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Research paper

The influence of foot posture, support stiffness, heel pad loading and tissue mechanical properties on biomechanical factors associated with a risk of heel ulceration

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ABSTRACT

Heel ulcers (HU) are the second most common type of pressure ulcers. In this work, we developed the first anatomically-realistic three-dimensional finite element model of the posterior heel for studying the risk for HU in bedridden patients. We specifically simulated a heel that is resting on supports with different stiffnesses at upright and inclined foot postures. Our objective was to examine the effects of foot posture and stiffness of the support on strains and stresses within the fat pad of the resting heel. We found that strains and stresses in the fat pad of the heel are considerably reduced when the foot is positioned so that its lateral aspect is at 90° with respect to the horizon compared to an abducted (60°) foot posture. The study therefore indicates that theoretically, an inclined foot posture puts a bedridden patient at a higher risk for HU with respect to an upright foot posture, which may be explained by the anatomy of the heel that faces a lower curvature and better cushioned region against the support when the foot is upright.

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1. Introduction

Heel ulcers (HU) are the most common pressure ulcers (PU) acquired in care facilities, as well as the second most common type of PU overall, accounting for one-quarter up to one-third of the PU occurring in care facilities in western countries (Amlung et al., 2001; Cheneworth et al., 1994; Fowler et al., 2008; Salcido, 2006; VanGilder et al., 2010, 2008; Whittington and Briones, 2004). Similar to other types of PU, HU are associated with sustained mechanical loads in soft

tissues (Agam and Gefen, 2007; Black, 2005; National Pressure Ulcer Advisory Panel, 2007). The clinical appearance of HU is either as an open wound at the posterior heel region which was in contact with a mattress or other support, or as tissue damage under intact skin, i.e. a deep tissue injury (DTI) (Campbell et al., 2010; VanGilder et al., 2010). The latter type of injury is often being described by clinicians as a “purple heel” due to the colour of the necrotic subcutaneous tissue mass under the intact skin of the posterior heel (Salcido, 2006). In both cases, HU are characterized by necrosis of skin and/or

Abbreviations: Deep tissue injury, DTI; Finite element, FE; Heel ulcers, HU; Pressure ulcer, PU; Strain energy density, SED; Three-dimensional, 3D.

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