INTRODUCTION

The ideal prosthetic would detect the patient’s motion intent to match both intensity and type of locomotion task similar to the healthy ankle. Implementation of motor intent detection should help restore normal limb function for lower limb amputees. Previous work established the potential for mode classification in transfemoral amputees [1]. The purpose of the current study was to evaluate the potential for walking mode classification from electromyography (EMG) for transtibial amputees.

METHODS

This study utilized surface EMG data collected from a sample of transtibial amputees (n=5, all male, age: 28.8 ± 5.4 years, weight: 78.9 ± 15.7 kg, height: 174 ± 4.3 cm) and non amputee subjects (n=5, 4 male/1 female, age: 39.2 ± 16.0 years, weight: 78.0 ± 5.1 kg, height: 173 ± 3.0 cm). Subjects were excluded if they had neuromuscular disorders. The institutional review board approved the protocol and informed consent was received from each subject prior to testing. Four muscles were selected for EMG: Tibialis Anterior, Medial Gastrocnemius, Biceps Femoris, and Vastus Lateralis. Myoelectric data were sampled at 1500 Hz using in-socket low-profile electrodes in a bipolar single differentiation configuration and band-pass filtered (20-500 Hz) to remove motion artifact and non physiological signal. Footswitches were placed on the heel and ball of each subject’s feet or prosthetic.

Level ground walking trials (7 strides/trial) were collected at three different speeds: self selected (SSW; 5 trials), fast (FTW; 2 trials), and slow (SLW; 2 trials). Stair ascent/descent trials (SUP/SDW; 4-5 strides/trial) and ramp ascent/descent trials (RUP/RDW; 9-10 strides/trial) trials were also completed (6 trials/mode). Heel strike (HS) and toe off (TO) events were identified by initial and final foot contact based on footswitch data. These events were used to define sub-windows of the gait cycle (Figure 1). Features from each sub-window were extracted for classification based on literature definitions [2,3]. The mean absolute value, variance, waveform length, number of zero crossings, and slope sign changes were evaluated. The total number of features was 24 (4 muscles x 6 features) per window.

RESULTS AND DISCUSSION

The classification accuracy of steady state cycles using LDA and SVM was 97.9 % (± 0.22) and 97.9 % (± 1.39) for amputees and 93.3 % (± 2.62) and 94.7 % (± 2.82) for non amputees, respectively. The accuracy of classification between different walking speeds for amputees with LDA and SVM was 91.9 % (± 14.1) and 91.5 % (± 8.43), respectively. LDA and SVM showed similar classification accuracies for both amputee and non amputee subjects. The classification confusion matrix for all amputee subjects using LDA can be seen in Figure 2. Of the 39 misclassifications for all amputee subjects when using LDA, 21 were speed misclassifications, 11 were misclassifications between level ground walking and ramp ascent/descent, and 5 were a misclassification between other modes. The amount of misclassification between different speeds is likely due to the similarity between gait patterns and is less concerning than other misclassifications. Focusing on the 5 major classes (level ground, RUP/RDW, SUP/SDW) results in a classification accuracy of 98.5 % (± 0.3) for amputees.

CONCLUSIONS

In previous lower limb myoelectric classification studies, SVM provided increased classification accuracies over LDA [1]. The current results show equivalent classifier accuracy. When accuracies are similar, LDA is a superior classifier [1]. The current results show equivalent classifier accuracy. When accuracies are similar, LDA is a superior classifier. The ideal prosthetic would detect the patient’s motion intent to match both intensity and type of locomotion task similar to the healthy ankle. Implementation of motor intent detection should help restore normal limb function for lower limb amputees. Previous work established the potential for mode classification in transfemoral amputees [1]. The purpose of the current study was to evaluate the potential for walking mode classification from electromyography (EMG) for transtibial amputees.

REFERENCES


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