, %)	2266 (60.0)	43 (72.9)	0.045
Body mass index, kg/m^2 mean (SD) [a]	26.6 (5.5)	24.6 (5.7)	0.009
Underweight BMI < 18.5 kg/m^2 (n, %) [a]	162 (4.3)	6 (10.2)	0.027
Mobility			
Completely dependent (n, %)	609 (16.1)	32 (54.2)	< 0.001
Mainly dependent (n, %)	475 (12.6)	11 (18.6)	
Partially dependent (n, %)	682 (18.1)	12 (20.3)	
Mainly independent (n, %)	758 (20.1)	3 (5.1)	
Completely independent (n, %)	1232 (32.6)	1 (1.7)	
Skin dryness trunk (n, %)	921 (24.4)	23 (39.0)	0.010
Mild (n, %)	591 (15.6)	13 (22.0)	0.521
Moderate (n, %)	209 (5.5)	8 (13.6)	
Severe (n, %)	67 (1.8)	2 (3.4)	
Skin cracks (n, %)	26 (0.7)	0 (0.0)	
Skin care independent (n, %)	1171 (31.0)	3 (5.1)	< 0.001
Alternating pressure/soft mattress (n, %)	713 (18.9)	34 (57.6)	< 0.001
Diabetes mellitus (n, %)	902 (23.9)	16 (27.1)	0.562
Dementia (n, %)	1158 (30.7)	23 (39.0)	0.169
Stroke (n, %)	549 (14.5)	7 (11.9)	0.564
Oncological (n, %)	418 (11.1)	7 (11.9)	0.846
Mental (n, %)	708 (18.7)	5 (8.5)	0.044
Cardiovascular diseases (n, %)	2285 (60.5)	42 (71.2)	0.095
Musculoskeletal diseases (n, %)	1768 (46.8)	32 (54.2)	0.256
Multi-medication (n, %)	808 (21.4)	10 (16.9)	0.409
Hospital (n, %)	1721 (45.6)	31 (52.5)	0.285

[a] n = 2 missing values in pressure ulcers group.

Table 3b
Comparison of subjects with and without pressure ulcers at heel or ankle (category 2 to 4 + DTI)

	No pressure ulcers at heel or ankle n = 3805	Pressure ulcers at heel or ankle n = 32	*p* value
Mean age, years (SD)	76.0 (15.5)	81.8 (11.1)	0.006
Female (n, %)	2291 (60.2)	18 (56.3)	0.649
Body mass index, kg/m^2 mean (SD) [a]	26.5 (5.5)	25.8 (5.8)	0.481
Underweight BMI < 18.5 kg/m^2 (n, %) [a]	167 (4.4)	1 (3.1)	0.758
Mobility [b]			
Completely dependent (n, %)	627 (16.5)	14 (43.8)	< 0.001
Mainly dependent (n, %)	474 (12.5)	12 (37.5)	
Partially dependent (n, %)	692 (18.2)	2 (6.3)	
Mainly independent (n, %)	759 (19.9)	2 (6.3)	
Completely independent (n, %)	1232 (32.4)	1 (3.1)	
Skin dryness feet and legs (n, %)	1630 (42.8)	23 (71.9)	0.001
Mild (n, %)	888 (23.3)	6 (18.8)	0.044
Moderate (n, %)	453 (11.9)	10 (31.3)	
Severe (n, %)	219 (5.8)	5 (15.6)	
Skin cracks (n, %)	58 (1.5)	2 (6.3)	
Skin care independent (n, %) [c]	1172 (30.8)	2 (6.3)	0.003
Alternating pressure/soft mattress (n, %)	730 (19.2)	17 (53.1)	< 0.001
Diabetes mellitus (n, %)	902 (23.7)	16 (50.0)	0.001
Dementia (n, %)	1173 (30.8)	8 (25.0)	0.477
Stroke (n, %)	552 (14.5)	4 (12.5)	0.748
Oncological (n, %)	422 (11.1)	3 (9.4)	0.758
Mental (n, %)	709 (18.6)	4 (12.5)	0.374
Cardiovascular diseases (n, %)	2303 (60.5)	24 (75.0)	0.095
Musculoskeletal diseases (n, %)	1777 (46.7)	23 (71.9)	0.004
Multi-medication (n, %)	808 (21.2)	10 (31.3)	0.168
Hospital (n, %)	1735 (45.6)	17 (53.1)	0.395

