Assessing Gait Metrics for Early Parkinson's Disease Prediction: A Preliminary Analysis of Underfit Models

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TITLE: Assessing Gait Metrics for Early Parkinson's Disease Prediction: A Preliminary Analysis of Underfit Models

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BACKGROUND

Parkinson's Disease (PD) is characterized by both motor and non-motor symptoms, and its diagnosis primarily relies on clinical presentation . There is a growing need for diagnostic tools to identify the early signs of PD, particularly the initial motor impairments often manifested as gait abnormalities. Here we seek to present preliminary findings to address this need. Our study focuses on using Machine Learning techniques (ML) to predict the PD clinical stage most efficiently and accurately. Specifically, we have sought to evaluate how spatiotemporal characteristics and other locomotor performance variables obtained on a walkway system can be utilized to identify the Hoehn and Yahr (HY) score in PD.

METHODS

Six individuals with PD and 6 Healthy individuals participated in the study. PD patients were classified on the HY scale by a physician (score range 0-5). Participants completed eight passes on the Zeno Walkway while Protokinetics Movement Analysis Software recorded and calculated the temporal, spatial, and pressure measurements of within-step recordings. Data preprocessing and predictive modeling were analyzed using R and the caret package. Multiple regression, utilizing predictors such as gait speed, left and right steps, and walking methods (socks, shoes, and barefoot), were employed to normalize the data. The data was underfitted using 5% for training and 95% for testing and used three repeated 10-fold cross-validations. Models included Random Forest, Neural Networks, Naive Bayes, Support Vector Machines with Linear Kernel (SVM), and Penalized Multinomial Logistic Regression. Models were compared based on a weighted rank system, prioritizing successful prediction of 6^{th} PD patient, followed by full data partition computational efficiency, model accuracy, interclass balanced accuracy, kappa, and weighted averages of area under the curve (AUC) for HY ratings.

RESULTS

The SVM algorithm demonstrated the best ability to predict HY scores, achieving an overall underfitted model accuracy of 76%, interclass balanced accuracy of 82%, weighted AUC of 55%, Kappa of 62%, and full data partition learning of 2.8 seconds. Multimodal Logistic Regression (MLR) demonstrated the next best performance and achieved an overall underfitted model accuracy of 75% with interclass balanced accuracy of 84%, weighted AUC of 59%, Kappa of 68%, and full data partition learning of 87 seconds. The top predictor outcomes in SVM were Stride Velocity, Stride Length, Step Length, and Single Support Center of Pressure Distance. Moreover, MLR, Neural Networks, and SVM algorithms were successful in predicting the correct HY score (3) of the final recruited PD participant using only a quarter of the requested gait protocol data.

CONCLUSIONS

Our data highlights the need to test the accuracy and efficiency of multiple models to provide real-time learning in clinical populations. Furthermore, the success of the deployed ML algorithms in this study motivates further exploration to identify the economic feasibility of early detection of PD. The Gait mat and programmed software may assist patients in accessing affordable, validated, and reliable clinical assessment for early-stage Parkinson’s Disease.

The University of Texas Rio Grande Valley
Institutional Review Board

October 18, 2023

Kelsey Baker, Principal Investigator
Department: School of Medicine
Via Electronic Routing System

Dear Principal Investigator:

RE: APPROVAL OF MODIFICATION OF ONGOING RESEARCH FOR IRB-23-0259 "ProtoKinetics Zeno Walkway Gait Analysis System Standardization"

Expiration Date: n/a

A modification request for the IRB protocol referenced above has been reviewed and approved. Approval has been granted for the following modification(s):

- Add personnel: Katherine Bolado and Gerardo Medellin

Recruitment and Informed Consent: You must follow the recruitment and consent procedures that were approved.

Modifications to the approved protocol: Modifications to the approved protocol (including recruitment methods, study procedures, survey/interview questions, personnel, consent form, or subject population), must be submitted to the IRB for approval. Changes should not be implemented until approved by the IRB.

Data retention: All research data and signed informed consent documents should be retained for a minimum of 3 years after completion of the study.

Closure of the Study: Please be sure to inform the IRB when you have completed your study, have graduated, and/or have left the university as an employee. A final report should be submitted for completed studies or studies that will be completed by their respective expiration date.

If you have any questions, please contact the Human Subjects Protection Program/IRB by phone at (956) 665-3598 or via email at irb@utrgv.edu.

Sincerely,

Institutional Review Board for the Protection of Human Subjects in Research
Office of Research Compliance/cr

The University of Texas Rio Grande Valley
Institutional Review Board

October 3, 2023

Kelsey Baker, Principal Investigator
Department: School of Medicine
Via Electronic Routing System

Dear Principal Investigator:

RE: APPROVAL OF MODIFICATION OF ONGOING RESEARCH FOR IRB-22-0184 "Role of Neurotoxin Pre-Exposure on Parkinson's Disease Progression and Neuroplasticity Changes"

A modification request for the IRB protocol referenced above has been reviewed and approved. Approval has been granted for the following modification(s):

- Corrections to ICF and recruitment pamphlet

Recruitment and Informed Consent: You must follow the recruitment and consent procedures that were approved.

Modifications to the approved protocol: Modifications to the approved protocol (including recruitment methods, study procedures, survey/interview questions, personnel, consent form, or subject population), must be submitted to the IRB for approval. Changes should not be implemented until approved by the IRB.

Approval expiration and renewal: Your study approval expires on the date noted above. Before that date you will need to submit a continuing review request for approval. Failure to submit this request will result in your study file being closed on the approval expiration date.

Data retention: All research data and signed informed consent documents should be retained for a minimum of 3 years after completion of the study.

Closure of the Study: Please be sure to inform the IRB when you have completed your study, have graduated, and/or have left the university as an employee. A final report should be submitted for completed studies or studies that will be completed by their respective expiration date.

If you have any questions, please contact the Human Subjects Protection Program/IRB by phone at (956) 665-3598 or via email at irb@utrgv.edu.

Sincerely,

Institutional Review Board for the Protection of Human Subjects in Research
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