The Electrophysiological Perspectives of Essential, Enhanced Physiological, and Physiological Tremors

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Abstract:

Background: The most frequent movement issue seen in clinical practice is tremors. It is known as repetitive, involuntary oscillations. The diagnostic process for tremor patients can be time-consuming and complicated, as the identification of "Essential Tremor" and its distinction from other types of tremor.

Objectives: This study aimed to describe the electrophysiological findings of essential, enhanced physiological, and physiological tremors, using surface electromyography and an accelerometer.

Patients and Methods: The study included 24 patients with essential tremors, 10 patients with enhanced physiological tremors, and 10 patients with physiological tremors. We assessed the frequency, amplitude, and muscular contraction pattern of tremors during rest, posture, and a 1 kg load.

Results: The tremor frequency of essential tremor patients was about 4.2-10.1 Hertz, while enhanced physiological tremor and physiological tremor were increased to 6.1–12.7 Hertz and 5.1-10.2 Hertz, respectively. The essential tremor group muscle contraction pattern was predominantly synchronous, as do all enhanced physiological, and physiological tremor patients, but with more fine low amplitude muscle bursts. By varying the tremor frequency and the weight load effect, tremor analysis could discriminate essential from enhanced physiological, and physiological tremors.

Conclusions: The tremor analysis using surface electromyography and an accelerometer is sufficient to differentiate between essential tremors, enhanced physiological tremors, and physiological tremors.

Keywords: Frequency, Accelerometry, Surface electromyography, Spectral analysis.

Introduction:

In clinical practice, the most prevalent movement disorder is tremor (1). Repetitive, involuntary oscillations of one or more bodily parts characterize it. Alternating or simultaneous contractions of antagonistic and agnostic muscles with reciprocal innervation result in tremors. Classifying a tremor depends on its genesis, phenomenology, location, and frequency. It manifests in both healthy persons and as a manifestation of a movement disorder, which is typically neuropathic in origin (2–5). Physiological tremor (PT), which is innate to healthy people, is often unnoticed due to its slight amplitude. It has a frequency range of 8 to 13 Hz, with an adult dominant rate of 10 Hz and somewhat lower rates in kids and the elderly. The frequency of physiological tremors ranges from the proximal to distal sections of an upper limb for example 7 to 10 Hz at the wrist and 12 to 30 Hz at the metacarpophalangeal joint (3). Stress, exhaustion, emotion, drugs, and other factors that enhance sympathetic activity can cause an increase in the amplitude of healthy people's tremors to result in enhanced physiological tremor (EPT), which can be seen during or shortly after times of increased muscle activity, such as during exercise. Each hand and all of the fingers are affected in the same way by this postural tremor, which has a frequency of 8 to 12 Hz (lower in kids and the elderly) (6). Essential tremor (ET) is a prevalent neuropathic condition manifested by the so called action tremor, which is subdivided into a postural and kinetic tremor (7). A postural tremor arises when a subject deliberately maintains a pose against gravity for example maintaining arms outstretched. Kinetic tremor manifests itself during voluntary movement. The frequency range of essential tremors is between 4 and 12 Hz (8–10). The primary features of each tremor are

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amplitude and frequency, which are utilized to characterize the kind and severity of the tremor (11). Many methods exist for measuring tremors. Neurologists routinely use spiral drawing and handwriting as the most common subjective clinical methods. Nevertheless, due to their accessibility, noninvasive nature, and affordability as diagnostic tools, accelerometer, and surface electromyography electrode techniques are gaining popularity and are considered the gold standard for determining tremor frequency and amplitude, they also provide an objective measurement (12). Fast Fourier transform (FFT, PSD) based techniques are widely used to determine the frequency and amplitude of the tremor (13–15). The prominent peak in the power spectral density (PSD) determines the tremor frequency, but the area beneath this peak can be used to determine the tremor amplitude. The objectives of this study were to describe the results obtained with surface electromyography and an accelerometer for the evaluation of tremors and to analyze their ability to discriminate oscillations in Essential Tremors, enhanced physiological tremors, and physiological tremors.

Patients and Methods:

Patients: Our research is a cross-sectional study performed at the neurophysiology unit in Al-Shaheed Ghazi Al-Hariri Hospital in Baghdad during the period from 1 November-2021-28 February-2022. The study groups included 24 patients with essential tremors, ten patients with enhanced physiological tremor. and ten patients with physiological tremor, who attended the neurophysiology unit after referral from the Neurology Department in Baghdad Teaching Hospital. Inclusion criteria included all adult males and females with tremors who were at least 18 years old and capable of walking independently without aids. Exclusion criteria included cardiologic and other neurologic conditions that interfered with the phenotype of tremor. After a thorough explanation of the study procedures, all patients gave their verbal consent to participate in it. The ethical committee of the college of medicine / University of Baghdad gave its approval to the research.

