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Classification of Gait Patterns in Autism Using Kinematic Data

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Extended Abstract

Previous research has demonstrated that children with autism spectrum disorder (ASD) walk with atypical gait patterns compared to neurotypical controls [1-3]. Machine learning (ML) tools allow the combination of biomechanical features for classifying ASD gait patterns to better understand the mechanics of gait and provide optimal treatment plans. The purpose of this study was to investigate the retrospective classification of gait patterns in children with ASD versus neurotypical controls using 3D kinematic data. Gait patterns in children with ASD were compared to controls using linear and radial basis function (RBF) support vector machine (SVM) models based on kinematic features, including temporal-spatial (TS) and joint angle (JA) data. The most contributing features were then determined. Nineteen children (n=19) diagnosed with ASD between the ages of 6-15 years participated in the study (16 males, 3 females; age=10.47±2.91years; height: 1.42±0.15 m; weight: 41.20±17.00 kg) and compared to a neurotypical control group consisting of twenty-one children (n=21) between the ages of 6-16 years (11 males, 10 females, age=11.38±2.91 years; height: 1.49±0.14 m; weight: 44.32±16.36). A 12 camera Vicon T160 motion capture system (Oxford Metrics Group Ltd.), sampling at a 100Hz, was used to track the three-dimensional trajectories of 32 reflective markers placed on the participant's skin as they walked at a self-selected speed. Six force plates (Kistler Instruments, Winterthur, Switzerland) sampling at 1000 Hz were used to aid in the identification of key gait events. The features extracted from the 3D kinematic waveforms included maximum and minimum pelvic, hip, knee and ankle angles at key gait events. TS features included cycle time, step length, walking velocity, single and double limb support time, time to toe-off, cadence, and stride length. These kinematic features, individually and combined, served as input to a SVM classifier with two kernels. ANOVA F-score analysis was used to determine individual feature importance. Results suggested that combinations of kinematic features retrospectively classified autism gait patterns with an accuracy of 97.5%, which was higher than using TS or JA features alone (68.8%, 96.3%, respectively). The RBF kernel models had an overall better performance than the linear models. Additionally, through F-score ranking, we identified that the internal/external rotation range of motion (ROM) of the knee angle (F-score = 12.53, rank = 1) had the highest contribution to the classification of ASD and control gait patterns, followed by internal/external rotation foot ROM, and sagittal hip ROM. These results were similar to past studies that achieved high classification accuracies of 95.8%, by combining kinematic, ground reaction force (GRF), and TS features using a SVM classifier [4], 91.7% using hip, knee, and ankle kinematics using an ANN model [5], and 99.3% using principal component analysis and linear discriminant analysis on 3D joint position data [6]. The present study demonstrated that kinematic features, supported by ML models, can provide an accurate and interpretable classification of autism gait patterns in children. Further research with higher sample sizes is needed to validate the ML model. Additional features from kinetic and EMG data should also be considered for future work. The application of ML models, combined with model interpretability, can facilitate an increased understanding of gait patterns in children with ASD and may lead to optimized treatment programs and improved function and quality of life.

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