



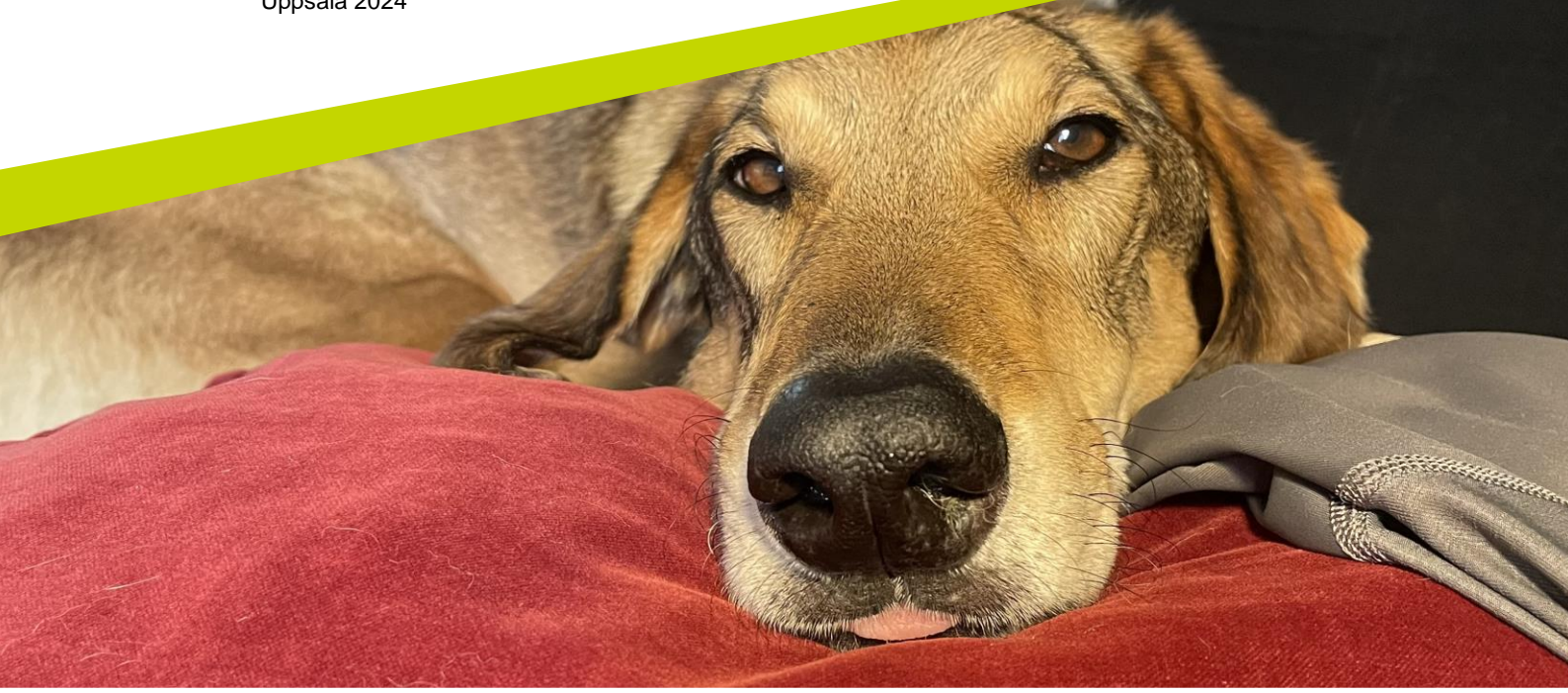
Symptoms and Behavior Changes During the Postictal Phase in Dogs with Idiopathic Epilepsy

A survey among dog owners and a behavioral observation study

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Swedish University of Agricultural Sciences, SLU
Faculty of Veterinary Medicine and Animal Science
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Abstract

Seizure conditions have been suggested to be the most common chronic neurological condition in dogs, with an estimated prevalence from 0.5% to 5.7%. One such condition is epilepsy. While epilepsy is not a diagnosis itself, it is a group of disorders that cause a predisposition for epileptic seizures. Idiopathic epilepsy (IE) is characterized by no indication of intracranial pathologies (including vascular, inflammatory/infectious, traumatic, anomalous/developmental, neoplastic and degenerative diseases) and a proven or suspected genetic background (A confirmed diagnosis of IE in genetically related individuals). There is a fair amount of terminology surrounding epileptic seizures, with *ictus* describing the seizure itself. The *postictal phase* refers to the period after ictus when the normal brain function is being restored.

There are reports of numerous symptoms and behaviors that are associated with the postictal phase in dogs with epilepsy, such as; hunger, fatigue, restlessness and ataxia, and the clinical manifestation varies largely between individuals. The International veterinary epilepsy task force (IVETF) current recommendation is to initiate medical treatment for patients with IE when the postictal symptoms are considered severe (for example aggression) or lasting over 24 hours. However, there is a paucity in the literature describing the postictal phase. To the authors knowledge there are no studies at the present time (2023) that describe postictal behavioral changes in detail and the existing reports regarding canine IE are only briefly mentioning the postictal period. Previous studies are based solely on dog owners' reports and no observational behavior studies with a standardized ethogram have yet been conducted.

The objective of this study was to further investigate what symptoms and behaviors are exhibited by dogs with IE during the postictal phase, using both the owners' descriptions of the postictal phase and observational study through video analysis. Additionally, this study investigated if some of the symptoms and behaviors can be missed by the pet owners. The purpose of this is to increase knowledge about the postictal phase that can be used by clinically practicing veterinarians to better evaluate an individual patient's need for starting medical treatment and to give practicing veterinarians further support for gathering a complete anamnesis.

The hypothesis was that the dog being "tired" would be the most frequently described postictal change based on dog owners' answers from the questionnaire, and that "resting" or "resting with eyes closed" would be the most registered behaviors from the video analysis.

A questionnaire was distributed to owners of epileptic dogs through social media, gathering information about their dog's epilepsy including questions about how the diagnosis was made, what medication their dog is being treated with, how the epileptic seizures are manifesting and what postictal changes they see in their dog. Dogs that did not meet the Tier I confidence level of diagnostic criteria for IE were excluded from the study. Owners whose dogs had a duration of the postictal phase no longer than 60 minutes were invited to further participate in this study and to film their dog's postictal phase. Dogs whose postictal period lasted for longer than 60 minutes were not invited to participate as the long period of filming in those cases was assessed to lower the dog owners' compliance. An ethogram was constructed based on previous reports and the owner's own description of the postictal phase and an observational behavioral study using continuous sampling

was used to analyze the video material provided by the owners. Only one video was obtained and after the video analysis was conducted, the owner received a follow-up questionnaire asking them to choose the behaviors they see in their dog from a list based on the ethogram.

The most described behavior based on the owners' answers was "restlessness", thus rejecting the hypothesis that "tired" was the most described postictal change. Numerous behaviors were described by the owners that have not been previously reported, indicating a large variety of clinical manifestations of the postictal phase. No statistically significant behavioral difference was found when comparing male and female dogs in the postictal phase.

