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ORIGINAL ARTICLE

Utility and limitations of homemade videos in differentiating functional seizures from other paroxysmal events: An Italian cohort study

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Abstract

Objectives: The gold standard for distinguishing epileptic seizures (ES) from non-epileptic events is video-EEG monitoring. In some cases, video alone might suffice, leading to increased utilization of home videos, to support the diagnosis. This study aimed to assess the feasibility of such practice and its accuracy compared to video-EEG, to identify key signs and symptoms of functional seizure (FS) and to establish if self-reported questionnaires would improve diagnostic accuracy.

Methods: All consecutive patients ≥14 years presenting to six Italian epilepsy centers with either recurrent paroxysmal events of uncertain nature or with confirmed ES were enrolled. Subjects had to record home videos of the events and to respond to ad-hoc questionnaires. De-identified data were randomly assigned to pairs of evaluators blinded to the gold standard diagnosis, one epileptologist and one neurologist, to predict the correct diagnosis in two steps: Step 1 (home video alone) and Step 2 (patient's and witness' questionnaires).

Results: Ninety-four videos (48 ES; 45 FS; 1 other), obtained from 36 patients, were independently evaluated by the 16 reviewers, providing a total of 188 assessments. Diagnostic accuracy for the whole group was 55.3% among epileptologists

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and 48.9% among neurologists ($p = 0.6892$) but was significantly higher in the FS subgroup (71.1%) compared to ES (41.7%) ($p = 0.0043$).

Significance: Diagnostic accuracy was moderate, without significant differences between epileptologists and neurologists, while it was higher for FS compared to ES. The addition of questionnaires did not improve accuracy. Eye closure for FS and abrupt ending for ES emerged as the only diagnostic signs. Thus, homemade videos have a role in differentiating these disorders.

Plain Language Summary: This study aimed to assess if home videos can distinguish epileptic seizures from functional seizures. Patients over 14 years from six Italian centers recorded videos of their episodes and answered questionnaires. Data were evaluated by epileptologists and neurologists. Results showed moderate diagnostic accuracy, with higher accuracy for functional seizures compared to epileptic seizures. Key diagnostic signs included eye closure for functional seizures and abrupt endings for epileptic seizures. Questionnaires did not improve accuracy. In conclusion, home videos can help differentiate these events.

KEYWORDS

differential diagnosis, epilepsy, functional seizures, home video, non-epileptic events

1 | INTRODUCTION

The differential diagnosis between epileptic seizures (ES) and paroxysmal non-epileptic manifestations (functional seizures (FS), parasomnias, movement disorders, and syncope) is part of daily clinical practice and is often difficult. FS, as well as ES, do not have uniform semiology and can be differentiated into subclasses.[1,2] In addition, FS can occur in patients who also have ES.[3]

The current gold standard for differentiating these types of events recommends recording attacks on video with concurrent electroencephalographic (EEG) and electrocardiographic (ECG) monitoring.[4] This approach requires the use of costly, often difficult-to-access, instrumentation. Furthermore, the recording of a typical event may be missed.[5]

In some cases, the semiology of a typical event captured on video provides sufficient features to predict the correct diagnosis.[6] Based on such evidence, an increasing number of neurologists/epileptologists are taking advantage of home video recordings of the events to support the diagnosis. Also, at times, patients spontaneously bring or send these homemade videos to their clinicians. The potential to bypass the concurrent EEG requirement is particularly appealing whenever access to monitoring facilities is limited. Still, while the semiology displayed on video in some cases clearly indicates the diagnosis, in others it does not. Additionally, homemade videos in most cases miss the event onset, which may be crucial for establishing the diagnosis. Therefore, the reliability of this approach remains an open question. An objective evaluation of the diagnostic contribution of home videos compared to the gold standard is still lacking. Furthermore, there is emerging evidence that review of systems' (ROS) inquiries,[7,8] self-assessment questionnaires,[9–12] linguistic analysis,[13,14] and a number of biomarkers[15] may contribute additional useful information in such cases.[16–18] In an important recent study about this topic, when histories and physical examination results were combined with smartphone videos, accuracy rose from 78.6% to 95.2%.[19]

Thus, the aims of the present study were the following: (1) to evaluate if a home video can be an effective tool in differentiating functional seizures (FS) from other events (epileptic seizures, syncope, parasomnias, movement disorders, etc.) as compared to the recommended

Key points

- The contribution of home video in the differential diagnosis between epileptic and functional seizures is still under investigation.
- This Italian cohort study confirms that a home video can be an effective tool in differentiating functional seizures from other events.
- Home video cannot substitute video-EEG monitoring but can be an effective tool as an extension of history taking.

gold standard approach; (2) to evaluate if the diagnostic accuracy of video alone is improved by the addition of specific demographic and historical information provided by structured questionnaires self-reported by patients and witnesses; (3) to identify specific signs and symptoms that discriminate FS from other disorders.

