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Title
Effect of elevated vacuum pressure during inactivity on residual limb circulation

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Summary
Theory suggests elevated vacuum suspension draws fluuid into the limb. Here we test this theory by measuring changes in skin tissue oxygenation during rest under elevated vacuum pressure.

Introduction
Elevated vacuum suspension has been shown to heal wounds while continuing to wear a prosthesis, a significant advantage over other forms of suspension. Several theories exist as to why this occurs but there is little empirical evidence to show the mechanism that leads to the healing of wounds. One study found that elevated vacuum suspension provided improvements in epidermal barrier function and tissue oxygenation after long-term use. The authors proposed that elevated vacuum suspension created a more stable environment allowing the limb to adapt. Others have hypothesized that the negative pressure generated by the vacuum pumps directly improves circulation in the residual limb. One could hypothesize that if the latter mechanism were correct then there should be measurable changes in tissue oxygenation as the atmospheric environment changes while the user is not ambulating. The purpose here is to investigate the influence of negative pressure on tissue oxygenation during rest.

Methods
This pilot study included two transfemoral amputees who regularly use an elevated vacuum suspended prosthesis. Two tissue oxygenation sensors (ForeSight, Casmed) were placed on the anterior and posterior aspects of the residual limb immediately distal to the seal on the limb. With the sensors adhered to their residual limb and an acclimation period complete, subjects donned their liner and tissue oxygenation data was collected for 5 minutes. After the 5 minute collection period, subjects donned their prosthesis, performing a few steps in place to ensure

the prosthesis was fully donned. With the system sealed but the LimbLogic vacuum pump turned off, the subjects returned to a seated position with their legs extended straight in front of them. Another 5 minute data collection was performed under these conditions. The 5 minute collection period was repeated with the vacuum setting in the following order: 7inHg, 14 inHg, 20 inHg, 14 inHg, 7 inHg, 0 inHg,socket doffed with liner on.

Results

Percent oxygen saturation did not indicate differences between the different environmental conditions. A relatively flat profile presented for both subjects. The data here suggests that likelihood of negative pressure directly impacting residual limb skin tissue oxygenation is low. Changes in tissue oxygen saturation appeared to be more flat and any changes random as opposed to correlated with the changes in environmental conditions. Several limitations impact the generalizability of the results. The etiology of amputation for the subjects were traumatic and cancer respectively. Second, the 5 minute period may have been too short to witness any changes in tissue oxygenation. Third, the light based modality of oxygenation measurement limits detection to the skin surface, so it is possible deeper effects were occurring and not translating to the skin surface during the 5 minute period.

Conclusion

These results support the theory of Rink et al, where the authors proposed the reduction and control of socket movement as the key mechanism leading to improved health outcomes. This study could set the stage for improvements to the reimbursement value for elevated vacuum suspension. The value of vacuum suspension could include volume management as well as movement control which has shown to directly affect limb health in related studies by the authors.

References

1. Rink C, et al. JRRD. 2016; 53 (6): 1121-1132.

Image: Oxy Sat_2637.jpg