Only one video of the postictal phase was obtained. "Proximity to owner" was found to be the behavior with the longest duration based on the video analysis, closely followed by "resting" and "ears back". When comparing the owner's answers on the follow-up questionnaire with the registered behaviors, the more subtle behavioral cues ("ears back", "wide eyes", "lip licking" and "sham chewing") were not recognized by the owner. In contrast, the more distinct behaviors ("proximity to owner", "resting" and "trembling") were correctly recognized and acknowledged by the owner. Further studies are required to investigate what behaviors dogs exhibit during the postictal phase and if some of these behaviors are harder to recognize by the owner.

Keywords: idiopathic epilepsy, canine epilepsy, postictal phase, symptoms, behavior, continuous observational study

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Abbreviations

IE	Idiopathic epilepsy
ILAE	International League Against Epilepsy
IVETF	International Veterinary Epilepsy Task Force
AEM	Antiepileptic medication

1 Introduction

Seizure conditions have been suggested to be the most common chronic neurological condition in dogs, with an estimated prevalence from 0.5% to 5.7% (Chandler 2006; O'Neill et al. 2021). One such condition is epilepsy. While epilepsy is not a diagnosis itself, it is a group of disorders that cause a predisposition for epileptic seizures (Fisher et al. 2005). In veterinary medicine these disorders are characterized by etiology. Structural epilepsy (SE) is caused by intracranial pathologies (including vascular, inflammatory/infectious, traumatic, anomalous/developmental, neoplastic and degenerative diseases) while idiopathic epilepsy (IE) is characterized by no indication of structural epilepsy and proven or suspected genetic background (a confirmed diagnosis of IE in genetically related individuals) (Berendt et al. 2015). There is a fair amount of terminology surrounding epileptic seizures, with *ictus* being a term that describes the seizure itself (Thomas 2010). The *postictal phase* refers to the period after ictus when the normal brain function is being restored (Berendt et al. 2015).

There are reports of numerous symptoms and behaviors that are associated with the postictal phase in dogs with epilepsy, such as; hunger, fatigue, restlessness and ataxia, and the clinical manifestation varies largely between individuals (Raw & Gaskell 1985; Jaggy & Bernardini 1998; Berendt & Gram 1999). The International veterinary epilepsy task force (IVETF) current recommendation is to initiate medical treatment for patients with IE when the postictal symptoms are considered severe (for example aggression) or lasting over 24 hours (Bhatti et al. 2015). However, the literature surrounding the postictal phase is still lacking. To the authors knowledge there are no studies at the present time (2023) that describe postictal behavioral changes in detail and the existing reports regarding canine IE are only briefly mentioning the postictal period. Previous studies are based solely on dog owners' reports and no observational behavior studies have yet been conducted.

The objective of this study was to further investigate what symptoms and behaviors are exhibited by dogs with IE during the postictal phase, using both the owners' descriptions of the postictal phase and observational study through video analysis. Additionally, this study will investigate if some of the symptoms and behaviors can be missed by the pet owners. The purpose of this is to increase knowledge about

the postictal phase that can be used by clinically practicing veterinarians to better evaluate an individual patient's need for starting medical treatment and to give practicing veterinarians further support for gathering a complete anamnesis.

The hypothesis was that the dog being "tired" or "fatigued" would be the most frequently described postictal change based on dog owners' answers from the questionnaire, and that "resting" or "resting with eyes closed" would be the most registered behaviors from the video analysis.

2 Literature overview

2.1 Epileptic seizures and epilepsy – definition of the terms

The word “*seizure*” is today often used in association with epilepsy. While seizures are indeed a clinical presentation of epilepsy, not all seizures are caused by an epileptic disorder. Both International League Against Epilepsy (ILAE) and International veterinary epilepsy task force (IVETF) define the term “*seizure*” as a sudden and transient event (Fisher et al. 2005; Berendt et al. 2015), but a seizure itself does not imply that the event is epileptic. Therefore, it is important to distinguish “epileptic seizures” from “reactive seizures”. Reactive seizures can, in general terms, be defined as seizures occurring as a natural response from the normal brain to a transient disturbance in function, metabolic or toxic in nature (Berendt et al. 2015). Reactive seizures are reversible when the disturbance in function is removed. That is not the case with “epileptic seizures”, where epilepsy is an underlying cause for seizure activity in the brain. In this paper, the term “epileptic seizures” will be referred to as “seizures”.

The term “Epileptic seizures” is used by ILAE to define a “transient occurrence of signs and/or symptoms due to abnormal excessive or synchronous neuronal activity in the brain” (Fisher et al. 2005). The definition itself contains 3 elements: nature of onset and termination, clinical manifestations, and enhanced neuronal synchrony. An epileptic seizure is an event with a clear start and finish and is limited in time. While the onset of the seizure is often distinct, the termination of a seizure can be harder to recognize because of the onset of postictal signs, which can make it challenging to distinguish if the seizure itself has ended or not. Clinical manifestation is a key element of the definition as a seizure is an event that can be observed, therefore signs and symptoms must be included as part of the definition. However, there is a wide range of clinical manifestation during a seizure (depending on location of onset in the brain, proliferation in the brain, confounding disease processes or medications) which makes it difficult to establish a detailed description of the symptoms. Enhanced neuronal synchrony is hard to apply in practice when

defining an epileptic seizure as patients with reoccurring seizures may have normal electroencephalography (EEG) during and in between seizures.

In veterinary medicine, IVETF has proposed to use a similar definition of an epileptic seizure. The term “epileptic seizure” is defined by Berendt et al. (2015) as manifestation(s) of abnormal excessive and/or synchronous epileptic activity in the brain, that results in a transient event of signs which may be characterized by short episodes with convulsions or focal motor, autonomic or behavioral features.

Both ILAE and IVETF defines epilepsy as not one condition but a family of disorders with different aetiologies that all have in common an abnormally increased predisposition to epileptic seizures (Fisher et al. 2014; Berendt et al. 2015). Another similarity between human and veterinary medicine is that epilepsy can be defined as an occurrence of two unprovoked epileptic seizures >24 hours apart.

2.2 Seizure classification

2.2.1 Generalized seizures

General-onset seizures refer to seizures where the clinical symptoms indicate involvement of both cerebral hemispheres (Thomas 2010; De Risio 2014a). The loss of motor function is bilateral and consciousness is often impaired.

The term “primary generalized” can often be seen used in veterinary medicine and refers to clinical manifestations that indicate involvement of both hemispheres from the onset of the seizure (De Risio 2014a). That is to differentiate from focal onset seizures that evolve into a generalized seizure, referred to as “secondarily generalized” seizures.

The most common type of generalized seizure is with tonic-clonic contractions (Heynold et al. 1997; Jaggy & Bernardini 1998). The first part of the seizure is a tonic phase which is recognized by contraction of all muscles, which results in rigid extension of all limbs and opisthotonos (Heynold et al. 1997; De Risio 2014a). The tonic phase lasts for about 30-60 s. (De Risio 2014a) and then transitions into a clonic phase distinguished by rhythmic contractions of the muscles, manifested as paddling or jerking of the limbs and chewing movements (Heynold et al. 1997). The clonic phase may alter with the tonic activity (De Risio 2014a). Irregular or absent respiration and cyanosis are common signs during a tonic-clonic seizure (Heynold et al. 1997; Jaggy & Bernardini 1998; De Risio 2014a). Usual signs in dogs with generalized tonic-clonic seizures include salivation, urination, defecation and mydriasis, although these signs are not constant for all dogs (De Risio 2014a).