2 | METHODS

This is an observational, multicenter study conducted in six Italian epilepsy centers, distributed throughout the national territory, all equipped with video-EEG monitoring facilities. Between January 2021 and November 2023, we recruited all consecutive subjects above the age of 14 who presented to the centers experiencing paroxysmal events of uncertain nature. In addition, we included those already followed at the center with a confirmed diagnosis.

The conditions to participate were the ability to sign the informed consent, commitment to produce home video recordings of the typical events made by a family member, and willingness to fill the structured questionnaires. The admission age was lowered to 14 years because recurrent paroxysmal events, particularly FS, are likely to occur in adolescents. Subjects with double diagnosis of ES and FS were not included in the study. Subjects living alone were automatically excluded.

Each patient underwent a full diagnostic investigation performed by the clinical team based on the following: comprehensive review of the patient's history, complete neurological examination, psychological assessment, brain imaging, video-EEG, and cardiac monitoring, including induction procedures when needed, and any other instrumental tests appropriate for the case (i.e., tilt table testing, if suspecting syncope). All subjects who completed the whole clinical investigation received the gold standard diagnosis based on those findings. Video-EEG was performed in all patients who had a final diagnosis of FS and in those with ES whenever the diagnosis was in doubt. In addition, all other necessary diagnostic investigations (EEGs, imaging, other clinical or instrumental/laboratory examinations appropriate for the case) were performed, as specified above. After the informed consent was signed, a designated family member or friend was instructed to record on a smart phone typical events that may occur at home and return the videos to the investigating team. All participants were instructed to record the events as extensively as possible, with full frontal view of body and face. In addition, each participating patient and one family member or friend most familiar with past events (witnesses) were asked to fill out independently two distinct self-reporting questionnaires. The patient's questionnaire reviewed in detail the patient's history, possible risk factors and all subjective experiences that may be related to the events. The witness' questionnaire investigated characteristic signs and manifestations commonly observed during the unfolding of the events. The patient's questionnaire consisted of two parts. One concerned patient's demographic data, seizure history, symptoms before, during, and after the attack, history of abuse, and other symptoms or disorders (Part 1). The other explored perceived stress, emotion regulation, coping strategies, personality traits, social ability, anxiety, depression, and self-harm (Part 2).

Home video samples, responses to questionnaires, and the gold standard diagnosis were filed into a central database at the coordinating center.

A pool of 16 raters (8 epileptologists and 8 general neurologists), blinded to the gold standard diagnosis, reviewed the home video samples provided by recruited subjects.

Epileptologists were neurologists working in epilepsy centers dealing primarily with subjects with seizure disorders, while general neurologists were physicians dealing primarily with a variety of neurological diseases. The epileptologists were identified within the epilepsy centers where the study participants were enrolled. Each epileptologist was asked to identify a competent general neurologist to act as a co-reviewer. The study coordinator assigned each video to a random pair of raters (one epileptologist, one neurologist) for review with the exception of videos provided by patients enrolled in the same center where the assigned raters were affiliated. This assured that one epileptologist and one general neurologist reviewed the same video, both blinded to the gold standard diagnosis. Each rater was assigned the following tasks: Step 1: (a) after viewing the video, predict the diagnosis out of four possible choices: ES, FS, other type of seizures (i.e., syncope, movement disorder, parasomnia), cannot say; (b) mark on a 5-point Likert's scale the degree of confidence in the diagnosis of choice: very low, moderately low, neutral, moderately high, very high; (c) explain in writing the reasons why they opted for the diagnosis of choice; Step 2: repeat the same evaluation after having surveyed the responses to the self-reporting questionnaires submitted by patients and witnesses.

The primary outcome was the percentage of diagnosis correctly predicted using the gold standard diagnosis as reference (accuracy) by epileptologists and, separately, by general neurologists, after reviewing the same home videos (Step 1).