[a] n = 2 missing values at pressure ulcers group.
[b] n = 1 missing value at pressure ulcers group.
[c] n = 2 missing values at pressure ulcers group.

Table 4a
Multivariate logistic regression model with random intercept (level: institution) showing the association between subject characteristics and pressure ulcers at sacrum or trochanter (category 2 to 4 + DTI, n = 59)

Independent variables	OR	CI (95%)	*p* value
Mean age	1.00	0.98–1.03	0.701
Female (0 = no, 1 = yes)	1.68	0.87–3.23	0.121
Underweight BMI < 18.5 kg/m^2 (0 = no, 1 = yes)	1.56	0.61–3.97	0.354
Mobility			
Completely dependent vs. completely independent	27.13	2.98–247.10	0.003
Mainly dependent vs. completely independent	12.47	1.30–119.47	0.029
Partially dependent vs. completely independent	11.87	1.31–107.94	0.028
Mainly independent vs. completely independent	3.90	0.36–42.22	0.263
Skin care independent (0 = no, 1 = yes)	0.34	0.09–1.31	0.117
Skin dryness trunk (0 = no, 1 = yes)	1.11	0.62–2.00	0.722
Alternating pressure/soft mattress (0 = no, 1 = yes)	4.17	2.15–8.07	< 0.001
Mental diseases (0 = no, 1 = yes)	0.42	0.16–1.09	0.074
Type of institution (0 = nursing home, 1 = hospital)	4.54	2.17–9.09	< 0.001

Total n = 3837, missing values n = 431.

Possible differences between sacral and heel pressure ulcer development have been described previously. For instance, prolonged loading of heel skin causes a variety of functional changes which are different to sacral skin (Kottner et al., 2015). Previous research also indicated that a low BMI is associated with sacral, but not with heel pressure ulcer development (Kottner et al., 2011). The results of the current study support this observation: being underweight as defined according to the BMI was associated with sacral/trochanter pressure ulcers, but not with heel pressure ulcers.

Furthermore, a number of additional differences between heel and sacral pressure ulcers have been reported. Diabetes mellitus seems to be a risk factor for developing pressure ulcer at the foot, but not at the

Table 4b
Multivariate logistic regression model showing the association between subject characteristics and pressure ulcers at ankle or heel (category 2 to 4 + DTI, n = 32).

Independent variables	OR	CI (95%)	*p* value
Mean age	1.01	0.98–1.05	0.444
Mobility			
Completely dependent vs. completely independent	16.01	1.36–188.45	0.027
Mainly dependent vs. completely independent	16.48	1.32–206.20	0.030
Partially dependent vs. completely independent	2.06	0.14–29.74	0.595
Mainly independent vs. completely independent	2.59	0.20–33.97	0.469
Skin care independent (0 = no, 1 = yes)	0.70	0.10–5.13	0.726
Skin dryness feet and legs (0 = no, 1 = yes)	1.85	0.83–4.14	0.133
Alternating pressure/soft mattress (0 = no, 1 = yes)	2.54	1.15–5.61	0.021
Diabetes mellitus (0 = no, 1 = yes)	2.55	1.25–5.21	0.010
Musculoskeletal diseases (0 = no, 1 = yes)	2.49	1.13–5.48	0.023
Type of institution (0 = nursing home, 1 = hospital)	3.33	1.51–7.69	0.003

n = 3837 in total, n = 199 missing values.

