



# Development of Metrics for Quantitative Evaluation of Socket Fit

## INTRODUCTION

A quality socket fit is essential to optimize the performance of the prosthesis and lead to patient acceptance of the device. Currently, patient feedback and qualitative prosthetist assessment are often the sole methods used to compare socket fit and performance. New socket designs are regularly being developed, but comparing these new approaches to more standard designs is difficult. Therefore, as part of a larger study that focused on the development of a volume adjustable socket, LTI endeavored to develop quantitative metrics to differentiate between good-fitting and poor-fitting sockets.

## METHODS

*Subjects:* 9 subjects with transfemoral amputation participated in the study.

*Research Tools:* Three tests were developed to compare three different socket fit conditions. These are referred to as the 1) resisted pursuit tracking (RPT) test, 2) balance pursuit tracking (BPT) test and 3) wobble test. The RPT (Figure 1) requires the user to control a cursor by moving their residual limb to track a moving target. Resistance to this movement is created by restricting air flow through pneumatic cylinders. The BPT requires the user to shift their center of pressure to move a cursor to track a moving target. The wobble test is a modified postural sway test in which the users are required to bear a majority of their weight on the prosthesis while standing with the prosthetic leg on a hemispherical balance board. The concept behind each test was that a better coupling between the residual limb and the socket would lead to better performance on the test.

*Procedures:* Three socket conditions were tested for each subject: 1) their everyday socket, 2) a volume adjustable socket that was purposely oversized (since limb volume couldn't be reliably controlled the socket was oversized to simulate limb volume loss and a poor socket fit), and 3) the adjustable socket tightened by the user to a level that was deemed most comfortable by the user.

*Data Analysis:* The output of the RPT and BPT tests were the tracking error between the target and the user controlled cursor. Various postural sway metrics were calculated for the wobble test (Collins, 1995). A quadratic mixed effects model was created to determine the relationship between socket volume and scores on each of the tests.

## RESULTS

All three tests showed better performance with better fitting socket conditions. The mixed effects model of the resisted pursuit tracking (RPT) test data showed a statistically significant relationship ( $p < 0.05$ ) between socket volume and the score on the RPT test. While trends were observed, no statistically significant

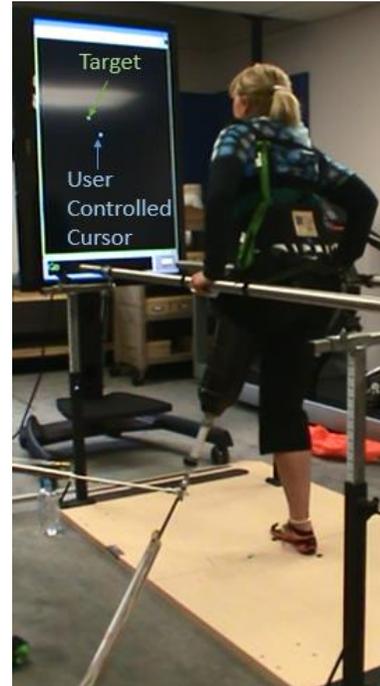


Figure 1 – A photograph of a test subject completing the RPT test.

relationship was observed for the BPT and wobble tests ( $\alpha = 0.05$ ).

## DISCUSSION & CONCLUSION

The resisted pursuit tracking (RPT) test showed the ability to detect a relationship between increasing socket volume (i.e., decreasing quality of socket fit) and the score on the RPT test. This indicates that the RPT gives an objective and quantitative method for comparing sockets with different qualities of fit. The work presented here was focused on evaluating volume adjustable sockets. In the future, instead of changing socket volume, we intend to compare different socket designs including sub-ischial, elevated vacuum, 'Hi-Fi', osseointegration, etc. as well as test below-knee amputees. This will allow us to perform an objective evaluation of these socket designs to quantify how well they couple the prosthesis to the residual limb. In addition, it was clear that subject engagement had a substantial effect on the RPTs ability to differentiate between different socket volumes. Alterations to the test to mitigate this effect will be incorporated.

## REFERENCES

Collins and De Luca, Exp Brain Res 103: 151-63, 1995.

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