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Basic research

Challenges to measure hydration, redness, elasticity and perfusion in the unloaded sacral region of healthy persons after supine position

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Abstract *Aim of the study:* To combine measurement methods of biophysical skin properties in a clinical setting and to measure baseline values in the unloaded sacral region of healthy persons after lying 30 min in supine position.
Methods: Hydration (Corneometer® CM 825), redness (Mexameter® MX 18), elasticity (Cutometer® MPA 580) and perfusion (PeriFlux System 5000) of the skin in the sacral region of 10 healthy participants (median age: 26.9 years) were measured consecutively in the laying position by two trained examiners.
Results: The assessment duration for all four parameters lasted about 15 min. Intraclass correlation coefficients were overall moderate to strong (hydration $r = 0.594$, redness $r = 0.817$, elasticity $r = 0.719$, perfusion $r = 0.591$). Hydration (median 27.7 arbitrary units (AU)) mainly indicated dry skin conditions. Redness (median 158.5 AU) was low. Elasticity (median 0.880 AU) showed similar values as in the neck region. Perfusion (median 17.1 AU) showed values in the range of results reported in the literature.
Conclusion: Biophysical skin properties in the sacral region after supine position can be measured within periods of 15 min. The results provide baseline data for the skin of healthy persons as well as insights into skin-physiological variations. But it remains challenging to optimize measurement procedures and test protocols when transferring preclinical tests in a clinical application.

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1. Introduction

Elderly people or people with a spinal cord injury (SCI) are at high risk to develop pressure ulcer (PU) especially in the sacral region [1—4]. Beside established risk factors for PU [1,5—7] the special susceptibility for PU in the sacral region arises out of several factors such as the bone prominence, the characteristics of the tissue like reduced density of elastin fibers [8], higher level of perfusion [9] and the regional stress in the sitting and laying position [3,10—15]. Biophysical skin properties (e.g. perfusion, hydration, elasticity) are increasingly examined as predictors for the PU development at different locations such as the sacrum, the neck, the forearm and the cheek in healthy persons [3,16—18]. Based on the literature review we focused on hydration, redness, elasticity and perfusion as important factors to describe biophysical skin properties as predictors for the development of PU.

Abnormal skin hydration, either elevated or diminished, reduces skin resistance [1,19] and increases the risk for infection and PU [17,19—24]. The friction between human skin and textiles increases with epidermal hydration, thereby causing additional shearing stress on the skin surface [16,21,24].

Visual and manual detection of redness is the most important part of the diagnosis and classification of a PU stage 1 (non blanchable redness) [1,25]. The redness index is higher at the location of the ulcers than in the surrounding skin and therefore it is a possible predictor of pressure relief sufficiency [26]. Although redness is known as a sign of an increased perfusion after local ischemia, paleness is observed in the early first phase of local ischemia, e.g. after pressure load [10,27].

Skin elasticity is an important individual, gender and age dependent property [18,20]. Skin elasticity decreases with age and reduces the capacity for adaptation in different stress situations [20,28—30]. Elasticity is altered around a PU compared to unaffected skin [26].

Local ischemia is widely accepted as a primary etiology of PUs and is correlated with reduced perfusion [1,27,31]. Pressure, shear forces, temperature and body position can influence perfusion [11,12,15,32—34]. Reduced perfusion at specific anatomical regions influences the risk for PU [12].

The knowledge about measurement techniques of different biophysical properties in the sacral region in a clinical simulated setting is still limited, so that more data about baseline values of biophysical skin properties at PU prone sites and the applicability of technically advanced measurement devices are needed [3,35,36].

Therefore the aim of this study was to measure the biophysical skin properties in the unloaded sacral region in healthy persons after supine position and to assess the absolute and relative reliability of the measurement methods. In addition, baseline values are presented including the correlation between the different parameters and the influence of gender on skin physiology.

2. Materials and methods

2.1. Participants and setting

A total of 10 healthy Caucasian volunteers as a convenience sample were chosen as participants for this study (Table 1).

2.2. Protocol

Measurements were taken following a standardized procedure: participants were laying for half an hour in supine position in a standard hospital bed with a standard mattress (PUO, Senectovia, Urdorf, Switzerland) and bed sheet (Typ Romanit, 3071, color yellow, 80% cotton, 20% polyester, Pfeiffertextil AG, Schindellegi, Switzerland) in the examination room. The room temperature was kept at 24 °C ± 4 °C. Each participant underwent four consecutive measurements performed alternately by two examiners (A-B-A-B) with half an hour between each measurement.

For the measurements, participants turned from the supine position into the lateral position. To minimize the effects of the circadian rhythm on the biophysical skin properties and skin function, all measurements were carried out in the morning. The sacral region was identified by manual palpation [1]. No cleaning procedures were performed to prevent mechanical or chemical irritation.

Table 1 Subject characteristics (n = 10).

	Median (25 and 75% quartiles)
Age [years]	26.9 (24.0, 42.7)
Sex [m/f]	5/5
Weight [kg]	75.0 (62.3, 88.5)
Height [cm]	174.5 (166.3, 184.3)
BMI [kg/m^2]	24.3 (21.4, 29.8)
Smoker/Non-smoker	1/9