The secondary outcomes were: the accuracy of the diagnosis made by epileptologists and general neurologists after the additional review of patients' and witnesses' questionnaires (Step 2); the accuracy of epileptologists and general neurologists at Step 1 and Step 2 according to seizure type (FS, ES, and other types of seizures); the percentage of epileptologists and general neurologists with different levels of confidence in the diagnosis of choice at

Step 1 and Step 2; the percentage of cases with key signs and symptoms detected in home videos of patients with a definite gold standard diagnosis of FS, ES, or other types of seizures.

2.1 | Statistical analysis plan

Descriptive statistics were reported for demographic and clinical characteristics of the sample. Categorical variables were described by counts and percentages, continuous variables using means with standard deviations, medians, and ranges, as appropriate.

Accuracy was calculated as the percentage of cases correctly diagnosed by the raters, and reported with a 95% binomial confidence interval for epileptologists and general neurologists, in the entire sample and in subgroups. Accuracy was compared between epileptologists and general neurologists, and between Step 1 and Step 2, using McNemar's test. Differences in accuracy between subgroups defined according to gold standard diagnosis were evaluated with the chi-square or the Fisher's exact test.

The level of confidence in the diagnosis of choice at Step 1 and Step 2 was described as the percentage of very low, moderately low, neutral, moderately high, and very high level of confidence. Data were presented in the entire sample and for FS, ES, and other types of seizures. All signs and symptoms listed as diagnostic by epileptologists were extrapolated from their individual notes and categorized by an experienced and reliable general neurologist (MP) blind to the gold standard diagnoses. The number and percentage of subjects with FS, ES, or other types of seizures who presented specific signs and symptoms were reported. For each sign and symptom, differences between FS, ES, and other types of seizures were tested with the chi-square or the Fisher's exact test. For each sign and symptom showing a statistically significant difference, sensitivity and specificity for the diagnosis of FS versus a diagnosis of ES or other types of seizures were also calculated. The same analysis was performed for signs and symptoms identified in patients' and witnesses' questionnaires.

2.2 | Sample size calculation

Based on a previous study indicating that trained epileptologists, after viewing blindly hospital-made videos, can predict the correct diagnosis in about one third of cases,[6] we assumed that after reviewing a homemade video, an epileptologist will predict the correct diagnosis in about 30% of cases. Thus, with 96 home videos available, the study has >99% probability of providing a 95% confidence interval (CI) with a half width of 10% for that percentage (i.e., 95% CI 20%–40%).

3 | RESULTS

A total of 94 home videos were included and assessed by 16 reviewers (8 epileptologists and 8 neurologists), providing a total of 188 evaluations (94 performed by an epileptologist and 94 by a neurologists). Home videos were provided by a total of 36 subjects (21 FS, 14 ES, 1 other), whose main demographic and clinical characteristics are summarized in Table 1.

In the case of patients providing more than one home video ($n = 14$), the videos were distributed at random to different raters belonging to a different center.

Nineteen additional subjects were originally enrolled but were not included because they were unable to provide a home video. According to the gold standard diagnosis, 48 home videos came from patients with ES, 45 from patients with FS, and one from a subject with paroxysmal ataxia. Patients with a dual diagnosis of ES and FS and those with multiple seizure types were excluded.

3.1 | Diagnostic accuracy

Table 2 shows the diagnostic accuracy of epileptologists and general neurologists at Step 1 and Step 2. Diagnostic accuracy at Step 1 was 55.3% among epileptologists and 48.9% among neurologists, without significant differences ($p = 0.6892$). In approximately 10% of cases, the diagnosis was not determined ("cannot say") by epileptologists, and in 9% by general neurologists.

At Step 2, 5 videos were excluded from the analyses because no questionnaires were collected from the corresponding subjects. Of the 89 videos included, 44 were ES, 44 were FS, and 1 was episodic ataxia. In 12 videos, Part 2 of the patient's questionnaire was not available, while for one video the witness questionnaire was missing. Raters' accuracy was 58.4% for epileptologists and 51.7% for neurologists, without significant differences by type of reviewer ($p = 0.3558$). Accuracy obtained at Step 2 was not significantly different from that obtained at Step 1, for both epileptologists ($p = 0.1118$) and neurologists ($p = 0.7505$).

The percentages of undetermined diagnoses were 8% and 7% for epileptologists and neurologists.

Table 3 shows diagnostic accuracy after excluding videos with an undetermined diagnosis. At Step 1, accuracy rose to 61.9% for epileptologists and 53.5% for neurologists while at Step 2, accuracy rose to 64.2% for epileptologists and 55.4% for neurologists.

TABLE 1 Demographic and clinical characteristics of the study sample.

