Journal of Tissue Viability (2015) **24**, 91–101

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JOURNALOF tissueviability

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Basic research

Effects on interface pressure and tissue oxygenation under ischial tuberosities during the application of an alternating cushion

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KEYWORDS
Perfusion;
Dynamic cushion;
Pressure ulcer;
Wheelchair user;
Stimulation

Abstract Pressure ulcers are hazardous to people with diminished sensory and motor functions who remain in the same position for a long time. An important reason for the occurrence of pressure ulcers is the inability of wheelchair users to make postural changes by themselves with no appropriate method of pressure release. In this study, we researched the effects of applying an air cell inflate-deflate alternating sequence cushion prototype to relieve pressure from tissue loaded areas. Moreover, the hypothesis that the alternating sequence could stimulate blood reperfusion in loaded tissues and redistribute interface pressure on support area was also tested. Ten healthy volunteers were recruited to try the prototype cushion for 65 min of continuous loading; 5 min on static mode and 60 min on alternating mode. This study was conducted on healthy people because

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http://dx.doi.org/10.1016/j.jtv.2015.05.002

their sensitivity allowed them to state clearly and in detail, in a feedback questionnaire, any discomfort experienced with the use of our cushion. In order to address our hypothesis, interface pressure, and bilateral ischial oxygenated and deoxygenated hemoglobin were measured. After applying the alternating cushion, the interface pressure was redistributed over a larger contact area. Besides, blood perfusion was improved according to increments in oxygenated hemoglobin and decrements in deoxygenated hemoglobin of ischial regions during loaded condition. Feedback questionnaire showed that the participants did not feel pain or discomfort using the alternating cushion. The overall results showed positive effects on healthy tissue which has encouraged us to design a study involving subjects who use wheelchairs for mobility.

1. Introduction

In a seated position, much of the human body weight is concentrated on the ischial tuberosities [1]. Although the buttocks can support this kind of load, the tuberosities with their small circumferences create significant peak pressures hence generating compressed soft tissues. Healthy people commonly reposition their posture whenever they feel pain or discomfort due to pressure, whereas people with limited sensory and motor functions who remain seated for a long time are at risk of having sustained and prolonged pressure on their buttock areas. This condition may diminish the blood flow and cause that toxic metabolites accumulate locally, increasing the risk of tissue death. This could induce necrosis of skin and underlying tissues as well as pressure ulcer development [2].

Pressure ulcers (PUs), also called pressure sores, are defined as localized tissue breakdown in the skin and adjacent tissue caused by high and prolonged pressure and mechanical forces over the bony prominences [3,4]. These external forces may reduce or interrupt the flow of blood within the skin, thus affecting not only the transport of nutrients into the cells but also causing ischemia associated with a decrease in tissue oxygenation which could eventually lead to tissue necrosis [5—7]. Pressure ulcers are hazardous to subjects, particularly those who have additional risk factors related to poor health [8]. In this sense, small injuries have large implications in the quality of life of disabled people; therefore, preventing PUs is highly desired.

Several static support surfaces have been developed in order to alleviate pressure beneath ischial tuberosities [1,9]. This has led to the design of a wide variety of wheelchair cushions which are available commercially. Some of them are composed of viscoelastic materials such as foam, gels, air, or a combination of all of them. Despite this diversity of supporting surfaces, pressure ulcers still remain as a challenging issue to wheelchair users and cushion designers.

Another strategy recommended for relieving pressure and prevent pressure ulcers includes activities such as push-up, recline and wheelchair tilt-in-space. Studies have proven the effectiveness of these activities in some people and suggest that these procedures should be adequately performed in order to promote blood reperfusion in the affected areas [7,10]. In cases of inability of wheelchair users to make postural changes by themselves, tissue perfusion is still a relevant reason for the occurrence of pressure ulcers; therefore alternative methods are required to relieve pressure and promote tissue perfusion.

Since both time and pressure are important factors involved in pressure ulcer development [11,12], some works that focus their operation on alternating supports in order to release pressure have recently appeared [13]. It has been suggested that relieving pressure at frequent intervals could allow reperfusion in tissues [14]. As a result, a variety of dynamic cushions has been proposed [5,15]; however, consensus about the optimal configuration and movement patterns of a dynamic cushion to prevent pressure ulcers is still being discussed. Therefore, determining the optimal alternating pattern of inflation and deflation of a cushion in order to maximize tissue health is a necessary area of study.

Consequently, the purpose of this study was to evaluate an air inflate-deflate alternating sequence developed for an air-cell cushion prototype by monitoring the effects in tissue oxygenation and pressure distribution on the supporting area of healthy volunteers during 65 min of continuous load; 5 min on static mode and 60 min