Tonic seizures refers to seizures that are characterized by only a tonic phase without a clonic phase (Heynold et al. 1997). In contrast, clonic seizures are characterized by repetitive, sudden, brief involuntarily contractions of muscle groups that are prolonged (De Risio 2014a). In both tonic and clonic seizures impairment of consciousness and autonomic signs can be present. Tonic or clonic seizures alone have uncommonly been reported in dogs (Heynold et al. 1997; Licht et al. 2002).

Being unresponsive to stimuli is a typical symptom in dogs with generalized seizures and is often reported by the owners, although not all dogs lose consciousness during a generalized seizure (Raw & Gaskell 1985; Heynold et al. 1997; Jaggy & Bernardini 1998).

2.2.2 Focal seizures

When the clinical signs indicate that the abnormal neuron activity is localized in a particular region of a cerebral hemisphere, the seizure is referred to as “focal seizure” (Jaggy & Bernardini 1998; De Risio 2014a).

Focal motor seizures are distinguished by involuntary, often unilateral, abnormal movement of a body part (Heynold et al. 1997; De Risio 2014a). Clinical manifestation of such seizures may include rhythmic constriction of a muscle (often muscles in the head region), turning the head to one side, chewing movement or flexion and/or extension of one limb.

Focal autonomic seizures present with one or more autonomic manifestations, such as vomiting, mydriasis, urination, defecation and salivation (Licht et al. 2002; Berendt et al. 2004).

While the abnormal neuron activity is localized to one particular region of the brain, the focal seizure can spread to bilateral cerebral involvement thus causing secondarily generalized seizures (Berendt et al. 2015). The seizure will start as a focal motor or autonomic seizure to then evolve into a convulsive stage with bilateral tonic, clonic or tonic-clonic activity and loss of consciousness. The focal onset is often very short (seconds to minutes) and can therefore easily be missed by owners.

2.3 Phases of an epileptic seizure

When describing an epileptic seizure several terms are used: prodrome, aura, ictus, postictal phase and inter-ictal phase. Ictus refers to the seizure itself and in most cases lasts a few minutes (Thomas 2010). Ictus can consist of an generalized epileptic seizure, a focal epileptic seizure or a focal epileptic seizure that evolves

into a generalized epileptic seizure (Berendt et al. 2015). Ictus is followed by a postictal phase when ictus itself has ended and numerous of symptoms and behavioral changes may be seen. The postictal phase will be described closer in the next section.

A study from 2020 (Finnegan et al.) showed that 59.6% of owners believed they could predict their dog’s seizure. The most common sign of prediction reported in that study was behavioral changes with clinginess, restlessness, and signs of fear. Behavioral changes before a seizure are referred to as “prodrome” and is defined by the IVETF consensus report as a long-term change of character (Berendt et al. 2015). These changes can be seen hours-days before an epileptic seizure occurs. In addition, pet owners have reported that they can predict a seizure when specific and to the owner well known signs appear within seconds or minutes prior to the convulsion. The term “aura” has been used to describe these short-term changes. However, IVETF recommends that the term aura is not to be used in veterinary medicine (Berendt et al. 2015). They mean that the symptoms interpreted by the dog owners as short-term warning signs, are a focal seizure onset and should be referred to as such.

The inter-ictal phase refers to the time between an ictal event is resolved and the start of a new ictal event. The timeline of the different phases of a seizure can be found in Figure 1.

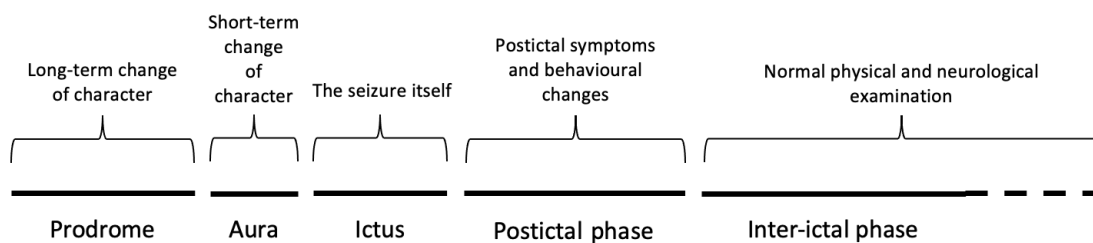


Figure 1. Phases of a seizure containing explanations as to what characterizes the phases in question.

2.3.1 Postictal phase

As mentioned before, the postictal phase occurs right after ictus is resolved, where the brains normal function is restored (Berendt et al. 2015). While the true prevalence of postictal signs in dogs with epilepsy is unknown, some studies have suggested a prevalence of 90-100% in study populations (Berendt & Gram 1999; Plonek et al. 2022).

Several symptoms and behavioral changes are associated with this phase. An example of this is a study carried out by Raw & Gaskell (1985) where dog owners reported hunger, thirst, disorientation, ataxia, excitement, attention seeking,

sleep/exhaustion and restlessness as postictal signs, with hunger being the most frequently reported sign. In contrast, Berendt & Gram (1999) has reported initial confusion followed by fatigue and deep sleep as the most common postictal signs. This is consistent with a study by Jaggy & Bernardini (1998) which also reported fatigue as the most dominant postictal sign. Other signs present in the study were blindness, hunger, thirst, mydriasis, disorientation, compulsive pacing, staggering, fear and barking.

Reports concerning the duration of the postictal phase varies in different studies. Jaggy & Bernardini (1998) showed that the postictal phase lasted between a few minutes up to two or more hours in dogs with epilepsy. On the other hand, Berendt & Gram (1999) reported that the postictal signs could be observed from 2 to 30 minutes after an epileptic seizure. However, some owners in the same study reported that their dog could appear depressed a couple of days following a seizure. Another study suggests that the postictal signs could last up to one hour (Raw & Gaskell 1985).

If the ictal phase affects the duration of the postictal period is still under debate. Koutinas et al. (1996 see Berendt & Gram 1999) has claimed that there is a correlation between the type, duration and/or intensity of a seizure and the duration of the postictal phase, while Berendt & Gram (1999) did not find any correlation in their study.

2.4 Idiopathic epilepsy

Several definitions of “idiopathic epilepsy” (IE) have been proposed over the years but to the authors knowledge there is still no consensus in veterinary medicine on how to define IE. IVETF has in their latest consensus report proposed to define “idiopathic epilepsy” as epilepsy with proven genetic background, epilepsy with suspected genetic background or epilepsy by unknown cause and no indication of structural epilepsy (Fisher et al. 2014).

The prevalence of IE among general dog populations have been estimated at 0.62-0.75% (Kearsley-Fleet et al. 2013; Heske et al. 2014b). In both studies it was shown that male dogs were more likely to have IE than females. In some dog breeds IE has been described having a genetic background, such as the Belgian tervueren (Famula et al. 1997), Labrador retrievers (Jaggy et al. 1998), English Springer Spaniels (Patterson et al. 2005), Irish wolfhounds (Casal et al. 2006), Belgian shepherd (Berendt et al. 2009) and Border collies (Hülsmeier et al. 2010). German shepherds and Boston terriers have also been reported to have increased odds of having IE (Kearsley-Fleet et al. 2013) compared to other dog breeds.