Age	
Years, median (IQR)	42 (30–50)
Sex	
Female, *n* (%)	22 (61.1)
Male, *n* (%)	14 (38.9)
Marital status	
Single, *n* (%)	11 (30.6)
Separated/divorced, *n* (%)	2 (5.6)
Married, *n* (%)	23 (63.8)
Widow, *n* (%)	0 (0.0)
With whom do you live?	
With roommates, *n* (%)	1 (2.8)
With parents, *n* (%)	8 (22.2)
With spouse/partner, *n* (%)	27 (75.0)
Alone, *n* (%)	0 (0.0)
Highest level of education	
Primary school, *n* (%)	3 (8.3)
Middle school, *n* (%)	15 (41.7)
High school diploma, *n* (%)	17 (47.2)
College degree and beyond, *n* (%)	1 (2.8)
Work status	
Unemployed, *n* (%)	20 (55.6)
Employed, *n* (%)	7 (19.4)
Student, *n* (%)	2 (5.6)
Other, *n* (%)	7 (19.4)
Age at seizure onset	
Years, median (IQR)	27 (15–38)
Seizure frequency in a month	
0–2, *n* (%)	9 (28.1)
3–5, *n* (%)	9 (28.1)
6–10, *n* (%)	2 (6.3)
>10, *n* (%)	12 (37.5)
Disability benefits	
Proportion, *n* (%)	21 (60.0)

Abbreviation: IQR, interquartile range.

3.2 | Diagnostic accuracy according to seizure type

The diagnostic accuracy at Steps 1 and 2, among epileptologists and neurologists, in the subgroups defined by seizure type (ES, FS, or other types of seizures) is shown in Table 4.

At Step 1, the diagnostic accuracy in FS videos was 71.1% for epileptologists and 62.2% for neurologists. In the subgroup of ES, accuracy was 41.7% for epileptologists and 37.5% for neurologists. Diagnostic accuracy was significantly higher in FS than in ES for both epileptologists and general neurologists ($p = 0.0043$ for epileptologists; $p = 0.0172$ for neurologists). As reported in Table 3, the accuracy in subgroups of ES and FS, obtained after excluding cases with undetermined diagnoses, increased for both epileptologists and neurologists. In particular, epileptologists reached a value of 78.0% in FS at Step 1 and 75.6% at Step 2.

3.3 | Level of confidence in the diagnosis

Table 5 describes the level of confidence in the diagnosis of choice at Step 1 and Step 2 for epileptologists and neurologists.

At Step 1, epileptologists declared that their level of confidence in the predicted diagnosis was moderately high or very high in 64% of videos, was neutral in 12%, and moderately low or very low in 24%. Similar results were observed for neurologists. The distribution of levels of confidence among neurologists was similar also for FS and ES. As shown in Table 3, considering only videos for which the reviewer declared a high or very high level of certainty and excluding the undetermined diagnoses, diagnostic accuracy rose to 66.7% for epileptologists and 58.5% for neurologists in the entire sample, and to 81.3% for epileptologists and 76.9% for neurologists in the case of FS.

At Step 2, in 66% of cases, the level of certainty in the chosen diagnosis declared by the epileptologists was

TABLE 2 Diagnostic accuracy at Step 1 and Step 2.

Step	Reviewers	*N* exact diagnoses	Diagnostic accuracy, % (95% CI)	*p*-Value epileptologists versus neurologists	*p*-Value Step 1 versus Step 2 epileptologists	*p*-Value Step 1 versus Step 2 neurologists	*N* (%) of not determined diagnoses
Step 1	Epileptologists	52	55.3 (44.7–65.6)	0.6892	0.1118	0.7505	10 (10.6)
	Neurologists	46	48.9 (38.5–59.5)				8 (8.5)
Step 2	Epileptologists	52	58.4 (47.5–68.8)	0.3558			8 (9.0)
	Neurologists	46	51.7 (40.8–62.4)				6 (6.7)

Abbreviation: CI, confidence interval.

TABLE 3 Diagnostic accuracy at Step 1 and Step 2 by gold standard diagnosis after excluding not-determined diagnosis and considering levels of certainty "high" or "very high."

