Musculoskeletal modeling of human lower limb during normal walking, one-legged forward hopping and side jumping: Comparison of measured EMG and predicted muscle activity patterns

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Abstract

This study focused on comparing muscle activities predicted by the Musculoskeletal Modeling System with EMG from ten healthy subjects who performed normal walking, one-legged forward hopping and side jumping. Eight EMG electrodes measured the activity of eight right leg muscles. Specific thresholds per muscle were applied on the EMG prior comparison. These thresholds were determined by equalizing the duration of EMG to AMS muscle activity. Three graph variables, number of onsets, offsets and hills were used to quantify the level of agreement by using Cohen's kappa analysis. The Pearson correlation coefficient was also calculated as a result comparison.

Overall, visual inspection showed comparable activity patterns. However, when quantifying them some differences became apparent. The mean level of agreement of all tests was <0.20, meaning poor agreement. Pearson correlation showed better agreement compared to kappa analysis. In general, a more prescribed motion like FH and SJ showed a better agreement than NW.

This explorative study shows that there are distinct differences between the model and EMG pattern. Those differences can be attributed to inevitable modeling limitation within the AMS framework like miscalculating the knee net moment, absence of co-contraction, simplified knee joint. Moreover, the delay between EMG and AMS has a clear effect on the comparison and this delay is obviously missing in the model. Despite those differences, this study can serve as a baseline measurement allowing progress in scientific work in order to reduce uncertainties with the aim to generate more reliable and robust musculoskeletal models in a valid manner.

Keyword: *Muscle activity prediction, EMG, Musculoskeletal Model, AnyBody Modeling System, Inverse dynamics analysis*

1. Introduction

Musculoskeletal modeling is a commonly used method to study and understand biomechanical aspects of the human body. It enables simulation of the human body in static and dynamic conditions and provides many practical insights for surgeons and practitioners in the development of new surgical techniques and rehabilitation procedures [Delp et al., 2006; Komistek et al., 2005; Damsgaard et al., 2006]. One of the most advanced modeling systems is the AnyBody Modeling System (AMS). This modeling system is commercially available and enables prediction of muscular forces and activity during movement [Damsgaard et al., 2006]. This modeling tool, especially the Gait Lower Extremity Model (GLEM), has already been studied by many scientists to explore human biomechanics knowledge [Carbone et al., 2015]. However, up to date, only a few studies have validated muscle activities predicted by AMS using EMG during various activity tests.