Most dogs with IE suffer their first epileptic seizure between 6 months and 6 years of age (Heynold et al. 1997; Jaggy & Bernardini 1998). In a study conducted by Pákozdy et al. (2008), dogs that had their first seizure between 1 and 5 years were 3.25 times more likely to be diagnosed with IE than structural epilepsy.

Some studies show that focal seizures with secondary generalization is the most common type of seizures in dogs with IE (Berendt & Gram 1999; Berendt et al. 2002, 2004, 2008; Licht et al. 2002). However Heynold et al. (1997) has suggested that generalized tonic-clonic seizures is the most common seizure type.

The mean seizure frequency in untreated dogs with IE varies, with some studies suggesting a mean 1.5-2.56 epileptic seizures per month (Gallucci et al. 2017; Stabile et al. 2019). It has been shown that seizures occur most frequently when the dog is sleeping and resting, with a study reporting that only 2.6% of dogs with IE had their seizure during a period of activity (Pákozdy et al. 2008).

In a study conducted by Pákozdy et al. (2008), the mean duration of an epileptic seizure in dogs with IE was 3.06 minutes, which supports Jaggy & Bernardini (1998) where 72% of the dogs in the study had ictal periods that lasted between 30 seconds to 5 minutes. This is consistent with Plonek *et al.* (2022) where 75% of the dogs had ictus that lasted up to 5 minutes. However, some dog owners have reported epileptic seizures that last more than 10 minutes (Jaggy & Bernardini 1998).

2.4.1 Diagnosis

The diagnosis of IE is based on exclusion of metabolic, toxic and structural cerebral disorders as a cause for seizures (De Risio et al. 2015). Furthermore, the diagnosis is strengthened by the age at epileptic seizure onset and normal inter-ictal physical and neurological examinations. The criteria for diagnosis of IE in companion animals is divided into different tiers to establish confidence levels of the diagnosis.

Tier I confidence level includes a patient history of two or more unprovoked seizures more than 24 hours apart, age at seizure onset between 6 months and 6 years, normal physical and neurological examination during the inter-ictal period and clinically insignificant findings on blood tests and urinalysis (De Risio et al. 2015). The blood tests must include complete blood cell count and a biochemistry serum profile. The urinalysis must consist of specific gravity, protein, glucose, pH, and sediment cytology. Confirmed diagnosis of IE in genetically related individuals can further support the diagnosis.

The neurological examination is crucial when establishing a diagnosis of IE. The goal of the neurological examination is to determine if the nervous system is affected and if that is the case, to identify a location and distribution of the lesion.

The presence of seizures is itself an indicator of a forebrain anomaly (De Risio 2014b). The neurological examination tests the functional integrity of the various components of the nervous system. It can be subdivided into evaluation of level of consciousness and behavior, posture, gait, cranial nerve function, postural reactions, muscle mass and tone, spinal nerve reflexes, nociception, and palpation of the head, spine and muscles.

It is important to remember that patients that are examined shortly after a seizure may present some abnormalities on the neurological exam. These can be associated with the postictal phase. In addition, some patients can have adverse reactions to certain antiepileptic medications which include obtundation, ataxia and decreased postural reactions. Neurological examinations should be repeated over time for these patients in both cases (De Risio 2014b).

Tier II confidence level includes analysis of fasting and post-prandial bile acids, MRI of the brain and CSF analysis in addition to the diagnostic tests listed in tier I (De Risio et al. 2015). If no abnormalities are found, the diagnosis of IE is supported.

In addition to diagnostics described in tier I and II, tier III confidence level includes identification of ictal or inter-ictal EEG abnormalities that are characteristic for seizure disorders (De Risio et al. 2015). However today there is no optimal protocol use for EEG in veterinary medicine and further research is needed to apply EEG in practice.

2.4.2 Treatment

The aim of long-term anti-epileptic treatment is to eliminate seizure activity (De Risio 2014c). If that is not possible the treatment should strive to decrease seizure frequency, duration and severity with no or tolerable adverse effects from antiepileptic medication (AEM)

There are today no evidence-based guidelines when choosing AEM for canine patients. The medication must therefore be chosen considering medication-specific factors (safety, tolerability, mechanism of action etc.), patient-related factors (seizure type, seizure frequency, seizure etiology) and pet owner-related factors (lifestyle, ability to cope with potential adverse effects, financial circumstances) (De Risio 2014c). Selection of AEM for treatment is therefore often determined by a case-case basis (Bhatti et al. 2015).

Evidence based guidelines as to when to start treatment with AED based on seizure frequency and type of seizure is also lacking. However, according to IVETF consensus proposal written by Bhatti et al. (2015), long term medical treatment for IE should be strongly considered when one or more of the following criteria is present:

- 2 or more epileptic seizures within a 6-month period.
- The patient is suffering from status epilepticus or cluster seizures.
- The postictal signs are considered especially severe (for example aggression) or last longer than 24 hours.
- The epileptic seizure frequency and/or duration is increasing and/or seizure severity is deteriorating over 3 interictal periods.

In addition to AEMs it is not uncommon for dog owners to use short term medication for acute management of epileptic seizures at home. Diazepam per rectum and Midazolam intranasally can be used by the owners to terminate an ongoing seizure at home (Podell 1995; Charalambous et al. 2017).

2.5 Observational behavior studies

Behavioral studies are an important tool in animal research for investigating animal welfare, identifying behaviors perceived as positive (such as foraging) and behaviors perceived as negative (such as stereotypies) (Carlstead et al. 1991; Fernandez & Timberlake 2008; Brereton et al. 2022). There are different types of sampling methods when conducting a behavioral study and choosing the suitable method depends on the researchers aim and hypothesis.

One of these methods is continuous recording. With this method, the researcher registers all occurrences of behavior and their durations. This method gives the opportunity to record the presence of a behavior, the frequency of a behavior and the percentage of time spent executing the behavior (Tyler 1979; Brereton et al. 2022). Continuous recording is therefore valuable when recording a *behavioral state* and a *behavioral event* (Spagnuolo et al. 2021). A behavioral state is best described as a prolonged activity, for example walking or lying down, and is best measured in duration. A behavioral event is an instantaneous body action, for example barking, and is measured in frequency. This type of sampling method can however be challenging when investigating behaviors of multiple animals in one group (Brereton et al. 2022). It may also be challenging when recording behaviors of an active animal that rapidly changes its behaviors. However the ability to record

behaviors to be analyzed later have eliminated many of these issues that are associated with continuous sampling (Amato et al. 2013).

A key element when conducting behavioral studies is an ethogram. An ethogram contains a catalog, specific for a species, of behaviors and a description of these behaviors (Lehner 1987; Spagnuolo et al. 2021). Ethograms can either be created from existing literature or from previous behavioral sampling. The descriptions should be detailed and should not contain the name of the behavior in its own description (Spagnuolo et al. 2021). Another important aspect of creating a definition is to describe a behavior with no regards of the animal's intent, a so-called *empirical description*. An empirical objectively describes the form and pattern of posture and movement associated with a given behavior, making it possible for someone who has no previous knowledge of animal behavior to recognize the behavior described.

