DEVELOPING A GAIT EVENT DETECTION FRAMEWORK FOR IMPLEMENTATION INTO A REAL TIME FEEDBACK SYSTEM BASED ON DATA FROM A PROSTHESIS INTEGRATED LOAD CELL.

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INTRODUCTION

Gait dysfunction is an impairment that can effect multiple patient populations (Prince,et al 1997; Perry and Burnfield, 1992), including those with limb loss, and become chronic and linger for years. It has been frequently reported that gait retraining with augmented sensory feedback improves dysfunctional lower extremity impairments and related gait patterns including those of amputees (Dingwell, et al, 1996). However, these previous studies have been criticized for the expense and tightly controlled laboratory conditions, which made translating findings to realistic clinical environments limited.

Overall goal of our research is to design a system to provide real time mobile visual feedback (RTMVF) to lower limb amputees for gait training. Feedback variables should be detectable by a prosthesis-integrated sensor and be meaningful for the user. Low latency in calculating feedback variables was another objective. We report on the development of mathematical algorithms to accurately detect gait events from a prosthesis-integrated sensor providing kinetic data only. The algorithms and mathematic models are an important first step in the process of integrating both hardware and programmatic components into a RTMVF system.

METHOD

The current prototype consists of load cell (ipecs, RCT Electronics, Dexter, MI), a laptop computer, and smart glasses (M100, Vuzix, West Henrietta, NY), connected by cables and WiFi. Initial algorithms based on raw sensor data from one subject with gait deviations unknown, determined what could be calculated given raw output. Detecting step cycles entailed sensing slopes at the approximate mean of Fz (the sensor's equivalent to vertical ground reaction force) and a lower 10N threshold crossing. Proximal and distal forces and moments of interest were extracted as possible feedback variables as well.

RESULTS

It was found that all variables of interest could be determined from the data, such as; the Peak proximal and distal moments, Peak Fz, Peak My, and range and Peak of Mz. Loading and toe off peaks were found efficiently, however refinement was needed as it was found that oscillations during swing phase were counted erroneously. For Prototype V.0 (Figure 1) a single threshold was implemented, for feasibility and latency testing. The delay is less than 1sec, however algorithms needed to be refined by the addition of several criterion including a double threshold for sufficient accuracy in detecting actual gait events.

Figure 1. Prototype of Feedback Device: Real Time kinetic feedback as relayed from sensor regarding percent stance.

DISCUSSION

The prototype allowed the evaluation of several potential feedback variables. Finding peak to peak values was insufficiently accurate (>5%) and required non-automated method to improve. Conversely, % stance suggests itself as easily calculated in real time and providing potentially meaningful information. Further testing is needed to assess the value of additional variables and to determine the appropriate target window for feedback purposes

CONCLUSION

Our findings suggest that generating and conveying RTMVF on gait variables is possible using our approach.

CLINICAL APPLICATIONS

The potential is to utilize the positive current findings regarding real-time visual feedback, to mobilize this type of training over ground, outside of the clinic, or even at home.

REFERENCES

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