Step	Reviewers	Gold standard diagnosis	*N* predicted diagnoses	*N* exact diagnoses	Diagnostic accuracy (%)	*N* not predicted diagnoses
Not-determined diagnosis excluded						
Step 1	Epileptologists	FS	41	32	78.0	4
		Epilepsy	42	20	47.6	6
		Other	1	0	0.0	0
	Neurologists	FS	43	28	65.1	5
		Epilepsy	43	18	41.9	2
		Other	0	0	–	1
Step 2	Epileptologists	FS	41	31	75.6	3
		Epilepsy	39	21	53.8	5
		Other	1	0	0.0	0
	Neurologists	FS	43	29	67.4	1
		Epilepsy	40	17	42.5	4
		Other	0	0	–	1
Not-determined diagnosis excluded, levels of certainty "high" or "very high" only						
Step 1	Epileptologists	FS	32	26	81.3	0
		Epilepsy	28	14	50.0	0
		Other	0	0	–	0
	Neurologists	FS	26	20	76.9	0
		Epilepsy	27	11	40.7	0
		Other	0	0	–	0
Step 2	Epileptologists	FS	29	24	82.8	0
		Epilepsy	29	16	55.2	0
		Other	1	0	0.0	0
	Neurologists	FS	20	15	75.0	0
		Epilepsy	19	6	31.6	0
		Other	0	0	–	0

TABLE 4 Diagnostic accuracy at Step 1 and Step 2 by gold standard diagnosis.

Step	Reviewers	Gold standard diagnoses	*N* of exact diagnoses	Diagnostic accuracy, % (95% CI)	*p*-Value[a]	*N* (%) of not determined diagnoses
Step 1	Epileptologists	FS	32	71.1 (55.6–83.6)	0.0043	4 (8.9)
		ES	20	41.7 (27.6–56.8)		6 (12.5)
		Other	0	0.0		0 (0.0)
	Neurologists	FS	28	62.2 (46.5–76.2)	0.0172	2 (4.4)
		ES	18	37.5 (24.0–52.7)		5 (10.4)
		Other	0	0.0		1 (100.0)
Step 2	Epileptologists	FS	31	70.5 (54.8–83.2)	0.0301	3 (6.8)
		ES	21	47.7 (32.5–63.3)		5 (11.4)
		Other	0	0.0		0 (0.0)
	Neurologists	FS	29	65.9 (50.0–79.5)	0.0104	1 (2.3)
		ES	17	38.6 (24.3–54.5)		4 (9.1)
		Other	0	0.0		1 (100.0)

Abbreviations: CI, confidence interval; ES, epileptic seizures; FS, functional seizures.

[a]Chi-square test for differences in diagnostic accuracy between gold standard diagnoses; the category "Other" was excluded.

moderately high or very high; in 9% it was neutral and in 25% it was moderately low or very low. The distribution of levels of certainty in videos of FS and ES was comparable. As reported in Table 3, considering only videos for which the reviewer declared a high or very high level of certainty, and excluding the cases with undetermined diagnosis, the diagnostic accuracy was 67.8% for epileptologists and 53.8% for neurologists in the entire sample, and was 82.8% for epileptologists and 75.0% for neurologists in FS.

3.4 | Diagnostic signs identified in home videos

Table 6 shows all the signs identified by epileptologists and their frequency in the 94 videos evaluated, divided according to the gold standard diagnosis.

Only two of the signs identified (abrupt ending of the seizure and eyes closed) were distributed in a significantly different way between the two groups of events. A third sign (irregular movements) showed a significantly different distribution but at the 0.1 level of significance.

True positive and negative, false positives, and false negatives for a diagnosis of FS, along with sensitivity and specificity for these three signs, are shown in Table 7.

The abrupt ending of seizures was identified only in the home videos of all patients with epileptic seizures (sensitivity of 100% for epilepsy).

Closed eyes and irregular movements were associated with the diagnosis of FS, with a sensitivity of 36% and 16%, and a specificity of 96% for both signs.

4 | DISCUSSION

Our study confirms what was reported by previous investigators that home video recordings can lead to the correct diagnosis.[20,21] We found that the overall diagnostic accuracy of home videos, recorded after adequate instructions and screened by experienced raters, was 55.3% among epileptologists and 48.9% among general neurologists. Such a level of accuracy is no more than moderate although the level of confidence in the diagnosis of choice expressed by both epileptologists and neurologists was "high" or "very high" in the majority of cases. Furthermore, our study

TABLE 5 Level of confidence in the diagnosis of choice.