3 Materials and methods

3.1 Literature search

The literature overview was done through a search for scientific published articles. The search was done through scientific databases PubMed, Google Scholar and Web of Science. Search words that were used included “epilepsy”, “idiopathic epilepsy”, “dog”, “canine”, “postictal”, “behavior”, “diagnosis”, “treatment”, “management”. References from articles were used to find further relevant literature.

3.2 Step I – initial questionnaire and distribution

A questionnaire was formed on the online survey website Netigate. The survey’s content was based on previously published articles concerning clinical manifestation of IE, the diagnostic approach and treatment. The purpose of this survey was to a) gain information about the duration and behaviors during the postictal phase, and b) to select individuals fit for the next stage of the study. The questionnaire was first constructed in Swedish and then translated to English by the author. The English translation was included to gain answers from pet owners outside of Sweden, thus widening the study’s reach. A few people were then asked to translate the questionnaire back to Swedish to validate the English translation. After the initial questionnaire was created, a few people were asked to answer the survey and leave feedback. The phrasing of some of the questions were then adjusted accordingly.

The first two pages of the survey included more information about the study and asked for contact information to the dog owner.

Next followed questions about their dogs age in half-years, breed, sex, if they were neutered or intact. Next followed general questions about their dog’s condition where the owners were asked if their dog suffers from seizures and if their dog has an established diagnosis of epilepsy. The term “idiopathic epilepsy” was not used

in the questionnaire to avoid confusion from the owners. Instead, the question asked if their dog was diagnosed with epilepsy without any signs of neoplasia, inflammatory disease, or other pathologies in the brain. The respondents were then asked to fill out information about how the diagnosis was established and at what age their dog had its first seizure in half-years.

Moreover, the questionnaire included questions about the clinical manifestation of their dog's seizures (generalized, focal or focal that evolve into generalized), seizure frequency and the average duration of an epileptic seizure. If the owners had at some point timed their dog's seizure duration, they were asked to write the time. The owners were also asked at what age their dog got its first seizure in and to answer in half-years.

Further, questions about their dog's medical treatment (if any) and use of acute medications to terminate an ongoing epileptic seizure at home were included. If the owner answered that they were using any kind of medication, the responder was asked to choose what drug or drugs from a list of the most frequently used AEMs and rescue drugs. The owners were also given the option "Other" if their choice of medication was not included in the list and were asked to specify what drug they were using instead.

Finally, the owners were asked if their dog experiences postictal symptoms. The term "postictal" was not used in the questions. Instead, the owners were asked if their dog was "its normal self" after a seizure. If the respondent answered "No" they were asked to describe what changes they see in their dog and how long it usually takes for them to recover.

The format of the questions varied, with most being multiple-choice questions where one or multiple answers were allowed. Some of the multiple-choice questions had a text box at the end to further specify the answer. A few questions asked only for answers written in an open text box. The whole questionnaire can be found as Appendix 1.

A webpage was constructed at SLUs official website, containing a short introduction of the study and a link to the questionnaire. The website and the direct link to the questionnaire was then distributed in Facebook groups for owners with dogs with epilepsy, from the author's private Facebook account. The data from the questionnaire was collected between 5/10-2023 and 14/11-2023.

3.3 Step II – Inclusion criteria

There were several criteria for participating in the next phase of the study. The first one is that the dog must suffer from seizures and be diagnosed with IE. Several questions were crucial for this purpose. If the owner answered that their dog did not suffer from seizures, or that it has been diagnosed with seizures caused by neoplasia, inflammatory disease, or other brain lesions, the dog was excluded from the next step. Furthermore, dogs that were diagnosed based only on medical history and normal physical and neurological examinations during the inter-ictal period did not meet the criteria for the next step. To meet the criteria for this study, the diagnostic workup should include at least blood analysis in addition to diagnostics mentioned earlier, thus meeting the Tier 1 confidence level of diagnostics described in an earlier section. Dogs that had their first seizure younger than at 6 months or older than 6 years of age were excluded, as they do not fit the Tier I confidence level of diagnostics. The second criteria were that the dog must show postictal symptoms or behavioral changes. Dogs that did not experience any postictal symptoms were excluded from the study.

3.4 Step III - video collection and video analysis

Owners of dogs that fit the criteria described in the previous section, and who in addition showed postictal changes for no longer than 60 minutes, received an e-mail inviting them to further participate and to film their dogs' postictal period. Dogs whose postictal period lasted for longer than 60 minutes were not invited to participate as the long period of filming in those cases was assessed to lower the dog owners' compliance. The email contained detail about the video collection and an owner agreement where the owner gave consent to analyse the video material and to store it for potential future projects. Only dogs whose owners agreed to the terms of participation were included in this study. The owners were asked to provide video material of their dogs postictal phase, a minimum of 30 minutes and a maximum of 60 minutes. The owners were asked to place the camera at the dog's eye level and so that the whole dog is visible and to start the recording at the end of the seizure or directly after a seizure. Furthermore, they were asked to place the camera so that the dog is visible obliquely from the front.

An ethogram was constructed based on previous studies and the preliminary data from the questionnaire. The ethogram contains definitions of behaviors and symptoms that dogs may present in the postictal phase (Table 1). The video material was analysed using continuous sampling using Behavioral Observation Research Interactive Software (BORIS). The data was then exported to Excel and presented

as diagrams using descriptive statistics. The values were rounded down to one decimal.

Table 1. Ethogram containing postictal behaviors and symptoms and their definitions based on existing literature and the owners' answers from the initial questionnaire

Behavior type	Behavior	Definition
Behavioral state	Hunger	To seek out and ingest food items.
Behavioral state	Thirst	To seek out and lap up liquid with the tongue.
Behavioral state	Ataxia	Walking with a lack of balance and/or coordination.
Behavioral state	Proximity to owner	The dog is within one body length of the owner.
Behavioral state	Resting	The dog is lying, in a ventral or lateral position, with all four legs resting.
Behavioral state	Resting with eyes closed	The dog is lying, in a ventral or lateral position, with all four legs resting. Eyes are closed.
Behavioral state	Running	Dog is moving at an accelerated pace, trotting or galloping.
Behavioral state	Compulsive pacing	To walk or trot uninterrupted in a circle or back and forth in a stereotypical manner.
Behavioral event	Yawning	The dog is inhaling with the mouth wide open, but not ingesting food or vocalizing.
Behavioral event	Lip licking	Repeated movement of the tongue directed toward the dog's own nose, lips, corners of the mouth.
Behavioral state	Tense posture	The dog is standing still, rigid, and/or crouches or cowers when approached. The head is kept low, beneath the level of the scapula.
Behavioral event	Barking	Loud, sharp vocalization, often repeated in quick succession.
Behavioral event	Whimpering/whining	A brief to medium length, often repetitive high-pitched vocalization, usually executed with a closed mouth.
Behavioral event	Growling	A low-pitched rumbling vocalization from the dog's throat.
Behavioral event	Screaming	A piercing, loud vocalization, usually executed with mouth open.
Behavioral event	Baring teeth	The dog's lips are pulled up, showing the teeth that become partly or totally visible.
Behavioral event	Bite	Taking any part of the recipient's body between its jaws while applying pressure.
Behavioral event	Snap	Attempting to bite while not moving more than a distance of 0,5 m towards the recipient, without physical contact.
Behavioral event	Lunge	Barking or attempting to bite while moving at high speed over a distance of 0,5 m towards the recipient, without physical contact.
Behavioral state	Drooling	Excessive production of saliva resulting in saliva running down lips or tongue.

