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Effects of Walking Speed on the Classification of Gait Patterns in Children with Autism

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Extended Abstract
Previous research has shown that children with autism demonstrate atypical gait patterns [1-2]. To further understand these patterns, there has been a recent increase in the number of studies using machine learning (ML) tools for classification based on combinations of kinematic and kinetic gait features [3-4]. Few studies have examined the influence of walking speed on ML algorithms for gait classification and even fewer studies have utilized explainability tools to further understand the effects of individual gait features on the ML models. This study developed a novel feature ranking method based on Shapley Additive exPlanations (SHAP) values to understand the importance of each feature in classifying the input sample. To test its usability, it was used to investigate the influence of walking speed on ML algorithms for classifying autism gait patterns. Therefore, the aim of this study was to examine the effects of walking speed on the classification of gait patterns in 26 children with ASD (age=9.15±2.68 years) vs neurotypical controls ((age=9.38±2.57 years). A 12-camera Vicon T160 system (Oxford Metrics Group Ltd., UK), sampling at 100 Hz, was used to track 36 retro-reflective markers (9 mm diam.) placed on the tibia and foot landmarks with a modified 5-segment MSF model [5]. Six force plates (Kistler Instruments, Winterthur, Switzerland) sampling at 1000 Hz, were used to measure 3D forces and moments and identify key gait events. While participants walked at their preferred speeds, gait trials were categorised into five speed categories based on percentiles (10, 30, 70, 90) derived from the neurotypical control data. Non-dimensional (ND) temporal-spatial (TS), and joint kinematic and kinetic features served as input to a radial basis function-based Support Vector Machine (SVM) model. A forward sequential feature selection algorithm was utilised to identify eight gait features with the best classification performance (Accuracy = 90.4%). For interpretation of the SVM models, SHAP values were calculated to determine the impact of features on predictions as well as how much each feature contributed to individual predictions within the model. For every prediction, the top contributing feature and their corresponding SHAP values were reported. These top features for each prediction were pooled for each gait trial to provide the global feature ranking. Results suggested that for typical walking speed, ND Speed had the highest contribution to the classification performance (mean SHAP = 0.072). For the very slow and slow category, the most contributing features were shank-foot flex/ext angle at toe-off (mean SHAP = 0.20) and ND speed (mean SHAP = 0.19), respectively. For the very fast and fast category, the most contributing features were calcaneus-metatarsal inversion/eversion angle at toe-off (mean SHAP = 0.10) and ND speed (mean SHAP = 0.28), respectively. ND Speed contributed to the classification in three out of five speed categories, suggesting autism participants tend to deviate from the typical walking speed. This study showed the impact of walking speed on the classification of ASD and neurotypical control gait patterns. Further analyses of gait speed-mediated bias in ML applications are needed to improve transparency and trust in automated gait classification ML tools across diverse clinical populations.

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