Reviewers	Level of confidence	Total, *n* (%)	FS, *n* (%)	ES, *n* (%)	Other, *n* (%)
Step 1					
Epileptologists	Very low	11 (11.7)	5 (11.1)	6 (12.5)	0 (0.0)
	Moderately low	12 (12.8)	6 (13.3)	6 (12.5)	0 (0.0)
	Neutral	11 (11.7)	2 (4.4)	8 (16.7)	1 (100.0)
	Moderately high	39 (41.5)	22 (48.9)	17 (35.4)	0 (0.0)
	Very high	21 (22.3)	10 (22.2)	11 (22.9)	0 (0.0)
Neurologists	Very low	12 (12.8)	4 (8.9)	7 (14.6)	1 (100.0)
	Moderately low	4 (4.3)	2 (4.4)	2 (4.2)	0 (0.0)
	Neutral	25 (26.6)	13 (28.9)	12 (25.0)	0 (0.0)
	Moderately high	32 (34.0)	17 (37.8)	15 (31.3)	0 (0.0)
	Very high	21 (22.3)	9 (20.0)	12 (25.0)	0 (0.0)
Step 2					
Epileptologists	Very low	9 (10.1)	4 (9.1)	5 (11.4)	0 (0.0)
	Moderately low	13 (14.6)	8 (18.2)	5 (11.4)	0 (0.0)
	Neutral	8 (9.0)	3 (6.8)	5 (11.4)	0 (0.0)
	Moderately high	41 (46.1)	16 (36.4)	24 (54.6)	1 (100.0)
	Very high	18 (20.2)	13 (29.6)	5 (11.4)	0 (0.0)
Neurologists	Very low	11 (12.4)	4 (9.1)	6 (13.6)	1 (100.0)
	Moderately low	6 (6.7)	4 (9.1)	2 (4.6)	0 (0.0)
	Neutral	33 (37.1)	16 (36.4)	17 (38.6)	0 (0.0)
	Moderately high	22 (24.7)	9 (20.5)	13 (29.6)	0 (0.0)
	Very high	17 (19.1)	11 (25.0)	6 (13.6)	0 (0.0)

Abbreviations: ES, epileptic seizures; FS, functional seizures.

TABLE 6 Frequency of the signs identified by epileptologists in the home videos.

	FS, *n* (%)	ES/Other, *n* (%)	*p*-Value
Abrupt onset	0 (0.0)	2 (4.1)	0.4955
Abrupt ending	0 (0.0)	7 (14.3)	**0.0128**
Long duration	4 (8.9)	3 (6.1)	0.7063
Short duration	1 (2.2)	3 (6.1)	0.6182
Preserved awareness	2 (4.4)	5 (10.2)	0.4381
Impaired awareness	1 (2.2)	2 (4.1)	1.0000
Fixed gaze	1 (2.2)	1 (2.0)	1.0000
Closed eyes	16 (35.6)	2 (4.1)	**0.0001**
Eyes open	5 (11.1)	2 (4.1)	0.2537
Eyes deviated	0 (0.0)	2 (4.1)	0.4955
Atypical eye movements	4 (8.9)	1 (2.0)	0.1900
Hypertonic/hypermotor movements	0 (0.0)	4 (8.2)	0.1183
Fixed position, no movement	1 (2.2)	1 (2.0)	1.0000
Non-critical movements	5 (11.1)	2 (4.1)	0.2537
Head nodding	1 (2.2)	1 (2.0)	1.0000
Side-to-side head movement	1 (2.2)	1 (2.0)	1.0000
Gestural movements	1 (2.2)	5 (10.2)	0.2061
Rhythmic movements	1 (2.2)	3 (6.1)	0.6182
Irregular movements	7 (15.6)	2 (4.1)	**0.0819**
Tremors	0 (0.0)	2 (4.1)	0.4955
Akinetic movements	1 (2.2)	0 (0.0)	0.4787
Agitation	2 (4.4)	0 (0.0)	0.2265
Loss of saliva	1 (2.2)	2 (4.1)	1.0000
Cry	1 (2.2)	0 (0.0)	0.4787
Stertorous breathing	0 (0.0)	2 (4.1)	0.4955
Irregular breathing	0 (0.0)	2 (4.1)	0.4955
Hyperventilation	1 (2.2)	0 (0.0)	0.4787
Reaction to external stimuli	1 (2.2)	5 (10.2)	0.2061
Voluntary reactions	2 (4.4)	0 (0.0)	0.2265
Trunk arching	0 (0.0)	3 (6.1)	0.2433
No reaction to stimuli	3 (6.7)	1 (2.0)	0.3463
Seizure during sleep	0 (0.0)	1 (2.0)	1.0000
Buccal automatisms	5 (11.1)	3 (6.1)	0.4733

Note: Statistically significant at the 0.05 level of significance in bold.