Behavioral state	Panting	Breaths repeated in quick succession with mouth open, tongue hanging out or tongue inside the mouth.
Behavioral state	Tail wag	Regular sideways movements of the tail, repeated in a quick succession.
Behavioral state	Tail low	T-1 and T-2 (see Figure 2)
Behavioral event	Jumping on owner	Both front paws are lifted from the ground and are in contact with owner.
Behavioral state	Staring	Fixated look directed at a object/recipient, for a minimum of 2 seconds.
Behavioral state	Trembling	Visible shaking while the dog is lying, sitting or standing.
Behavioral event	Urinating	The dog is squatting, sitting, lying down or is standing with one hind-leg lifted or all paws in contact with ground while expelling urine from the body.
Behavioral event	Defecating	The dog is squatting, sitting, lying down or is standing while expelling faeces from the body.
Behavioral state	Sniffing	The muzzle/nose is in contact with an object/recipient and a motion of nostrils can be observed.
Behavioral state	Wide eyes	The eyes are wide open with eye white showing around the iris.
Behavioral state	Ears back	Ea-2 and Ea-3 (see Figure 3)
Behavioral state	Out of sight	The dog is not visible in the video.
Behavioral event	Sham chewing	Vertical and lateral movement of the jaws without any visible food in the oral cavity.

Tail:	T-1	Tail is between the legs
	T-2	Tail is hanging down
	T-3	Tip of the tail is lower than the height of the back
	T-4	Tail is parallel to the back
	T-5	Tail is higher than the height of the back
	T-6	Tail is up almost vertically

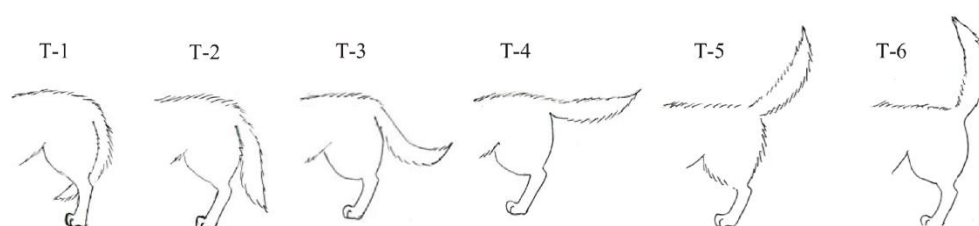


Figure 2. Categories of tail positions in dogs (Hasegawa et al. 2014). Image allowed to use according to Creative Commons statement by the authors (<https://creativecommons.org/licenses/by/3.0/>).

	Ea-1	Ears are turned forward
Ears:	Ea-2	Ears are slightly turned back
	Ea-3	Ears are turned back

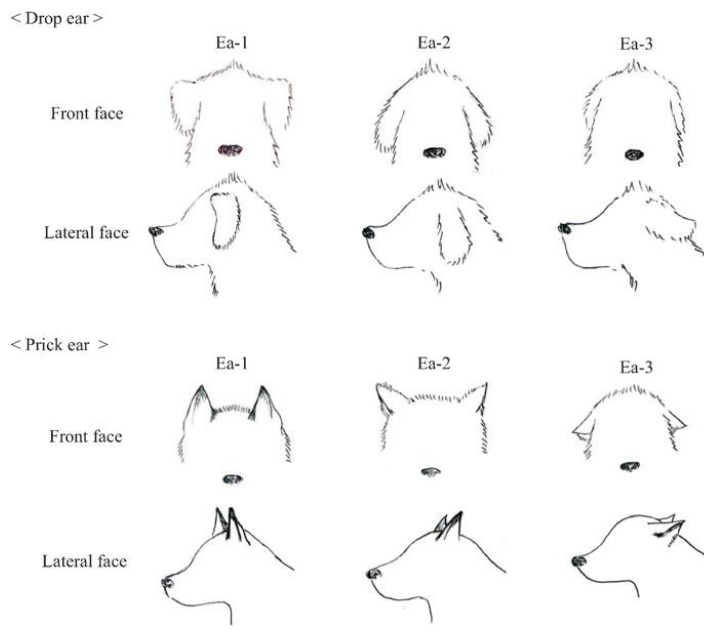


Figure 3. Categories of tail positions in dogs (Hasegawa et al. 2014). Images allowed to use according to Creative Commons statement by the authors (<https://creativecommons.org/licenses/by/3.0/>).

3.5 Step IV – follow up questionnaire

A second questionnaire was formed on the online survey website Netigate and distributed via e-mail only to owners that had provided video material. The contents of the questionnaire were based on the constructed ethogram and included a list of symptoms and behaviors that have been reported in previous studies and observed during the video analysis. The owner was asked to choose what behaviors and symptoms they see in their dog during the postictal phase. The owner was also asked to describe in their own words what symptoms and behavioral changes their dog displayed after a seizure. A question asked if their dog showed the same symptoms and behavioral changes every postictal phase, or if it varied between seizures. The whole questionnaire can be found as Appendix 2.

The questionnaire was first constructed in Swedish and then translated to English by the author. The English translation was included to gain answers from pet owners outside of Sweden. A few people were then asked to translate the questionnaire back to Swedish to validate the English translation. After the initial questionnaire was created, a few people were asked to answer the survey and leave feed-back. The phrasing of some of the questions were then adjusted accordingly. A direct link to the questionnaire was sent to the owner through email.

3.6 Statistical analysis

The data from both questionnaires was exported to Excel and presented as diagrams. The answers from open textbox questions were analyzed regarding trends and a word count was created using QI Macros SPC Software in Excel. The words were then placed in different categories, with regards of synonyms and context, and presented as diagrams. The results are described with descriptive statistics and statistical significance was calculated using the Chi-square test and Fisher's exact test. The values were rounded down to one decimal.

4 Results

4.1 Initial questionnaire

In total 248 owners opened the questionnaire, and 87 owners completed the whole questionnaire. The response rate for the complete questionnaire in the target group was 35.1%. From the responders (n=87) 44.8% (n=39) fit the inclusion criteria described in section 3.3. In total 33.3% (n=29) of the responders fit the criteria for video collection described in section 3.4. See Figure 4 for the detailed inclusion process.

