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The physiological response of soft tissue to periodic repositioning as a strategy for pressure ulcer prevention

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ABSTRACT

Background: Individuals who have reduced mobility are at risk of developing pressure ulcers if they are subjected to sustained static postures. To reduce this risk, clinical guidelines advocate healthcare professionals reposition patients regularly. Automated tilting mechanisms have recently been introduced to provide periodic repositioning. This study compared the performance of such a prototype mattress to conventional manual repositioning.

Methods: Ten healthy participants (7 male and 3 female, aged 23–66 years) were recruited to compare the effects of an automated tilting mattress to standard manual repositioning, using the 30° tilt. Measures during the tilting protocols (supine, right and left tilt) included comfort and safety scores, interface pressures, inclinometer angles and transcutaneous gas tensions (sacrum and shoulder). Data from these outcomes were compared between each protocol.

Findings: Results indicated no significant differences for either interface pressures or transcutaneous gas responses between the two protocols ($P > 0.05$ in both cases). Indeed a small proportion of participants (~30%) exhibited changes in transcutaneous oxygen and carbon dioxide values in the shoulder during a right tilt for both protocols. The tilt angles at the sternum and the pelvis were significantly less in the automated tilt compared to the manual tilt (mean difference = 9.4–11.5°, $P < 0.001$). Participants reported similar comfort scores for both protocols, although perceived safety was reduced on the prototype mattress.

Interpretation: Although further studies are required to assess its performance in maintaining tissue viability, an automated tilting mattress offers the ability to periodically reposition vulnerable individuals, with potential economic savings to health services.

1. Introduction

Pressure ulcers (PUs) are localised areas of injury to skin and/or underlying tissues, commonly occurring adjacent to bony prominences, which provide a focal point for the compression of soft tissues (EPUAP-NPUAP, 2009). PUs represent a disabling long term condition that has been recognised as both a Patient Safety and Quality of Care indicator for individuals in both hospital and community settings (Department of Health, 2010). Additionally, PUs negatively impact on patients' rehabilitation and quality of life (Spilsbury et al., 2007). Despite the increased attention within health services, their incidence rate remains unacceptably high with associated treatment costs estimated at £4 billion per annum in the UK (National Patient Safety Agency, 2010) with higher costs associated with the more severe grades of PU (Dealey et al., 2012).

International guidelines for pressure ulcer prevention (European Pressure Ulcer Advisory, 2009; National Institute for Health and Clinical Excellence, 2005) recommend frequent repositioning for individuals at risk. This is achieved in practice by periodically redistributing the pressure to enable relief of previously loaded areas. Individuals with reduced mobility often require clinicians or carers to assist in postural changes, which are maintained with the use of pillows and/or cushions. Although there is limited evidence surrounding the required frequency of repositioning on various support surfaces, guidance suggests changes in position every 2–4 h for individuals with reduced mobility (Vanderwee et al., 2007). This process of manual repositioning is time consuming and labour intensive. Indeed, a recent study estimated frequent repositioning to cost between €200 and €250 per patient over a four week period (Moore et al., 2013).

In order to provide repositioning and reduce the burden on healthcare providers, some manufacturers have introduced tilting mechanism in association with support surfaces. These so-called lateral rotation devices are designed to mimic manual repositioning and have been defined by the NPUAP Support Surface Standards Initiative

