Correlation between Kinesia™ System Assessments and Clinical TETRAS Scores in Patients with Essential Tremor

Giovanni Mostile[1], MD, Joseph P. Giuffrida[2], PhD, Octavian R. Adam[1], MD, Anthony Davidson[1], BS, and Joseph Jankovic[1], MD

[1]Parkinson's Disease Center and Movement Disorders Clinic, Department of Neurology, Baylor College of Medicine, Houston, Texas
[2]Division of Movement Disorders, Cleveland Medical Devices Inc., Cleveland, Ohio

Background

The Kinesia™ (CleveMed) motor assessment system is a portable, patient-worn wireless device integrating triaxial accelerometers and gyroscopes shown to accurately assess tremor in patients with Parkinson's disease[1]. The quantitative motion variables processed by this system have not yet been compared with Essential Tremor (ET) clinical rating scales.
Recently, a new scale, The Essential Tremor Rating Assessment Scale (TETRAS), was developed by the Tremor Research Group (TRG) for the assessment of action tremor in ET, utilizing a half-point interval, zero to four scale[2]. The scale measures the peak-to-peak amplitude range, which captures the level of excursion of a body part due to tremor.
There are no previous studies correlating TETRAS with quantitative measurements detected by motion transducers. The objective of this study was to determine whether Kinesia system assessments correlate with TETRAS clinical scores for postural and kinetic upper extremity tremor in patients with ET.

Methods

Population Study.
The research protocol was approved by the Institutional Review Board for Human Research at Baylor College of Medicine. We enrolled subjects who satisfied the diagnostic criteria formulated by the TRG for definite or probable ET[3].

Kinesia recording.
The Kinesia system consists of a finger sensor unit connected to a wrist-worn module (Fig.1). The device was attached to the wrist and subjects were instructed to hold their arms in an outstretched position and then touch their nose while data were wirelessly transmitted to a computer which stored the acquired data.

Fig.1: Kinesia™ portable wireless system:

Clinical assessment.
All subjects were rated on the arm where the system was placed using the TETRAS items for arm tremor (0: none; 1: barely visible; 1.5: visible, less than 1 cm of amplitude; 2: 1 - <3 cm; 2.5: 3 - <5 cm; 3: 5 - <10 cm; 3.5: 10 - <20 cm; 4: ≥20 cm). Subjects were also videotaped during the recording using a digital video camera on a tripod and subsequently rated by a second blinded rater.

Signal processing and statistical analysis.
A linear regression model was constructed for both tasks using the logarithmic values of the TETRAS scores detected during the clinical examination and the objective motion data parameters (the RMS amplitude or the peak-PDS of selected data vectors). The Kinesia scores for both tasks were computed using the exponential function of the predicted values. Normal distribution of the analyzed scalar variables was tested and correlation analysis was run comparing the outcome measures.

Results

Twenty subjects performed upper extremity postural and kinetic tremor tasks while symptom severity measures were captured both by TETRAS and Kinesia (Fig.2).
The average TETRAS scores for the postural and kinetic tremor components are summarized in Tab.1, together with demographic and clinical data.

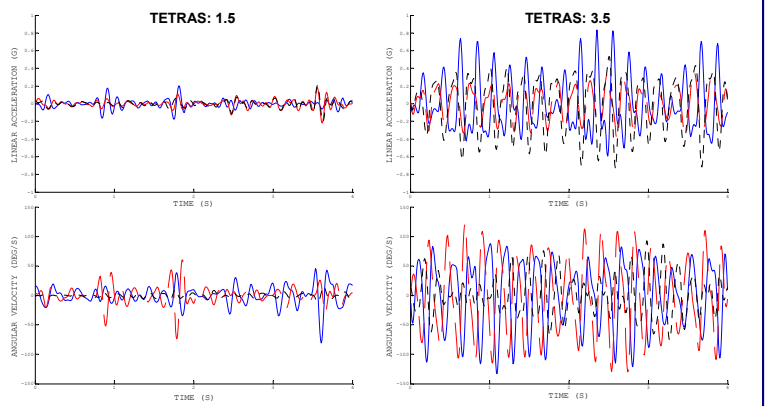
The TETRAS scores detected by the blinded rater using the videos significantly correlated with the scores detected during the clinical examination for postural ($r = 0.569$; $p = 0.009$) and kinetic ($r = 0.62$; $p = 0.004$) tremor.

