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An equation to calculate UPDRS motor severity for online and rural assessments of Parkinson’s

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ARTICLE INFO

Keywords:
UPDRS-III
Parkinson’s disease
Prediction
Regression analysis
Motor severity
COVID-19

ABSTRACT

Objective: Management of PD has largely been affected by COVID-19. Due to the restrictions posed by COVID-19, there has been a shift from in-person to online forms of assessment. This presents a challenge as not all motor symptoms can be assessed virtually. Two of the four cardinal symptoms of PD (rigidity and postural instability) cannot be assessed virtually using the gold-standard Unified Parkinson’s Disease Rating Scale (UPDRS-III). As a result, an accurate total motor severity score cannot be computed from the remaining subsections. Recently, one study stated that in order for accurate scores to be calculated, only three sections could be absent. Virtually, six sections are unable to be evaluated with online assessments. This inability to compute a total motor severity score may result in poor disease management. Thus, in this study a regression equation was developed to predict total motor severity scores from partial scores.

Methods: Total motor severity scores (UPDRS-III) from N = 234 individuals with idiopathic Parkinson’s were retrospectively analyzed. In order to conduct a linear regression analysis, predictor and outcome variables were created. The variables were then used for the linear regression. The equation was then tested on an independent data set N = 1168.

Results: The regression analysis resulted in the equation to predict total motor symptom severity of PD.

Conclusions: In conclusion, the developed equation will be very useful for outreach in rural communities, as well as the continued remote management of PD during COVID-19 and beyond.

1. Introduction

The Global Burden of Disease Study states while COVID-19 has been the leading cause of death since April 2020, deaths due to Parkinson’s disease (PD) remain among the top 4 causes of death by disease globally [1], making management of PD a global priority. However, COVID-19 has presented challenges in managing PD.

Management of PD has shifted from in-person to online assessments. This presents challenges as not all motor symptoms can be assessed virtually. The Unified Parkinson’s Disease Rating scale (UPDRS-III/ MDS-UPDRS) is the gold-standard assessment tool, however, 6 of 27 items cannot be assessed virtually. Interestingly, a previous study investigating the effects of missing values/items on the validity of the total score found that 3–4 consistently missing items from the MDS-UPDRS can result in a drop of validity [2]. With 6 items not able to be assessed virtually, approximately 25% of symptom severity is unaccounted for [3,4], making it invalid to derive a total score from the remaining subsections [5], negatively impacting disease management.

For optimal management of PD, prediction of overall motor symptom severity from partial scores obtained online is critical. To do so, total in-person motor scores must be used as a reference, with the items that cannot be assessed online removed (representing online assessments). Therefore, this study aimed to develop an equation to accurately calculate total motor symptom severity from partial assessments, reflecting what might be completed online. In this study, the accuracy of the developed equation’s ability to predict total motor severity was then assessed using a large independent data set. In order to be considered accurate we expected a strong correlation between the computed total motor symptom scores and the actual total motor scores [6]. While it might be assumed that values for specific missing sections cannot be predicted (retropulsion test or rigidity), predicted total symptom severity in the absence of these individual tests is important in disease management, or when clinical trials are unexpectedly interrupted.

While a regression equation would not replace missing data points, it would provide a useful estimation of total motor symptom severity scores.

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https://doi.org/10.1016/j.parkreldis.2021.11.028
Received 28 April 2021; Received in revised form 24 November 2021; Accepted 26 November 2021
Available online 30 November 2021
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2. Materials and methods

2.1. Participants and variables

Total, in-person “classic” UPDRS-III scores (not MDRS-UPDRS) from 234 individuals assessed by a qualified trained assessor were obtained from a single center database. All participants had idiopathic PD diagnosed by a neurologist. In order to conduct a linear regression analysis, predictor variables and outcome variables were created.

**Predictor variable.** To create the predictor variable, first, from the total in-person motor scores, postural instability (item 30) and rigidity (items 8–12) scores were removed (as these are the scores unable to be assessed via online assessment) to obtain a predicted online UPDRS score.

\[
\text{Predictor variable} = (\text{total in-person UPDRS-III} - \text{postural instability + rigidity})
\]

**Outcome variable.** For this linear regression, the outcome variable was the total in-person motor scores (UPDRS-III).

After the equation was developed, it was used to predict the total motor score (UPDRS-III) scores of a separate dataset containing \( n = 1168 \) partial scores (which did not include the 234 scores used to create the equation).