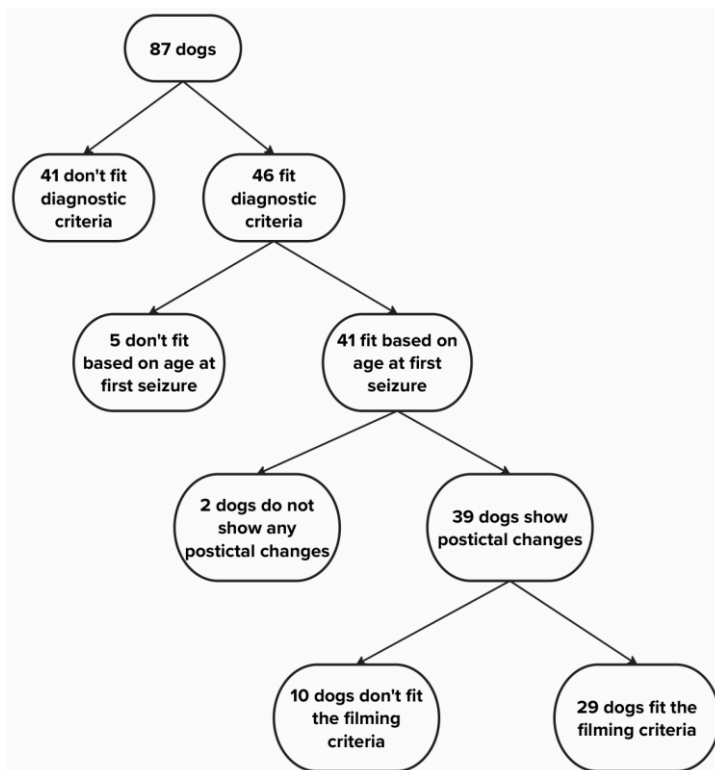


Figure 4. Flowchart describing the number of dogs that were eliminated due to the exclusion criteria in this study.

From the dogs that fit the inclusion criteria (n=39), 17.9% (n=7) of the dogs were intact females, 28.2% (n=11) spayed females, 23.1% (n=9) intact males and 30.8% (n=13) castrated males (Figure 5).

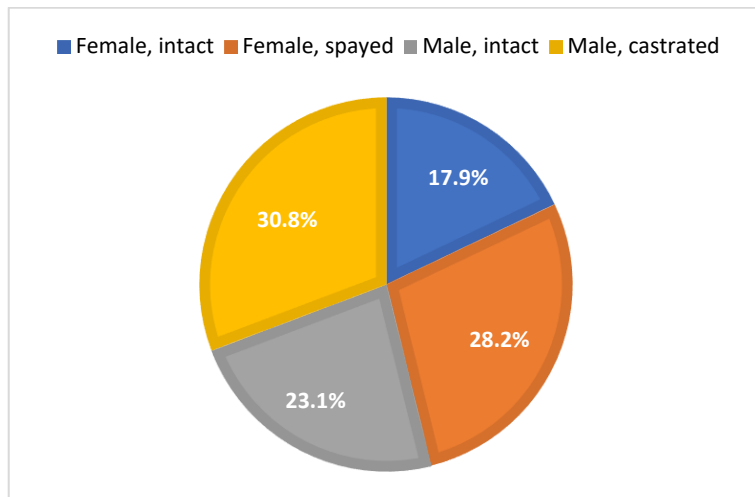


Figure 5. Sex distribution and castration status of the dogs within the study population (n=39) of this study.

The median age was 5.5 years (range from 1.5 to 13.0 years). A quarter of the dogs were mixed breed (25.6%, n=10), 10.3% (n=4) Australian kelpies, 7.7% (n=3) Golden retrievers, 5.1% (n=2) Irish setters and the rest 51.3% (n=20) of the dogs were from different breeds with only 1 dog of each breed (Siberian husky, Belgian shepherd, Smooth collie, Chodsky pes, Bichon havanais, Saint Bernard, Springer spaniel, German shepherd, Standard schnauzer, Boston terrier, Keeshond, Chihuahua, English bulldog, cane corso, Australian shepherd, Finnish lapphund, Flatcoated retriever, Dalmatian, Border collie and Standard poodle).

A 100.0% (n=39) of the dogs that fit the initial criteria obtained their diagnosis of IE due to the presence of an anamnesis that is typical for dogs with IE, a normal physical and neurological examination and through no findings in blood analysis significant to IE. In addition, 46.2% (n=18) of the dogs underwent an MRI examination, 23.1% (n=9) underwent analysis of the CSF and 7.7% (n=3) underwent an EEG. Of those dogs that underwent an MRI, 7 of the owners completed the questionnaire in Swedish and 11 owners in English. Of those that underwent CSF analysis, 1 owner completed the questionnaire in Swedish and 8 owners in English. For the dogs that underwent an EEG to obtain a diagnosis, 1 owner completed the questionnaire in Swedish and 2 owners in English.

The median age at first seizure was 2.0 years (range from 0.5 to 6.0 years). 71.8% (n=28) of the dogs have experienced, at the time of sampling (2023), only generalized seizures, 2.6% (n=1) only focal seizures and 5.1% (n=2) only focal

seizures that evolve into generalized. 20.6% (n=8) of the dogs have experienced two or more of the seizure categories (see Figure 6 for detail).

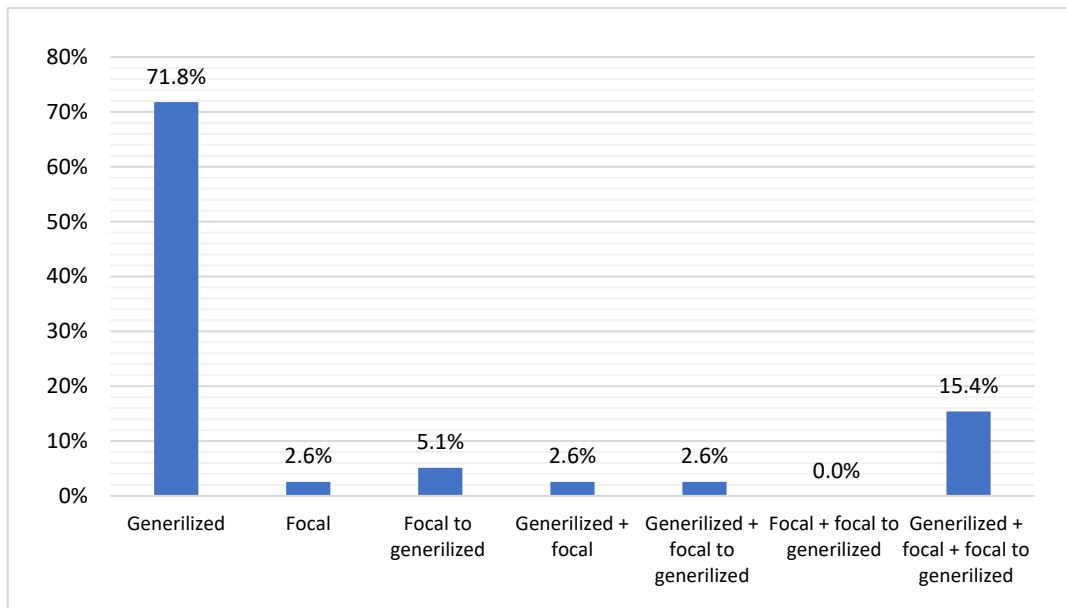


Figure 6. The percentage of dogs experiencing the different types of seizures and combinations of different types of seizures within the study population (n=39) of this study.

When asked if their dog urinates or defecates during a seizure, 38.5% (n=15) owners answered that their dog have always urinated or defecated, 20.5% (n=8) answered that their dog have never urinated or defecated and 41.0% (n=16) answered that it varies between seizures.

Three quarters (74.4%, n=29) of the owners answered that the average length of a seizure was between one and three minutes. 12.8% (n=5) had an average seizure length of < 1 minute, 5.1% (n=2) three to five minutes, 2.6% (n=1) >5 minutes and 5.1% (n=2) answered that they don't know the average seizure length or that it varies between seizures (Figure 7).

