# PROOF OF CONCEPT TESTING FOR AN INERTIA-BASED PROSTHETIC TAIL

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## INTRODUCTION

Maintaining balance is essential for mobility and preventing fall-related injuries while walking. In the US alone, more than one in four adults over the age of 65 falls each year (Bergen 2016). The risk increases in users of O&P devices, regardless of age, with 52.4% of lower extremity amputees reporting to have fallen in the previous year (Miller 2001). To reduce the risk of falling, improve mobility, and maintain balance while walking, 81% of surveyed prosthesis users employ assistive technology (canes, walkers, wheelchairs, etc.) in conjunction with their prosthesis (Amputee Coalition, 2015).

An unconventional alternative approach to enhancing balance has been proposed in the form of a prosthetic tail, inspired by examples from the animal kingdom. Squirrels or cats use their tails to generate forces that counter perturbations while balancing on narrow structures. These forces result of muscle-powered movement against the tail, whose inertial mass offers the needed resistance to maintain stability. Thus, the conceptual viability of a tail-like device to enhance human balance was investigated. Initial findings and effects on human balance are presented here.

## METHOD

Our experimental "tail" was designed by modifying a 20 W battery-powered right-angle drill. The trigger mechanism was removed such that the drill could be activated away from the wearer. The drill was attached to the lower back of subjects via a body shell component similar to a trunk orthosis (Figure 1).

Subjects were healthy adults without balance impairments, recruited among the research team. For the four tests (2 each at baseline and intervention), subjects wore the tail and were asked to stand still for 10 seconds. In the intervention condition, the tail device was activated for a short (<1 s) burst of rotation at a random point during the test period.

**Figure 1: Experimental setup of inertia-based prosthetic tail**

A "composite balance score" (CBS) generated by a wearable inertial measurement unit (Biomech Inc, Midlothian, VA) was obtained (Figure 2). A one-tailed (no pun intended) paired t-test was conducted in Microsoft Excel to test the hypothesis that tail motion significantly disturbed balance ($\alpha$=0.05).

## RESULTS

The participants were 4 males (35 years, 173 cm, 72 kg on average). The difference in CBS for the baseline (1.66) and intervention (4.69) conditions was statistically significant ($p < 0.001$), as seen in Figure 3.

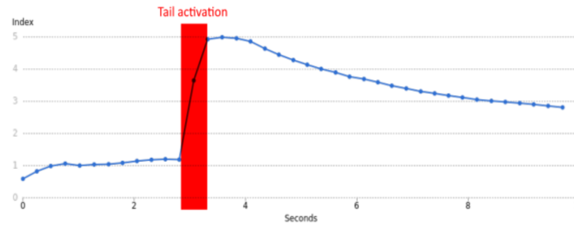


**Figure 2: Illustrative example of CBS change after tail activation**

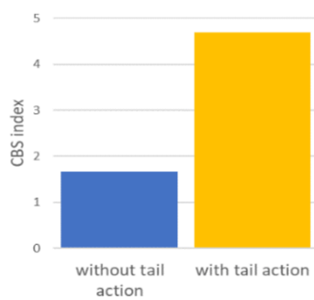


**Figure 3: Mean balance scores across the sample.**

## DISCUSSION

The collected data on the CBS values support the hypothesis that the tail device affects the balance of healthy adults by producing a significant disruption in balance. These initial findings should lead to further work on exploring the potential of prosthetic tail devices in (positively) influencing balance in humans. Limitations to the device design (such as size, weight, and power of the tail) as well as to the study design (sample size, inclusion criteria, standardization of interventions) are likely addressable in subsequent studies.

## CLINICAL APPLICATIONS

As our prosthetic tail device successfully disrupts the balance in healthy adults, it can be argued that its function principle could be inversely applied to a device that improves balance in people with physical impairments. Such a tail device could help new O&P device users regain mobility without external assistive technology or as a temporary rehabilitative device during reconvalescence.

## ACKNOWLEDGMENT

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## REFERENCES

Bergen et al, *MMWR Morb Mortal Wkly Rep* 2016; 65: 993–8.
Miller et al. *Arch Phys Med Rehabil* 2001; 82: 1031-7.
People with Amputation Speak Out. *Amputee Coalition of America*. 2014; 11.

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