Ethics approval for secondary data usage was obtained by the Research Ethics Board at Wilfrid Laurier University.

2.2. Statistical analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS). In order to conduct a simple linear regression, multiple assumptions were assessed. First, descriptive testing was used to explore the distribution of the data (Shapiro-Wilk). Next, the correlation between both variables was assessed (should have a correlation > 0.3). Then, minimum and maximum values of standardized residuals were assessed (should be between –3 and 3). Finally, Cook’s distance was also used to identify the influence the predictor variable has on the observation of the outcome variable.

Once assumptions were assessed, the predictor and outcome variables (see methods) were used to compute a regression equation. The predictor variable was inputted as X (independent) and the outcome variable was inputted as Y (dependent). The unstandardized B coefficients were used to compute the regression equation. Finally, to assess the accuracy of the predicted total motor scores (UPDRS-III), a Pearson correlation was conducted on the partial and computed scores of a separate dataset (\( n = 1168 \)). Alpha level for significance was set for 0.05 at 95% confidence intervals (CIs).

After the equation was developed, it was used to predict the total motor scores (UPDRS-III) of a dataset containing \( n = 1168 \) partial scores.

3. Results

Assumption testing: Both the predictor and outcome variables were continuous no outliers were present. Both variables were normally distributed according to Shapiro-Wilk test for normal distribution (\( p = 0.52 \)). Both variables were highly correlated (\( R = 0.93, p < 0.0001 \)). Next, there was a minimum standardized residual of −4.79 and a maximum of 2.193. Finally, Cook’s distance for this linear regression was 0.146 (< 1).

Regression analysis: The linear regression established that the incomplete UPDRS-III (predictor variable) could predict total UPDRS-III motor scores (outcome variable), \( F(1,232) = 79.91, p = 0.0001 \). The regression equation was:

\[
\text{The Almeida-Sang equation (Predicted total UPDRS-III scores) } = 2.529 + 1.164(\text{partial UPDRS-III score})^* 
\]

4. Discussion

The purpose of this study was to develop an equation that can accurately predict overall motor symptom severity from partial online assessments. Due to the global pandemic, it has become increasing important to be able to accurately assess motor severity in those with PD has with the shift to online platforms for assessment. The equation will help clinicians and researchers better adapt to this shift and maintain optimal disease management. The combination of the regression equation with the partial scores from online assessments can be used as a valid alternative to in-person assessments to obtain overall motor severity.

Although the derived equation computes a total UPDRS-III motor score, it should be noted that the equation was developed from in-person assessment scores. Previous studies have suggested in-person UPDRS scores to be highly correlated with online UPDRS scores, making it a valid alternative [6–8]. However, this equation does not account for potential barriers to online assessment, such as internet connection quality, video lag, etc., which could affect certain subsections of the UPDRS assessment. This is an important consideration for future research.

Other subsections that cannot be assessed online (rigidity and postural instability), while accounted for with this equation, cannot be differentiated to determine how they are individually contributing to overall UPDRS scores. For example, if the equation showed worsening of overall symptoms, it cannot identify if this was a result of rigidity or postural instability (or a combination of the two). In addition, unlike rigidity which is related to bradykinesia [9], postural instability is a
single item and may be less strongly correlated to the other UPDRS-III items, and as a result maybe more difficult to estimate it from the other values. However, when aiming to manage the symptoms of PD, clinicians and researchers often opt to use the total UPDRS-III score rather than to focus on individual symptom effects [10–15]. Thus, having a total UPDRS-III motor score (that is not symptom specific) may be more valuable than having an incomplete UPDRS-III motor score.

In addition, the traditional/classic UPDRS-III was utilized in this study as data was gathered retrospectively. However, as the items of UPDRS-III are very similar to the MDS-UPDRS, the equation could potentially be applicable. Testing this may also be a possibility for future research.

Finally, the results of this paper suggest that the equation may be essential for the continued management of PD with the limitations brought on by COVID-19, making in-person assessments more challenging. While the driving force behind the necessity of this work to be completed was the limited access to in-person assessments during the pandemic, telemedicine and virtual assessments are an important and growing tool that will continue to be used in the future. The utility of the equation is that clinicians and researchers can offer more specialized assessments and management of participants in rural areas and locations with shortage of movement disorders specialists.

To truly validate the effectiveness of this equation, studies should use the regression equation in combination with partial scores obtained online and compare the results to total motor scores of in-person assessments of the same participants.

Declaration of competing interest

This study was unfunded. Authors have conflicts of interest to disclose.

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