Tab.1. Clinical data of the enrolled patients:

N = 20	
Gender:	
Male	8 (40%)
Female	12 (60%)
Age at the evaluation (years):	62.03 ± 12.95
Disease duration (years): *	32.55 ± 22.5
TETRAS items score: †	
Upper limb - postural tremor ‡	1.93 ± 0.82
Upper limb - kinetic tremor §	2 ± 0.76

Notes: data are means ± SD; frequencies (percents)
* from the first motor manifestation of ET;
† evaluated on the side where the Kinesia system was placed;
‡ score using video assessment: 1.65 ± 0.96
§ score using video assessment: 1.93 ± 0.89

Fig.2: Differences in captured sensor data during postural task among different clinical scores (solid, dash and dot lines are respectively signals detected on the *x*, *y* and *z* axes):

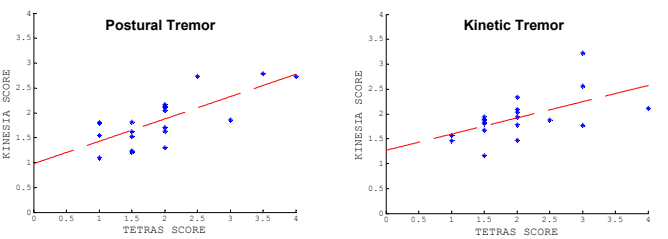


Peak power spectral density provided the greatest correlation with the postural tremor task while RMS amplitude provided the greatest correlation for the kinetic tremor task. Peak frequencies were not significantly correlated to either tremor tasks.

The postural tremor regression model was obtained using linear acceleration spectral data. The model explained 44.2% of the variation of the dependent variable, with a good correlation between observed and predicted values ($r = 0.67$). Statistical variation in the dependent variable accounted for by the model was significant (ANOVA: $F = 14.25$; $p = 0.001$), as well as coefficients model values.

For the kinetic tremor regression model, the largest correlation to subjective clinical scores was obtained using the RMS values of both linear acceleration and angular velocity. The model explained about the 35.3% of the variation of the dependent variable, with a good correlation between observed and predicted values ($r = 0.59$). Statistical variation in the dependent variable accounted for by the model was significant (ANOVA: $F = 4.63$; $p = 0.025$), as well as coefficients model values.

Fig.3: Quantitative variables processed by the Kinesia system showed a significant correlation with clinical TETRAS scores for postural ($r = 0.738$; $p < 0.001$) and kinetic ($r_s = 0.6$; $p = 0.005$) tremor.



Conclusions

This study demonstrates a significant correlation between two different methods of evaluating action tremor severity in patients with ET: the clinical TETRAS score and the quantitative variables processed by the Kinesia system. Our findings provides evidence that Kinesia measurements are correlated to clinical TETRAS scores, therefore the system may provide a useful adjunct to supplement data from more subjective clinical rating scales.

References:
1. Giuffrida JP, Riley DE, Maddux BN, Heldman DA. Clinically deployable KinesiaTM technology for automated tremor assessment. *Mov Disord* 2009;24:723-30
2. Elble RJ, Comella S, Fahn S et al. The essential tremor rating assessment scale (TETRAS). *Mov Disord* 2008;23(Suppl 1):S357
3. Findley L, Koller W. Definitions and Behavioral Classifications. In: Findley L, Koller W, editors. Handbook of tremor disorders. New York: Marcel Dekker; 1995. p 1–5.

Acknowledgements: We would like to thank CleveMed Medical Device Inc. (CleveMed) and the National Parkinson Foundation (NPF) for their support of the NPF Center of Excellence at Baylor College of Medicine.

The *Movement* Disorder Society