Methods: In this work, a Natus EMG machine was used along with KEYPOINT.NET Software version 2.40, four EMG surface electrodes, and one unidirectional piezoelectric accelerometer. The patient sat in a comfortable chair with pronated arms resting on the armrests, while his /her hands were free in the air. Based on the clinical observation and patient's history, the upper limb with the most severe Tremor was chosen for the recording. The electrodes were implanted in the longitudinal axis of the flexor and extensor carpi ulnaris muscles, 2–3 cm apart. The accelerometer was affixed to the dorsal region of the index finger of the same hand. In addition, a ground electrode is placed on the patient with no placement preference. Using the following aspects, the frequency and amplitude of patients' tremors were determined:

- The forearms are supported by the armrests while the hands are hanging in the air, unattached to the chair.
- Instruct the patient to extend the wrist against gravity while maintaining a pronated forearm on the armrest and extending the hand beyond the armrest's edge.
- The weights are affixed on dorsum of the affected hand to observe the impact of a 1kg weight load on the main frequency peak of postural Tremor. The sampling rate ranged from 800 Hz to 24 kHz, and the 60-second signal recording segments were used for the analysis. In the case of the electromyograph, the data that was captured will be a time series exhibiting a change in voltage over time, and in the case of the accelerometer, the data will display a change in acceleration over time. The signals were reviewed in this shape to ensure that it is free of artifacts and to observe the pattern of antagonistic muscle activation (alternating or synchronous) and burst duration. To determine Tremor's amplitude and frequency, Fast Fourier transformation is applied to transform data from the time domain to the frequency domain. A tremor's frequency can be determined by looking for distinct great peaks in its accelerometry spectrum, while its amplitude can be calculated by looking at the total power value (as represented by the area under the curve) (8).

Statistical Analysis:

Data management was done using the statistical package SPSS (version 25). Numerical data and normally distributed data were analyzed using the ANOVA test and compared using the Post hoc Tukey test, with (P-values ≤ 0.05) being considered as statistically significant.

Result:

The demographic distribution of the study groups by age, age of tremor onset, and tremor duration are illustrated in Table (1).

Table (1): Distribution of the ET, EPT, and PT patients by age, and tremor characteristics.

Parameter		ET	EPT	PT
Age	Mean ±SD	45.29 ±11.69	27.71 ±6.75	21.2 ±2.86
	Median (Range)	44 (27-75)	28 (18-38)	21 (18-25)
Age of onset	Mean ±SD	33.88 ±14.38	25.43 ±7.39	17.2 ±3.03
	Median (Range)	31.5 (10-74)	26 (16-37)	18 (14-20)
Duration	Mean ±SD	11.42 ±5.88	2.29 ±1.38	4.0 ±2.24
	Median (Range)	10 (1-20)	2 (1-5)	4 (1-7)

**ET: essential tremor, EPT: enhanced physiological tremor, PT: physiological tremor, SD: standard deviation.*

Table (2): Tremor frequency of resting, posture, and loaded of ET, EPT, and PT patients.

Parameter		ET	EPT	PT	P-value
Resting Hz	Mean ±SD	6.93 ±1.28	9.06 ±1.62	8.8 ±1.11	<0.001
	Median (Range)	6.8 (4.2-9.5)	8.5 (7.2-11.3)	8.86 (7-9.9)	
Posture Hz	Mean ±SD	7.03 ±1.49	11.73 ±0.86	9.32 ±1.18	<0.001
	Median (Range)	6.8 (4.5-10.1)	11.8 (10.3-12.7)	9.7 (7.3-10.2)	
Loaded Hz	Mean ±SD	6.68 ±1.45	9.13 ±1.44	6.22 ±0.65	<0.001
	Median (Range)	6.6 (4.4-9.9)	9.3 (6.1-10.3)	6.4 (5.1-6.7)	

**ANOVA test was used for the difference between independent means; a P-value ≤ 0.05 was regarded as statistically significant.*

The tremor frequency of essential tremor individuals at rest, posture, and 1Kg weight were approximately 4.2-10.1 Hertz, but the frequency of enhanced physiological, and physiological tremors increased to 6.1-12.7 Hertz and 5.1-10.2 Hertz, respectively. with statistically significant group differences (P-value ≤ 0.05). Figure (1) compares the tremor frequencies of patients with ET, EPT, and PT.

