SENSITIVITY OF AN INVERSE-PROBLEM SOCKET PRESSURE MEASUREMENT SYSTEM TO CHANGES IN APPLIED FORCES FROM STANDING

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BACKGROUND

Measurement of relative pressure distribution in prosthetic sockets using an inverse problem solution has seen promising results in preliminary testing [1, 2]. Such a system has the potential for significant advantages over existing methods, including avoiding interference at the interface, providing complete coverage of the socket and not requiring detailed knowledge of the limb/socket properties [3]. However, a system that is intended for clinical use must be sensitive to measured changes in applied force, and this is the subject of this report.

AIM

The aim of this study was to assess the ability of an inverse-problem solver in measuring the magnitude of differences in total applied pressure through a transtibial amputee's socket during the application of different proportions of body weight.

METHOD

The TSB socket of a traumatic transtibial amputee (M, age 53, amputee for 24 years) was instrumented with 11 strain gauges on the external surface. These strains were recorded using 3 LXRS devices (Lord Microstrain) and transmitted wirelessly to the host PC. The relationship between these the changes in these strain values and the sum of internal pressures in 8 positions was estimated using an ensemble of 100 neural networks. Data collection was performed using custom LabView (National Instruments) software, and neural networks of a feedforward-backpropagation design were implemented with the MATLAB (Mathworks) neural network toolbox.

The participant was asked to stand with their prosthesis side on a force platform, and to stand while applying ~25%/50%/75% of bodyweight through the prosthesis side. The proportional change in applied load was compared to that recorded by the force platform, taken as an average over two seconds of stable standing.

Ethical approval study was granted by the University Ethics Committee.

RESULTS

The participant's comfortable standing placed 49% of total bodyweight through the prosthetic side. Heavy standing increased this to 81%, and light standing reduced this to 20%. Estimates from the artificial neural network mirrored this pattern: the sum of estimates from the 8 sites measured increased for heavy weight-bearing and reduced for light weight-bearing (Table 1).

Condition	Force Plate	Pressure Measurement
Heavy Standing	167%	138%
Balanced Standing	100%	100%
Light Standing	42%	60%

Table 1 - Changes in measured and estimated total applied force in response to different measurement conditions, expressed as a percentage of the 'balanced' standing condition.

DISCUSSION & CONCLUSION

The system correctly evaluated the change in overall applied pressure magnitude. The exact changes in pressure magnitude did not reflect the changes in total applied force – this may be because the measurements did not completely cover the socket interface, that there was a significant component of force applied as shear rather than as normal stress or it may reflect a residual systemic inaccuracy in the neural network estimation.

The fact that light standing was overestimated and heavy load underestimated may point to a previously reported bias in the ANN method which can be substantially corrected using a polynomial correction factor [4]. Through developing and refining the parameters used in the construction and validation of the neural networks, the reliability may be improved further, as will increased understanding of the changes in pressure measurement in different circumstances.

REFERENCES

[1] Davenport et al, (2015) *ISPO World Congress, Lyon*
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