Objective assessment of Parkinson's disease motor symptoms during leg agility test using motion sensors

Somayeh Aghanavesi [1,*], Filip Bergquist [2], Dag Nyholm [3], Marina Senek [3], Mevludin Memedi [4]

1 Computer Engineering, School of Technology and Business Studies, Dalarna University, 2 Dept. of Pharmacology, University of Gothenburg, 3 Dept. of Neuroscience, Neurology, Uppsala University, 4 Informatics, Business School, Örebro University,

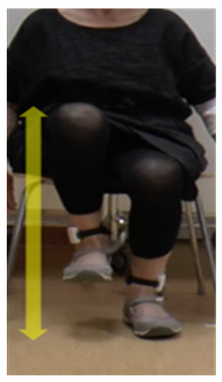
Email: Saa@du.se;
Tel: +46 23 778592
+46 720316706;

Objective:

To develop and evaluate machine learning methods for assessment of Parkinson's disease (PD) motor symptoms using leg agility (LA) data collected with motion sensors during a single dose experiment.

Background:

19 advanced PD patients (mean years with PD: 9.7, mean years with levodopa: 9.5) were recruited in a single center, open label, single dose experiment [1].
Leg agility tasks were performed by patients at predefined timepoints up to 15 times while wearing motion sensors on their foot ankle.
The time points were: starting from baseline, at the time of morning dose (150% of the normal levodopa equivalent dose), and at follow-up time points until the medication wore off.



Movement disorders specialists rated the videos of the PD patients on scales of treatment response scale (TRS), UPDRS #26 (leg agility), #27 (arising from chair), #29 (gait), #31(bradykinesia), and dyskinesia.

Quantitative measures from motion sensors were calculated and the most important features were selected.

Methods:

Machine learning methods of support vector machines (SVM), linear regression, and decision trees used to map the calculated features to rating scales of TRS, UPDRS #31, SUMUPDRS (sum of #26,#27,#29), and dyskinesia.
Validity of the machine learning methods to mean clinical ratings were assessed by Pearson correlation coefficients and Root Mean Squared Error (RMSE).
Test-retest reliability of the methods during baseline measurements were examined by intra-class correlation coefficient (ICCs) and their 95% confidence intervals (CI).
Responsiveness of machine learning-based scores to levodopa effects was assessed by calculating the effect sizes [2].

Results:

Validity: SVM method provided the best validity to clinical ratings.

	SVM
TRS	0.81(0.77)
UPDRS #31	0.83(0.53)
SUMUPDRS	0.78(1.65)
Dyskinesia	0.67(0.50)

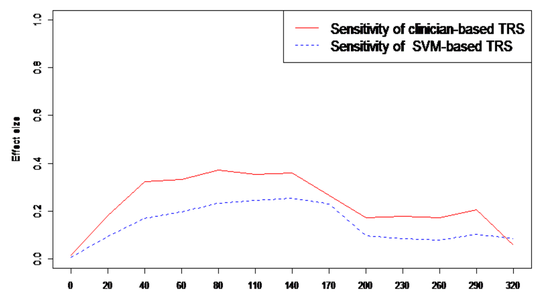
Test-retest reliability: The reliability of the scores during first two measurements were high for both clinical rating and SVM scores.

ICC(with 95% CI).

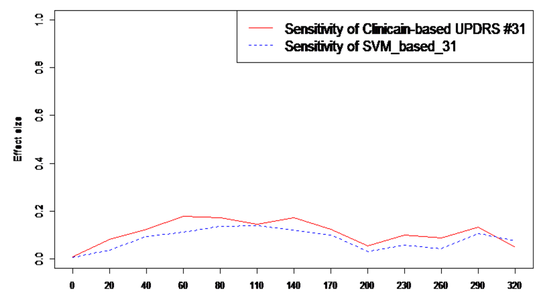
	Clinical scores	SVM
TRS	0.91(0.78-0.96)	0.81(0.57-0.92)
UPDRS #31	0.85(0.65-0.94)	0.89 (0.73-0.95)
SUMUPDRS	0.91 (0.78-0.97)	0.91 (0.78-0.96)

For reliability of the clinical dyskinesia ratings during the first two baseline measurements, all patients were rated with 0.

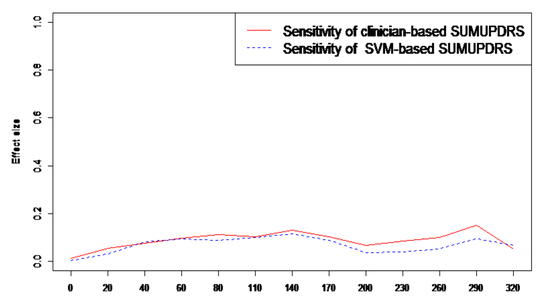
Responsiveness: The effect sizes from SVM-based scores showed reasonable responsiveness to UPDRS #31 and SUMUPDRS, but small responsiveness to TRS and dyskinesia rating scales.



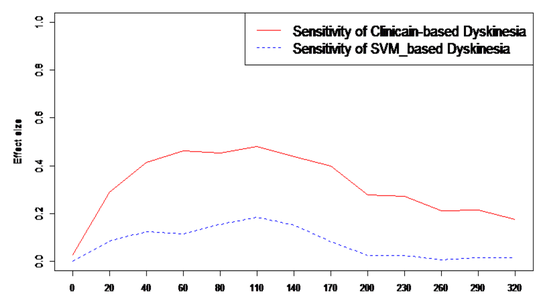
TRS is the treatment response scale



UPDRS #31 is bradykinesia scale



SUMUPDRS is sum of #26(leg agility), #27(raising from chair), and #29 (gait)



Conclusions:

The proposed machine learning methods are able to assess motor symptoms in PD comparable to clinical ratings.
Leg agility data were not highly responsive to the levodopa related changes.

References:
[1] M. Senek, S. M. Aquilonius, H. Askmark, F. Bergquist, R. Constantinescu, A. Ericsson, et al., "Levodopa/carbidopa microtablets in Parkinson's disease: a study of pharmacokinetics and blinded motor assessment," Eur J Clin Pharmacol, vol. 73, pp. 563-571, May 2017.
[2] C. G. Goetz, G. T. Stebbins, K. A. Chung, R. A. Hauser, J. M. Miyasaki, A. P. Nicholas, et al., "Which dyskinesia scale best detects treatment response?," Mov Disord, vol. 28, pp. 341-6, Mar 2013.