Abbreviations: ES, epileptic seizures; FS, functional seizures.

TABLE 7 Sensitivity and specificity of the three statistically significant signs for the diagnosis of functional seizure.

	True-positive	False-positive	False-negative	True-negative	Sensitivity (95% CI)	Specificity (95% CI)
Abrupt ending of seizures	0	7	45	42	0.0	85.7 (75.9–100.0)
Closed eyes	16	2	29	47	35.6 (21.6–49.5)	95.9 (90.4–100.0)
Irregular movements	7	2	38	47	15.6 (5.0–26.1)	95.9 (90.4–100.0)

Abbreviation: CI, confidence interval.

shows that, excluding the cases where the diagnosis could not be determined due to insufficient evidence displayed on the video, diagnostic accuracy increased to 61.9% for epileptologists and 53.5% for neurologists. Likewise, considering only cases with "high" or "very high" levels of certainty in the diagnosis of choice,

accuracy increased further to 66.7% for epileptologists and 58.5% for neurologists.

Success rate in establishing the correct diagnosis by home video alone depends on multiple factors. First, it depends on the frequency of the attacks during the observation period. Second, homemade videos are not as easy to obtain as one would expect. In our sample, a home video was not recorded in 34% of the originally enrolled cases (19 out of 55 total) because no attacks occurred during the study period or, if they occurred, did not get recorded. Most importantly, the level of accuracy varies according to the type of seizure under scrutiny, strongly favoring FS versus ES. One possible explanation could be that FS tend to be more prolonged, and therefore are easier to capture in a home video, and are likely to be associated with highly diagnostic and visible signs easy to detect if the patient is properly displayed.

There are few data available in the literature for comparison. The impact of home videos on diagnosis was explored in three recent studies.[19,20,22] The first study reports an accuracy of 81.9% with only home videos, but it rose to 95.5% after adding medical history and physical examination.[19] In the second, accuracy ranged from 49% to70% depending on video quality,[20] while in the third it was 88%.[22] Notably, the latter study by Karakas et al.[22] focused on a cohort with a higher rate of FS, for which home videos specifically demonstrate higher accuracy.

We found no significant difference between neurologists and epileptologists in reaching the correct diagnosis by simply inspecting the home video alone. Previously published data are mixed, indicating that diagnostic accuracy for seizures is better for neurologists than for medical students[23]; better for epileptologists than for neurology residents[24] though this can be improved with video training.[25] On the other hand, the study by Ramanujam et al. indicates that epilepsy fellows evaluating home videos and expert epileptologists interpreting the findings of video-EEG monitoring in the same subjects reached highly concordant diagnoses despite the different levels of expertise and the different sources of material examined.[20]

According to the recommendations of the ILAE study group,[4] in order to reach a reliable diagnosis, the results of the video-EEG monitoring should be corroborated by a concordant medical history. Contrary to our expectation, the addition of self-reported clinical and historical information (the questionnaires) did not change significantly the raters' accuracy. This is probably due to the fact that raters focused mainly on visual clues, how the body moved, whether the eyes were open or closed, paying lesser attention to further inputs such as the subjects' medical history.

We also evaluated the raters' diagnostic accuracy by seizure types (FS, ES, or other) and found that FS were significantly easier to identify on home videos than ES. The easier recognition of FS compared to ES may be due to the presence of specific signs (i.e., eye closure) or to the longer duration of the attack, two well-known characteristics of FS, both easily identifiable in a video recording of the event. The study by Tatum et al.,[19] also found a high diagnostic accuracy for FS (85.9%), although it was slightly lower than for ES (89.1%).

In our study, raters indicated that two signs were particularly helpful in reaching the diagnosis: abrupt ending of the seizure and eyes closure. Surprisingly, many other signs that have been reported as typical for ES were rarely mentioned by our raters as diagnostic (e.g., fixed gaze, stertorous breathing, automatisms). One possible explanation is that family members are more likely to record events, either FS or ES, with mild clinical semiology, that is, without respiratory distress or other life-threatening manifestations that would require urgent intervention. Other signs like fixed gaze and dissociated behavior like automatisms frequently occur in either syndrome. Therefore, they are not helpful in the differential diagnosis. Despite such inherent bias, our findings confirm that home videos of the typical events can be helpful, especially in the case of FS. Obviously, the accurate identification of FS is of paramount importance, as they are often misdiagnosed.[4,26,27]

This study has limitations. Firstly, the home videos assessed in our sample were obtained from a restricted cohort of patients. Initially, slow recruitment was mainly attributed to the Covid-19 pandemic. Subsequently, it appeared related to an underlying reluctance on the part of the caregivers to record the event. We must consider that accessibility to video facilities and familiarity with its use varies with the age and socio-economic status of the people involved.

