MAINTAINING LIMB VOLUME: EFFECTS OF DOFFING BETWEEN PERIODS OF ACTIVITY

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INTRODUCTION

Maintaining residual limb volume over the course of the day can be a challenge for people with limb loss. An increase or decrease in volume may change prosthetic fit, influencing comfort, stability, and activity. Though periodic doffing is suggested clinically to patients as a means to counter volume change, it is unknown if residual limbs return back to their pre-doff volumes once the prosthesis is donned and activity resumed. The purpose of this research was to evaluate the effect of a doffing period in between periods of activity on limb fluid volume.

METHOD

Subjects: Eight subjects with trans-tibial amputation (6 male, 2 female) were tested. Subjects averaged 55.4 years of age and 91.8 kg in mass. Mean time since amputation was 15.0 years. Five subjects had comorbidities, and three did not.

Instrumentation: A custom bioimpedance analyzer was used to monitor residual limb fluid volume during 90-min test sessions. Electrical current (~350μA) was injected through surface electrodes on the thigh and the distal residual limb. Voltage sensing electrode pairs sensed from two anterior regions (proximal; whole segment), and two posterior regions (proximal; whole segment). Data were sampled at a 25 Hz rate and stored to a PC.

Procedures: After mounting the electrodes, we asked subjects to conduct a series of test cycles, with each cycle including: 90s sitting, 90s standing, and 5 min walking on a treadmill at their self-selected walking speed. After the 3rd cycle, subjects sat quietly in a chair with their prosthesis doffed for 30 min. Subjects then donned their prosthesis and conducted three more cycles of sitting, standing, and walking.

Data Analysis: Bioimpedance was calculated from the current and voltage signals. Bioimpedance change was proportional to fluid volume change, thus we expressed all results in percent fluid volume change relative to that measured at the end of the first walk cycle.

RESULTS

Typically, regions that experienced fluid volume losses during the first three cycles within a session also experienced fluid volume losses during the last three cycles within a session. During a set of three cycles, five subjects demonstrated fluid volume decreases in three of the four regions tested (termed here Group A subjects) while three subjects underwent fluid volume increases in three of the four regions tested (termed here Group B). Previous efforts suggest a relationship between direction of change and subject health[1].

All regions for all subjects experienced fluid volume increases during the 30-min doffing period.

Compared with right after the 3rd walk cycle, fluid volumes after the 6th walk cycle averaged 1.8% higher for Group A subjects and 0.3% lower for Group B subjects. Thus Group A subject residual limb fluid volumes did not return back to their pre-doff volumes after donning and walking but instead remained elevated. The 30-min doffing period thus had a long-lasting effect on increasing residual limb fluid volume. For Group B subjects, the 30-min doffing period tended to counteract their tendency to swell over time while wearing their prosthesis.

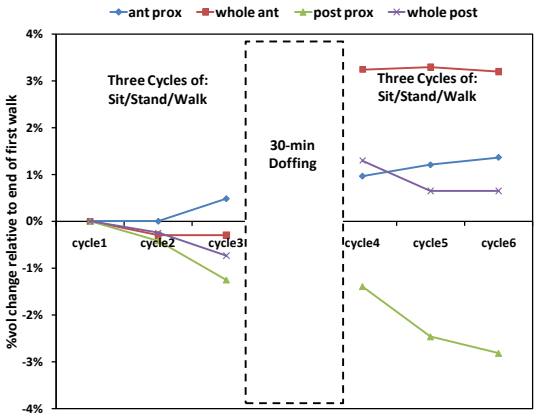

Figure 1. Example results. Fluid volume changes right after each walk cycle relative to the first cycle are plotted.

DISCUSSION

A 30-min doffing period in between periods of activity had a long-lasting impact on maintaining limb volume. Data supports clinical intuition that periodic doffing helps to reduce diurnal volume change. To establish how much resting contributed and how much doffing contributed to these trends, studies with the prosthesis donned during the 30-min rest period will be conducted and results compared with those from the present investigation.

The results have application to emerging technologies to manage residual limb fluid volume change. Potentially a person's physiologic volume recovery capabilities can be facilitated by enlarging the socket upon sitting after physical exertion, and then reducing it during activity to enhance suspension.

CONCLUSION

Thirty min doffing periods had a long-lasting effect upon maintaining residual limb fluid volume in 8 test subjects.

REFERENCES

[1] Sanders *et al.* J Rehab Res Dev. 2011; 48(9): in press.

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