Developing a Tool for Remote Digital Assessment of Parkinson's Disease

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BACKGROUND

- Patients with Parkinson's disease commonly experience symptoms that fluctuate in intensity over the course of the day and in relation to their medication dosing.
- Traditionally, assessment of the symptoms are made at clinic visits using objective clinical rating scales such as the UPDRS (now replaced by the MDS-UPDRS[1]).
- During the last few years a remarkable development of commodity mobile communication devices such as smartphones has occurred.

We provide the first report on the development and testing of standalone software for mobile devices that could be used to assess their motor symptoms of PD for clinical trials or as part of routine clinical follow-up.

METHODS

Participants

A total number of 14 PD patients (mean age 54.7, range 34-75, 7women)

Subject number	Gender	Age	Disease duration	Dopaminergic treatment
1	F	61	72	Levodopa
2	F	52	42	Levodopa
3	M	71	28	no therapy
4	M	64	24	no therapy
5	F	52	46	Levodopa
6	M	75	70	Levodopa
7	F	40	84	Pramipexole,Rasagiline
8	F	34	28	ropinirole
9	M	50	48	no therapy
10	F	56	8	Ropinirole
11	M	66	9	rasagiline
12	M	49	24	Rasagiline
13	M	55	80	no therapy
14	F	41	60	Pramipexole,Rasagiline

Design

All patients were assessed with the smartphone and the MDS-UPDRS.

Smartphone recordings	MDS-UPDRS
Rest tremor	3.17 (rest tremor amplitude)
Postural tremor	3.15 (postural tremor of the hands)
Action tremor	3.16 (kinetic tremor of the hands)
Pronation-supination movements	3.6 (pronation-supination movements of hands)
Leg agility	3.8 (leg agility)
Finger tapping	3.3 (rigidity) & 3.4 (finger tapping)
Gait	3.10 (gait) & 3.11 (freezing of gait)

Data collection and analysis

Tremor (rest, postural, action)

- the sum acceleration was high-pass filtered at 2Hz and converted into a power spectrum (FFT).
- the total amplitude of the frequencies between 2Hz to 30Hz was calculated.

Bradykinesia

Pronation-supination and leg agility (accelerometry)

- the sum acceleration was low-pass filtered at 4Hz and converted into a power spectrum (FFT).
- the dominant frequency and the total amplitude of the frequencies up to 2Hz was calculated.

Finger tapping (two targets on screen)

- tap the targets alternatively as fast and as accurately as possible for 60 seconds.
- Frequency and distance between taps was calculated.

Gait

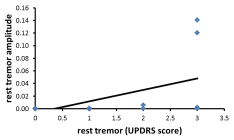
Accelerometry data for walking and turning

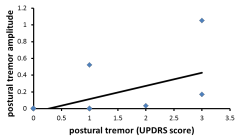
- Stride frequency
- Velocity [2]
- Turning time

1. Goetz CG et al; Movement Disorder Society UPDRS Revision Task Force. Movement Disorder Society-sponsored revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS): scale presentation and clinimetric testing results. Mov Disord. 2008 Nov 15;23(15):2129-70
2. Eladio M et al; Determination of a Patient's Speed and Stride Length Minimizing Hardware Requirements. 2011 IEEE

RESULTS

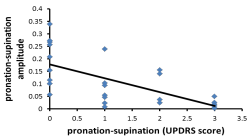
Tremor

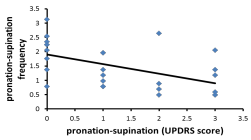




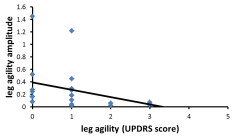
The 3.17 UPDRS score (**rest tremor amplitude**) correlated significantly with the amplitude of rest tremor measured with the smartphone r=0.60, p<0.001.
The 3.15 UPDRS score (**postural tremor of the hands**) correlated significantly with the amplitude of postural tremor measured with the smartphone r=0.65, p<0.001.
The amplitude of the **kinetic tremor** did not correlate significantly with the UPDRS scores r=-0.17, p=0.420.

Bradykinesia

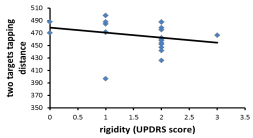


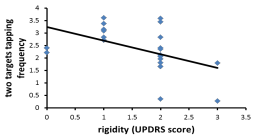


The 3.6 UPDRS scores (**pronation supination movements**) correlated significantly with both the movement amplitude r=-0.72, p<0.001 and frequency r=-0.55, p=0.003.

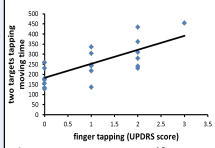


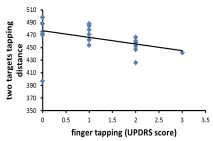
The 3.8 UPDRS score (**leg agility**) correlated significantly with the leg movement amplitude as measured with the smartphone r=-0.5, p=0.015 but not with the leg movement frequency r=-0.31, p=0.162

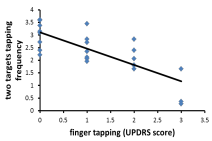




The 3.3 UPDRS score (**rigidity**) correlated significantly with the mean distance between taps r=-0.42, p=0.050 and the tapping frequency r=-0.56, p=0.040 in the two tapping targets test.







The 3.4 UPDRS score (**finger tapping**) correlated significantly with the mean moving time r=0.65, p=0.001, the distance between taps r=-0.61, p=0.003 and the tapping frequency r=-0.75, p=0.001.

Gait

The mean stride frequency was 1.90 Hz (SD=0.08), the mean velocity 1.13 m/s (SD=0.50) and the mean turning time 1.31sec (SD=0.34). None of the variables correlated significantly with UPDRS.

CONCLUSIONS

- We found significant correlation of 6 subscores of MDS-UPDRS (rest tremor, postural tremor, pronation-supination, leg agility, rigidity and finger tapping) with 10 parameters of the data collected with the smartphone.
- With this study we provide evidence as a proof of principle that mobile communication devices such as smartphones could be used to objectively assess motor symptoms at comparatively low cost in patients with Parkinson's disease in a convenient way

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