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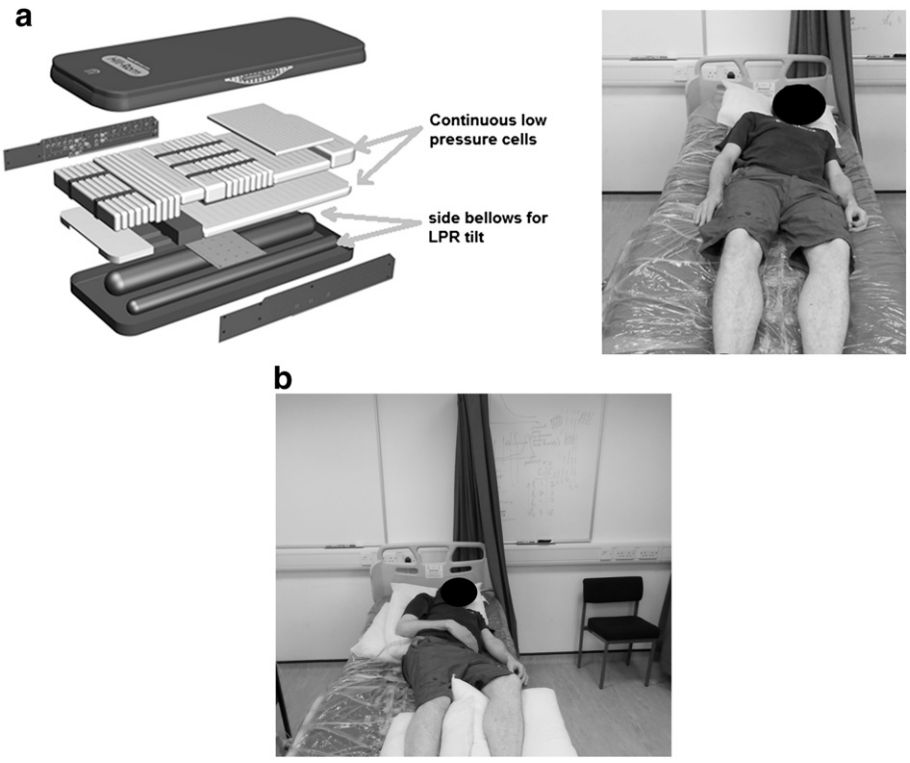

Fig. 1. (a) Schematic of the prototype LPR device with air billows to provide tilt. (b) Example of manual tilt to the left with the individual supported by pillows.

(2007) as "…a support surface that provides rotation about a longitudinal axis as characterized by degree of patient tilt, duration and frequency" (National Pressure Ulcer Advisor Panel, 2007). Despite their intended purpose, evidence regarding the efficacy of lateral rotation devices remains predominantly anecdotal in nature. Of the few published studies, Melland et al. (1999) evaluated the Freedom Bed™ in 24 adults with degenerative disease, residing at home or in a long-term care facility. The authors reported a significant improvement in sleep quality using the tilting bed, although its performance with respect to maintenance of tissue viability was not fully assessed. Yi et al. (2009) investigated the effect of tilting using 3 prototype lateral rotation beds with twenty healthy volunteers using interface pressure as a primary outcome measure. Results indicated a significant reduction in peak interface pressure measures in one bed with two segments rotating about one axis, compared with the supine position.

The performance of support surfaces have been evaluated using several different measurement techniques. One of the most common approaches, adopted in both clinical and research settings, involves measurement of the interface pressure distribution between the surface and a supported individual. However, it is well established that interface pressures alone do not alert the clinician to risk of pressure ulcers and the imprecise relationship between pressure magnitude and duration limits the predictive or prognostic value of the measured parameter (Reenalda et al., 2009). Accordingly, much research has utilised measures of tissue viability, often in the form of transcutaneous gas monitoring, to examine the tissue response to mechanical loads (Chai and Bader, 2013; Kim et al., 2012; Makhsous et al., 2007). These studies have shown distinct changes in tissue oxygen ($TcPO_2$) and carbon dioxide ($TcPCO_2$) tensions when measured at differing skin sites subjected to representative external pressures (Knight et al., 2001). Thus the combination of interface pressures and transcutaneous gas values provides considerable insight into the biomechanical cause and physiological effects of tissue loading as a result of a periodic loading on various support surfaces.

There is only limited evidence in the literature to suggest that lateral rotation might prove an effective alternative to manual repositioning,

Table 1
Summary of the physiological response from the ten healthy participants as defined by the Chai and Bader (2013) criteria (Section 2.4), for each postural phase of both LPR and Manual protocols.

Shoulder											Sacrum									
Participant	LPR					Manual					LPR					Manual				
	Sup.	Left	Sup.	Right	Sup.	Sup.	Left	Sup.	Right	Sup.	Sup.	Left	Sup.	Right	Sup.	Sup.	Left	Sup.	Right	Sup.
1	1	1	1	3	1	1	1	2	3	2	1	2	2	2	2	1	1	1	1	1
2	2	2	2	3	2	2	1	3	1	3	1	1	1	1	1	2	2	2	2	2
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	3	2	2	1	1	3	2	2	1	2	2	3	2	1	1	1	1	1
5	1	2	1	3	1	1	1	1	3	2	1	3	2	3	2	1	2	1	2	2
6	1	1	1	1	1	1	1	1	2	3	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	2	1	1	1	1	2	3	1	1	1	1	1	1	1	1	1	1
10	1	1	2	2	1	1	1	2	2	2	1	1	1	1	1	1	1	1	1	1