In addition, family members may be naturally inclined to record more prolonged and more benign-looking events. Such preferential recording constitutes an additional bias that further limits the generalizability of our results. Third, only subjects with frequent episodes during the study period provided the opportunity to capture one or more events on video. However, it is important to note that patients with infrequent episodes will unlikely provide video documentation also during standard clinical procedures such as video-EEG monitoring. Thus, our sample was representative of typical clinical scenarios. Finally, our study sample included only one video of a paroxysmal event different from FS or ES. This is likely because other types of paroxysmal events tend to be referred to other facilities rather than epilepsy centers.

5 | CONCLUSION

Our findings support the notion that a simple, preliminary review of home videos, when available, can be helpful in the differential diagnosis between functional and epileptic seizures. The barriers and limitations previously mentioned, such as the low frequency of the events and the preference toward recording benign-looking events of longer duration, do not prevent a successful outcome, which favors FS over ES.

We must emphasize that instructing who records the events on how to perform a good-quality video is crucial to obtain informative recordings.

Clearly, at the current stage of knowledge, home videos can represent an effective screening device before resorting to full video-EEG monitoring, which remains the procedure of choice in case of uncertainty. Home videos represent a valuable extension of history taking by providing the visual component of the events. We conclude that homemade videos should be included in the clinical diagnostic arsenal. In particular, we recommend that new patients presenting for consultation be encouraged to provide home video recordings of their typical events, especially if FS are suspected.

However, though promising, this approach needs to be further investigated in larger cohorts and in different cultural settings.

AUTHOR CONTRIBUTIONS

Sara Gasparini: Drafting/revision of the article for content, including medical writing for content; major role in the aquisition of the data; study concepts and design; analysis and interpretation of the data. **Giorgia Giussani:** Drafting/revision of the article for content, including medical writing for content; major role in the aquisition of the data; study concepts and design; analysis and interpretation of the data. **Elisa Bianchi:** Drafting/revision of the article for content, including medical writing for content; study concepts and design; statistical analysis and interpretation of the data. **Adriana Magaudda:** Drafting/revision of the article for content, including medical writing for content; major role in the acquisition of the data; interpretation of the data. **Angelo Labate:** Acquisition of the data. **Angela Laganà:** Revision of the article for content, role in the acquisition of the data. **Chiara Martellino:** Revision of the article for content, role in the acquisition of the data. **Marina Casazza:** Revision of the article for content, role in the acquisition of the data. **Giuseppe Didato:** Revision of the article for content, role in the acquisition of the data. **Valentina Chiesa:** Revision of article for content, role in the acquisition of the data. **Maria Paola Canevini:** Acquisition of the data. **Vincenzo Belcastro:** Revision of the article for content, role in the acquisition of the data. **Tommaso Bocci:** Revision of the article for content, role in the acquisition of the data. **Elisabetta Domina:** Role in the acquisition of the data. **Angela La Neve:** Revision of the article for content, role in the acquisition of the data. **Stefano Meletti:** Revision of the article for content, role in the acquisition of the data. **Marco Poloni:** Drafting/revision of the article for content, including medical writing for content; major role in the acquisition of the data; analysis and interpretation of the data. **Ettore Salsano:** Revision of the article for content, role in the acquisition of the data. **Vittorio Velucci:** Revision of the article for content, role in the acquisition of the data. **Stefano Martini:** Web design. **Valentina Bova:** Role in the acquisition of the data. **Anna Mammì:** Role in the acquisition of the data. **Angelo Pascarella:** Role in the acquisition of the data. **Vittoria Cianci:** Role in the acquisition of the data, interpretation of the data. **Edoardo Ferlazzo:** Role in the acquisition of the data, interpretation of the data. **Umberto Aguglia:** Role in the acquisition of the data, interpretation of the data. **Giuseppe Erba:** Drafting/revision of the article for content, including medical writing for content; major role in the acquisition of the data; study concepts and design; analysis and interpretation of the data.

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DATA AVAILABILITY STATEMENT

Data can only be shared with the permission of the study coordinator.

ETHICS APPROVAL STATEMENT

All prospective participants and informants provided written informed consent before screening. These studies received favorable ethical approval from Calabria Region Ethics Committee (protocol registration n.212/2019) as coordinating center and from all the participating centers.

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