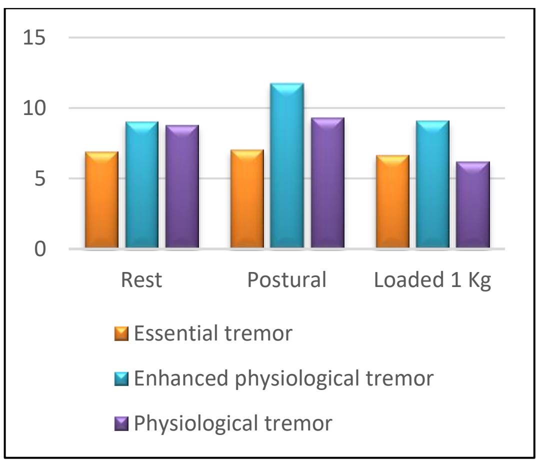

Figure (1): Mean tremor frequencies for ET, EPT, and PT patients, in Hz.

The weight load impact significantly reduces the frequency of enhanced physiological, and physiological tremor, by more than 1 Hertz. Compared to essential tremor patients who showed no decrease or a decrease lesser than 1 Hertz. There was no large difference between the EPT and PT patients in terms of tremor frequency at rest and posture (P-value ≥ 0.05), as illustrated in Tables (2), and (3).

Table (3): Comparison of the frequency at resting, posture, and loaded between pairs of tremor groups.

Parameter	1st Tremor Group	2nd Tremor Group	P-value
Resting Hz	Essential	Enhanced physiological	0.001
	Essential	Physiological	0.014
	Enhanced physiological	Physiological	0.995
Posture Hz	Essential	Enhanced physiological	0.001
	Essential	Physiological	0.014
	Enhanced physiological	Physiological	0.995
Loaded Hz	Essential	Enhanced physiological	<0.001
	Essential	Physiological	0.001
	Enhanced physiological	Physiological	0.006

**By the Post hoc Tukey test, A P-value ≤ 0.05 was regarded as statistically significant.*

The major tremor muscle contraction pattern of the essential tremor was synchronized in (83.3%) of essential tremor patients and the remaining (16.7%) demonstrated an alternating pattern. While (100%) of enhanced physiological tremor and physiological tremor patients, was a synchronized pattern with more fine low amplitude muscle bursts as illustrated in Figures (2), and (3).

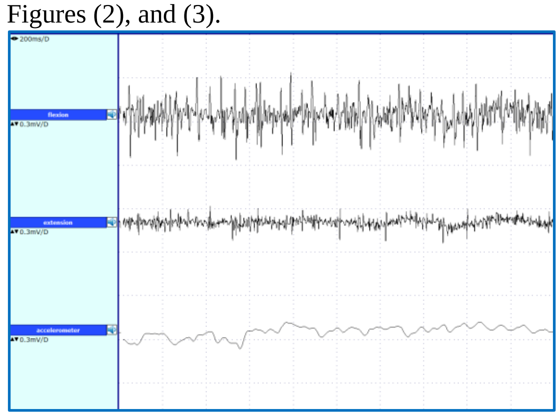

Figure (2): Muscle contractions in essential tremors demonstrate synchronization.

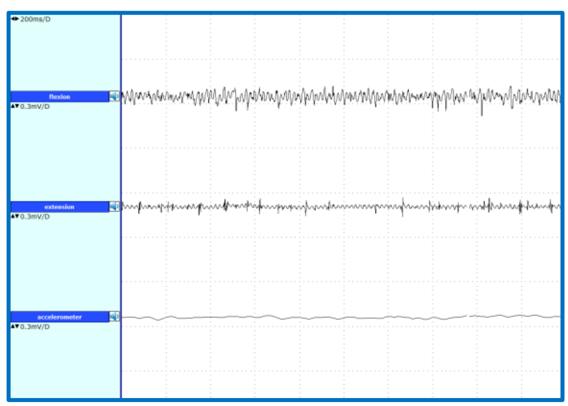

Figure (3): Enhanced physiological tremor produces finely synchronized muscular ntractions.

Discussion:

