AI-BASED IDENTIFICATION OF ADULT SPINAL DEFORMITIES BASED ON MUSCLE ACTIVATIONS

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Introduction

Adult Spinal Deformity (ASD) is a three-dimensional condition affecting both skeletal and muscle structures. The impact of ASD on functional capacity has been recognized through increasing research on spinopelvic motion strategies during functional tasks, using marker-based motion capture[1]. Despite the involvement of muscles, ASD research investigating muscle properties is scarce. Few studies reported physiological changes, such as increased fatty infiltration[2] and decreased strength[3] of spinopelvic muscles in static conditions. A recent study showed that muscle activity in ASD increased over time during walking[4]. However, this study lacked a control group. The role of muscles during dynamic conditions thus remains understudied. Also, due to the overload of data in biomechanical research, including kinematics, kinetics and electromyography (EMG), and the associated challenge in discovering patterns, we recently started to explore the use of explainable artificial intelligence (AI) in pattern recognition. The goal of this pilot study was to explore the use of an AI algorithm to classify subjects with ASD from subjects with normal spinal alignment solely based on spinal muscle activation during overground walking.

Methods

In this pilot study, a sample of 43 subjects was included (33 ASD / 10 control). People walked at self-selected speed in our motion lab, during which muscle activity of 8 trunk and lower limb muscles around the pelvis was bilaterally measured using surface EMG. For this pilot study, bilateral muscle activation data of the iliocostal erector spinae was used. Pre-processing of the EMG signals included Butterworth bandpass filtering with cut-off frequencies at 20 and 450 Hz and full-wave rectification followed by lowpass Butterworth filtering with a cut-off frequency of 2.5 Hz. For each subject, the full strides of one step sequence were averaged into one left and one right stride. EMG signals were normalized by dividing by the max value per trial. Lastly, the EMG signal was reduced to 16 data points per side, resulting in 32 features per subject (Fig.1). A classifier was then applied on these 32 features using a supervised machine learning approach based on a random forest implementation trained with a 5-fold cross validation (WEKA v3.9[5]). To explain the classifiers predictions, data was then reduced to two single features (a. baseline muscle activity; b. average left-right difference (Fig.1)), after which the classifier was retrained and reevaluated.

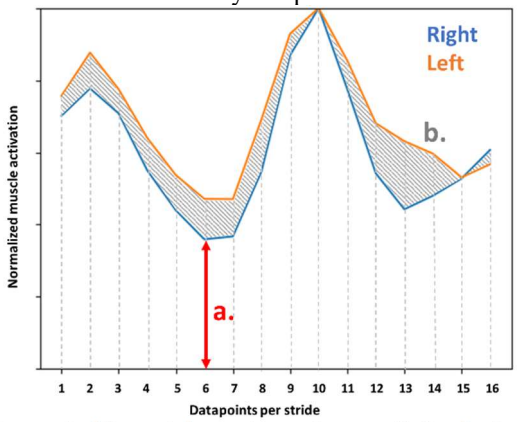

Figure 1: Iliocostal erector spinae activity during one left and right stride represented by 2x16 datapoints; a. baseline muscle activity; b. left-right difference (grey shaded).

Results

Table 1 shows that the model was able to correctly classify 88% (F=0.88) of subjects based on 2x16 datapoints of iliocostal erector spinae activity during walking. Retraining and reevaluation of the model on two single features resulted in 72% correct classification for baseline muscle activity (F=0.72) and average left-right difference (F=0.66), showing these are two relevant biomarkers to discriminate ASD from controls.

Classifier output		Actual	
		Control	ASD
Predicted	Control	9	4
	ASD	1	29

Table 1: Confusion table for the classifier output.

Discussion

This pilot study indicated that an AI algorithm can discriminate deformed from healthy spines with almost 90% accuracy, based on EMG waveforms of one left and right spinal muscle. Secondary analysis showed that higher left-right asymmetry and increased baseline activity can partly explain the difference between ASD and controls. Future studies using AI, on larger datasets and other motor tasks, should further explore which other biomarkers can discriminate between ASD and controls, as well as between different ASD subtypes. Eventually, studying the contribution of muscle parameters during dynamic conditions to deformity progression and investigating the effects of interventions (e.g. fusion surgery or physiotherapy) on these muscle parameters will improve our understanding of ASD and lead to improved evaluation and treatment.

References

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