Socket Motion Stabilization Using the LimbLogic Elevated Vacuum System

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Background

Individuals with lower limb loss (N=92) identified prosthesis fit as their primary concern[1], yet there are still high levels of dissatisfaction with comfort[2,3]. More concerning is the high prevalence of skin sores or irritation occurring within the socket, with fit being a contributing factor[4,5]. Ulcers are the most common skin problem clinically presented[6], with the incidence of chronic or chronic-recurrent ulcers as high as 50 percent in people with traumatic lower-limb amputation[7]. The standard of care for ulcers on residual limbs typically requires disuse of the prosthesis, which negatively affects rehabilitation efforts and quality of life for people with amputation. In extreme cases, chronic ulcers in people with amputation necessitate surgical revision of the residual limb[8,9]. Ulcers typically develop from a mechanical mechanism, suggesting changes in residual limb movement and pressure applied to the limb within the prosthetic socket will have a major impact on skin injury. Here we study how elevated vacuum suspension impacts socket movement.

Methods

Twenty lower extremity amputees (10 transtibial and 10 transfemoral) participated in the study. A well fit socket was made for each subject. Once this shape was finalized, two additional sockets were made by modifying this shape in the OMEGA® system. One was a loose socket where the volume was expanded by 1.5% globally and the other was a tight socket where the volume was reduced by 1.5% globally. Subjects were instrumented with an inductive sensor with sensing units. Subjects completed a series of walking tasks with each socket and with different settings of the LimbLogic® Vacuum System.

Figure 1: Inductive targets were placed on the outside of the gel liner and inductive sensors placed on the outside of the socket and tracked the position of the limb inside each socket.

Results

Socket fit and elevated vacuum suspension (EVS) impacted the amount of movement occurring within the socket. Interestingly, a tight fitting socket resulted in the most movement while the normal fit socket resulting in the least movement. The results also highlight the value of elevated vacuum suspension for reducing forces on the residual limb. Figure 1 shows total movement over 10 consecutive steps. For a well fit suction suspended socket (0 inHg), there was approximately 55 mm of motion over 10 steps. If we want a prosthesis user to walk the daily recommended 10,000 steps a day, they would experience 55 meters of motion inside the socket, thereby exposing them to mechanical stress that could lead to a wound. Alternatively, the motion associated with 20 inHg of EVS would equate to 5 meters of motion inside the socket over 10,000 steps. This shows how EVS can significantly reduce the exposure to mechanical stress that could result in skin tissue injury.

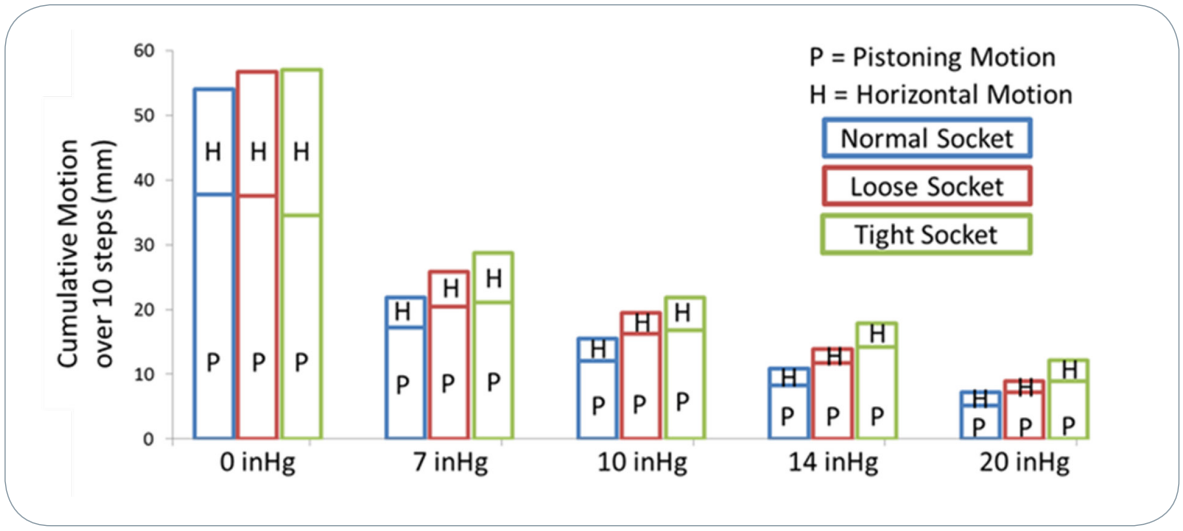

Figure 2: Relationship of socket fit to cumulative movement of the residual limb over 10 consecutive steps inside an elevated vacuum suspended socket ('P' = vertical pistoning, 'H' = horizontal movement, as determined by the inductive sensors). The results illustrate the importance of proper socket fit and suspension to reduce movement, and therefore harmful forces on the limb.

Conclusion

Here we show achieving an appropriate socket fit and suspension is critical for reducing mechanical stress that can injure a patient. EVS provided by the LimbLogic Vacuum System was able to significantly reduced movement with each increase in vacuum pressure setting. This supports the theory that EVS improves limb health by creating a more stable socket environment[10].

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