Tremor is a frequent clinical symptom that can be classified as a resting tremor, positional tremor, or intentional tremor. The most prevalent subtype of tremor is the Essential Tremor. In this study, the frequency range of ET tremor was 4.2–10.1 Hz, but the frequency ranges of EPT and PT tremor were 6.1–12.7 Hz and 5.1-10.2 Hz, respectively, which are slightly higher and overlap with ET. Normal tremor frequency is determined by the limb oscillation rather than any central oscillator frequency. A limb oscillation can be modified by external loading. This point was examined to distinguish tremors originating from a central oscillator. During the loaded condition, the tremor frequency of all normal physiological tremors decreases by more than 1 Hertz, while only a little proportion of patients with essential tremors show a decrease of larger than 1 Hz (10). In our study, we revealed that the weight load impact significantly reduces the frequency of enhanced physiological, and physiological tremor, with a reduction higher than 1 Hertz compared to essential tremor patients who showed no decrease or a decrease of less than 1 Hz. The tremor frequency of the ET subjects was substantially different from that of the EPT and PT subjects for several situations, including rest, posture, and weight bearing (1) kg (P-value ≤ 0.05), whereas there was no substantial difference between the tremor frequency of the EPT and PT subjects at rest and posture (P-value ≥ 0.05) as shown in Tables (2), and (3). Our study examined the association between EMG bursts in agonist and antagonist muscle pairs. For ET, muscle contraction was a mainly synchronous contraction in (83.3%) of patients, and alternating contraction was uncommon. while all EPT and PT were synchronized. The present results agree with previous studies which investigated muscle contraction patterns in tremor patients (2, 11, and 16). An interesting finding in the present study was that one patient with ET has a muscle contraction pattern that slips over the course of a few minutes, in which the same agonist and antagonist muscle pair show transitions from synchronous to alternating contractions. Such results were reported by a previous study (17). Essential, enhanced physiological, and physiological tremors can be diagnosed via electrophysiological tremor analysis. The technology is established by accelerometers and electrodes for electromyography. It is a simple, non-invasive, and cost-effective diagnostic technique that is widely available. However, large samples are required for further research due to the small sample size of the current study. Future research will be conducted following therapy for essential tremor and idiopathic tremors in conjunction with a clinical evaluation scale.

Conclusions:

Accelerometer and EMG can be used in clinical settings. By the variation of the tremor frequency and the weight load effect, it could discriminate ET from EPT and PT in which tremor frequency is constant in individuals with a central oscillator, as in the case of essential tremors, but inconsistent in patients with a peripheral oscillator, a mechanical reflex oscillator as EPT or a mechanical oscillation as PT.

Conflict of interest:
None.

Author's contributions:

Nawras Sabah Najim: Contributed to study conception, study design, data analysis, interpretation, drafting of the manuscript, and critical revision.

Abdulnasir Hussin Ameer: Supervisor, and contributed to study conception, study design, data analysis, interpretation, drafting of the manuscript, and critical revision.

Azad Akram Mohammed: Contributed to study conception, study design, and drafting of the manuscript.

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المنظورات الفيزيولوجيا الكهربائية للرعاش مجهول السبب، الفسيولوجي المعزز، والفسيولوجي

الدكتورة نورس صباح نجم: بكلوريوس طب وجراحة عامة
الاستاذ الدكتورعبد الناصر حسين أمير: كلية الطب/جامعة بغداد
الدكتور آزاد أكرم محمد: أخصائي طب الجملة العصبية

الخلاصة:
خلفية البحث: تعتبر الرعشات من أكثر مشاكل الحركة شيوعًا في الممارسة السريرية. وتعرف ب التذبذبات المتكررة واللاإرادية. يمكن أن تستغرق عملية التشخيص لمرضى الرعاش وقتًا طويلاً وتكون معقدة ، لأن تحديد الرعاش الأساسي وتمييزه عن الأنواع الأخرى من الرعاش يمكن أن يكون مستهلكًا للوقت ومعقدًا.
الأهداف: باستخدام التخطيط الكهربائي السطحي للعضلات ومقياس التسارع ، هدفت هذه الدراسة إلى وصف النتائج الفيزيولوجية الكهربية للرعاش الأساسي(مجهول السبب) والفسيولوجي والفسيولوجي المعزز.
المواد وطرق العمل: إشتملت الدراسة على 24 مريضا يعانون من رعشات أساسية ، و 10 مرضى يعانون من إرتعاشات فسيولوجية معززة ، و 10 مرضى برعشات فسيولوجية. قمنا بتقييم التردد والسعة ونمط الإنقباض العضلي للرعاش أثناء الراحة والوضعية وحمل 1 كجم.
النتائج: تردد الرعاش لمرضى الرعاش مجهول السبب كان حوالي 4.2-10.1 هرتز ، بينما حدثت زيادة الرعاش الفسيولوجي المعزز والرعشة الفسيولوجية إلى 6.1-12.7 هرتز و 5.1-10.2هرتز على التوالي. كان نمط تقلص العضلات لمجموعة الرعاش الأساسي متزامنًا في الغالب ، كما هو الحال مع جميع مرضى الرعاش الفسيولوجي والفسيولوجي المعزز ، ولكن مع رشقات عضلية أكثر دقة منخفضة السعة. من خلال تغيير وتيرة الرعاش وتأثير حمل الوزن ، يمكن أن يميز تحليل الرعاش الرعاش الأساسي من الرعاش الفسيولوجي المعزز والرعشة الفسيولوجية.
الإستنتاجات: تحليل الرعاش باستخدام التخطيط الكهربائي السطحي للعضلات ومقياس التسارع كافٍ للتمييز بين الرعشات الأساسية والإرتعاش الفسيولوجي المعزز والرعشات الفسيولوجية.
مفتاح الكلمات: التردد ، قياس التسارع ، التخطيط الكهربائي السطحي ، التحليل الطيفي.