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Logarithmic relationship between head tremor and 5-point tremor rating

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Objectives

1. To determine the mathematical relationship between the amplitude of head tremor and 5-point Fahn-Tolosa-Marín (FTM) clinical ratings.
2. To compare the head tremor-FTM relationship with previous estimates of the hand tremor-FTM relationship

Background

The tremor rating scale (TRS) of Fahn, Tolosa and Marín[1] is used commonly in the clinical assessment of tremor. We recently demonstrated that hand tremor (T), measured with a motion transducer, and TRS have the following logarithmic relationship.[2]

$$\log T = \alpha \bullet TRS + \beta$$

This relationship is predicted by the Weber-Fechner laws of psychophysics.[3] We found that α is approximately 0.5 for log base 10.

We now report the relationship between head tremor and the FTM TRS.

1. Clinical rating scale for tremor. In: *Parkinson's Disease and Movement Disorders*, Jankovic J and Tolosa E (eds). Williams and Wilkins: Baltimore 1993: 225-234.
2. Elble RJ, Pullman SL, Matsumoto JY, Raethjen J, Deuschl G, Tintner R. Tremor amplitude is logarithmically related to 4- and 5-point tremor rating scales. Brain 2006;129:2660-2666.
3. Schiffman HR. *Sensation and Perception. An Integrated Approach*, 4th ed. New York: John Wiley & Sons, Inc, 1996.

Design/Methods

Four normal adults, 15 patients with tremulous cervical dystonia, two people with essential tremor, one patient with Parkinson disease and one with pure head tremor were studied after giving informed consent (N = 23).

Head tremor was recorded for one minute with a motion sensor mounted on the vertex of the head while subjects were seated in a chair with head in neutral position (Figure 1). The motion transducer contained a triaxial accelerometer and triaxial gyroscope (CleveMed Kinesia), which provided three-dimensional recordings of translational (linear) motion and rotational motion of the head.

During the recording, two movement disorders specialists rated head tremor with the FTM.

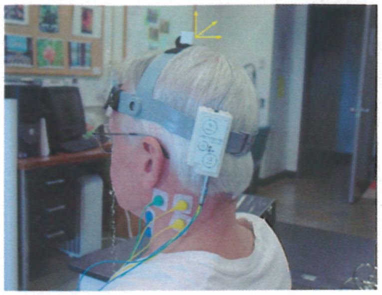
Tremor recordings were analyzed with the fast Fourier transform and with the Morlet wavelet transform to compute the mean and maximum tremor amplitudes over time. These methods produced virtually identical results, except that the wavelet method did a better job of computing time-frequency spectra. Therefore, the results reported here were computed with the wavelet method.

The x-y-z displacements of head tremor were computed from the triaxial accelerometer recording, and the x-y-z rotations of head tremor was derived from the triaxial gyroscope.

The resultant $(=\sqrt{x^2+y^2+z^2})$ mean and maximum tremor amplitudes were subsequently correlated with the FTM ratings.

1. Torrence C, Compo GP. A practical guide to wavelet analysis. Bulletin of the American Meteorological Society 1998;79:61-78.

Figure 1:



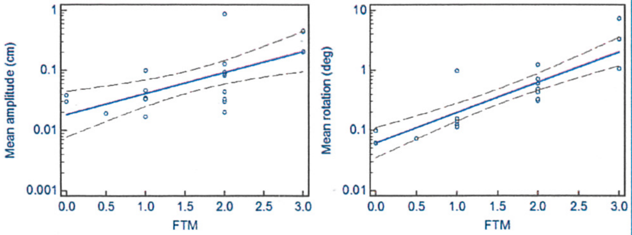
Results

Mean and maximum tremor displacement and rotation (T) had a logarithmic relationship with tremor ratings (TRS):

$$\log T = \alpha \cdot TRS + \beta$$

The correlation for mean displacement was less ($r = 0.643$, $p = 0.002$) than the correlation for mean rotation ($r = 0.869$, $p < 0.0001$). The slope α was 0.349 for displacement and 0.506 for rotation, and β for these measures was -1.730 and -1.204 (Figure 2).

Figure 2:

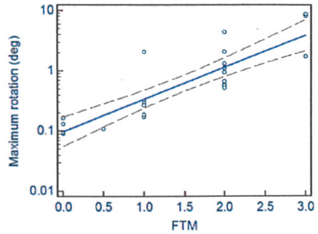


Results (continued)

The relationship between maximum tremor amplitude and FTM did not differ significantly from that of mean tremor amplitude vs FTM (Figure 3).

The values of α and β were 0.533 and -1.0067.

Figure 3:



Discussion

The gyroscopic measure of tremor (rotation) correlated better with clinical ratings of head tremor than did accelerometry (translation). This result is predictable because nearly all head tremor is rotational motion, not translation. In rotational motion, there is considerable gravitational artifact in accelerometric recordings of body rotation.[1]

The Weber-Fechner (logarithmic) relationship for head tremor is very similar to that previously reported for upper limb tremor,[2] and this relationship can be used to estimate the actual tremor amplitudes associated with clinical ratings.[3]

Mean and maximum tremor amplitudes did not differ significantly in their relationship with the clinical rating. Maximum tremor might be more important when there is intention tremor.

The Weber-Fechner relationship between tremor (measured with a motion transducer) and clinical ratings is a robust observation that has been documented for 11-point spiral ratings.[4,5]

1. Elble RJ. Gravitational artifact in accelerometric measurements of tremor. Clin Neurophysiol 2005;116:1638-1643.
2. Elble RJ, Pullman SL, Matsumoto JY, Raethjen J, Deuschl G, Tintner R. Tremor amplitude is logarithmically related to 4- and 5-point tremor rating scales. Brain 2006;129:2660-2666.
3. Deuschl G, Raethjen J, Hellriegel H, Elble R. Treatment of patients with essential tremor. Lancet Neurol 2011;10:148-161.
4. Haubenberger D, Kalowitz D, Nahab F, et al. Validity and reliability of computerized tremor spirography as outcome measure for clinical trials in essential tremor. Neurology 2010;74:A349.
5. Kraus PH, Hoffmann A. Spiralometry: computerized assessment of tremor amplitude on the basis of spiral drawing. Mov Disord 2010;25:2164-2170.

Conclusions

1. Triaxial gyroscopy does a better job of measuring head tremor than triaxial accelerometry.
2. Triaxial gyroscopy and wavelet spectral analysis provide measures of mean and maximum rotational tremor that correlate strongly with 5-point clinical ratings, according to the Weber-Fechner relationship $\log T = 0.5 \cdot TRS - 1$, which is similar to that observed for hand tremor and spirography.

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