sacral areas (Hader et al., 2004). The present study supports this hypothesis. During the course of diabetes, advanced glycation end products accumulate in the collagen of the dermis and are assumed to be responsible for the characteristically increased skin stiffness (Sakai and Tagami, 2015). Further, frequent consequences of hyperglycemia are neuropathy and circulatory disorders at the feet (Sakai and Tagami, 2015). Due to a loss of sensation at the feet, the perception of long enduring pressure and the impulse to change position for pressure relief is reduced (Boulton, 2014). In addition, an impaired blood flow is likely to enhance tissue susceptibility for pressure ulcer development (Sakai and Tagami, 2015). In conclusion, results indicate a rather close association between pressure and diabetic foot ulcers.

The variable “Alternating pressure/soft mattress” shows in both logistic regression models a significant association with pressure ulcers. This must not be interpreted as a risk factor but rather shows the association that patients with pressure ulcers are more likely to be positioned on a special support surface which is supported by guideline recommendations (National Pressure Ulcer Advisory Panel et al., 2014).

Overall, the study findings raise questions about the nature, appropriateness andefficacy of skin care interventions for people with pressure ulcer risk and dry skin. In the current National Pressure Ulcer Advisory Panel et al. (2014) guideline, moisturizing care of dry skin is recommended as preventive measure. However, the strength of evidence supporting the recommendation to moisturize dry skin is low. Randomized controlled trials are needed to investigate whether the regular application of skin moisturization products to areas of the skin which are vulnerable to breaking down reduces the risk of pressure ulcer formation.

4.2. Limitations

This study has some limitations which must be taken into account when interpreting its results. Due to the cross-sectional study design, no statements about causal relationships can be made. A selection and non-response bias cannot be ruled out because of the voluntary participation. The multilevel structure was only taken into account for the sacral/trochanter pressure ulcers.

4.3. Generalizability

The generalizability of the data based on the annual performed cross-sectional prevalence study was evaluated previously by comparing the characteristics of the sample with population characteristics based on the database of the German Federal Statistical Office (http://www.gbe-bund.de). With some limitations, the study samples were considered to be representative for all hospitals within Germany. A definitive exclusion of confounding variables or selection bias was not possible as participation of institutions was voluntary. The results may further be affected by non-response bias, as the patients were requested to give informed consent for study participation. Though the study of Kottner et al. (2009b) tested the data from 2001 to 2007, the results can be adopted to a certain extent to 2014 and 2015, as the respective samples were received by the same method.

In addition, the proportions of females in this study sample were compared to the data of 2015 of the German Federal Statistical Office. The proportion of 64% female nursing home residents and 52% female hospital patients in the general German population are comparable to our study samples with proportions of 68% in nursing homes and 51% in hospitals. The prevalence of skin dryness (46.9%) in the sample was comparable to previous findings of Lichterfeld et al. (48.8%) (2016).

The strongest predictors for pressure ulcer development at sacrum/trochanter and heel/ankle were being completely or mainly dependent regarding mobility, which is in line with the latest pressure ulcer development framework (Coleman et al., 2014).

Furthermore, similar intra-cluster correlation coefficients of 0.02 for the influence of the institutions in the fully adjusted model were reported previously (Wilborn et al., 2010).

4.4. Conclusions

The results of this study indicate that dry skin at the feet may be considered as a possible risk factor for heel pressure ulcer development. Skin dryness maybe less of a factor in the formation of sacral pressure ulcers. Therefore, the variable skin status should be better defined in future studies and pressure ulcer risk models. The results further support differences in pressure ulcer aetiologies between anatomical locations. Whether skin care interventions that moisturize dry skin are helpful for preventing pressure ulcers is unknown. If at all, skin care interventions may help in preventing heel pressure ulcers only.

Conflicts of interest

The authors declare that they have no conflict of interest.

Ethical approval

Medical Association of Berlin (Eth-837-262/00).

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ijnurstu.2017.05.011.

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