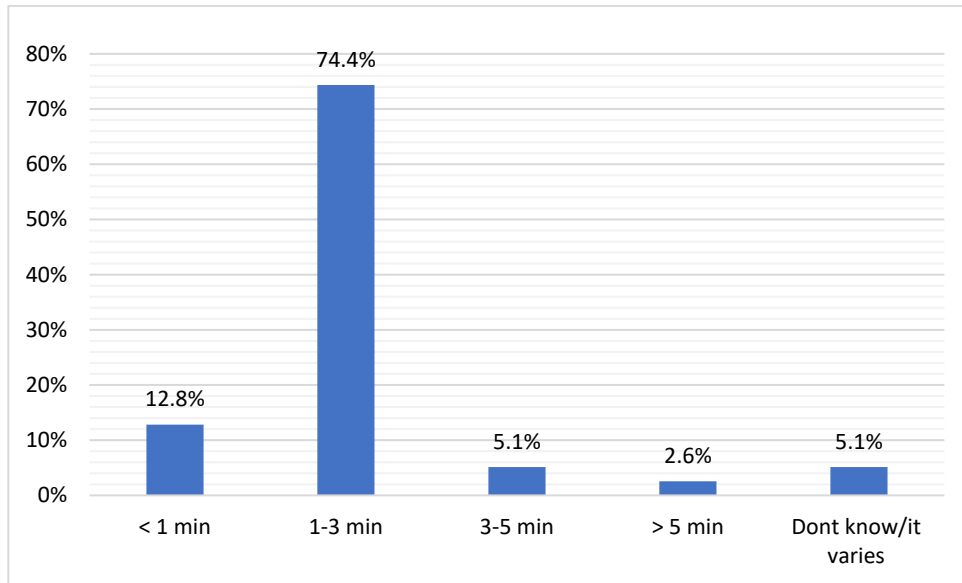


Figure 7. The average seizure length within the study population (n=39) of this study.

Almost half of the dogs (48.7%, n=19) had an average seizure frequency of <1 seizure per month during the past six months. A third (33.3%, n=13) of the dogs had been having seizures between one to three times a month and 17.9% (n=7) had experienced seizures >3 times a month (Figure 8).

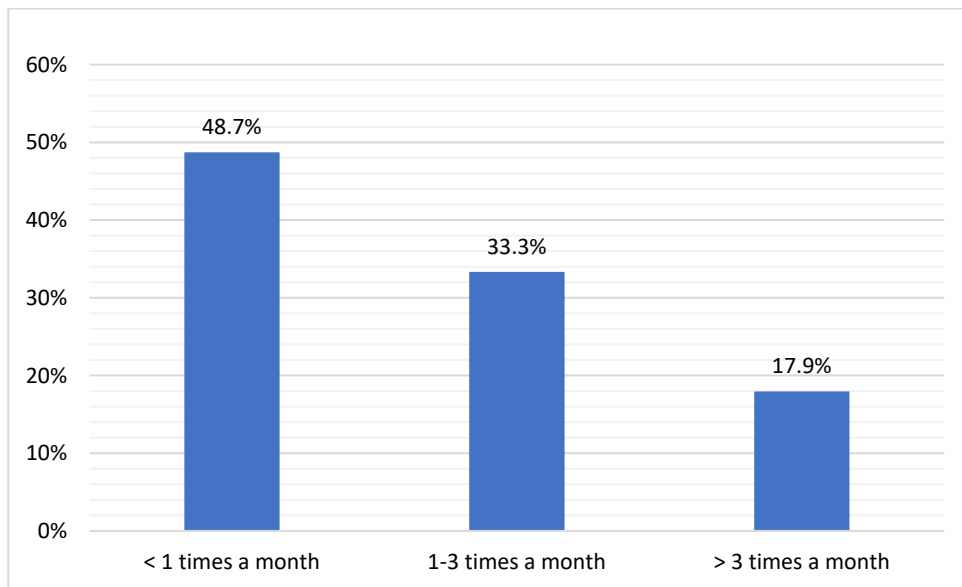


Figure 8. The seizure frequency, for the past six months, within the study population (n=39) of this study.

Most of the dogs (94.9%, n=37) were, during the sampling of this study (2023), treated with long-term antiepileptic medications for IE and 5.1% (n=2) were not under any long-term medication treatment. Of those who were treated with AEMs, 91.9% (n=34) were treated with phenobarbital, 59.5% (n=22) with levetiracetam,

24.3% (n=9) with potassium bromide, 8.1% (n=3) with zonisamide and 5.4% (n=2) with imepitoin (Figure 9). 10.8% (n=4) of the dogs were treated with pregabalin, sodium bromide, CBD oil or topiramate.

79.5% (n=31) of the owners were using some kind of acute medication to stop an ongoing seizure at home. See Figure 10 for detailed information about the type of acute medication used by the owners.

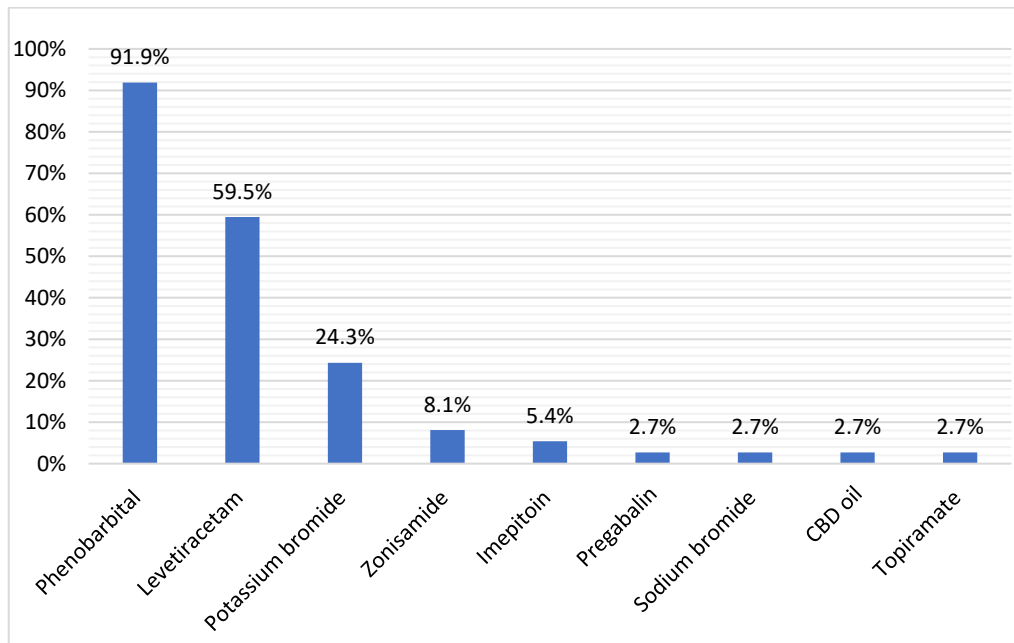


Figure 9. The percentage of dogs that were being treated with respective AEM for IE among the dogs that were treated with long term medication treatment (n=37) of this study.

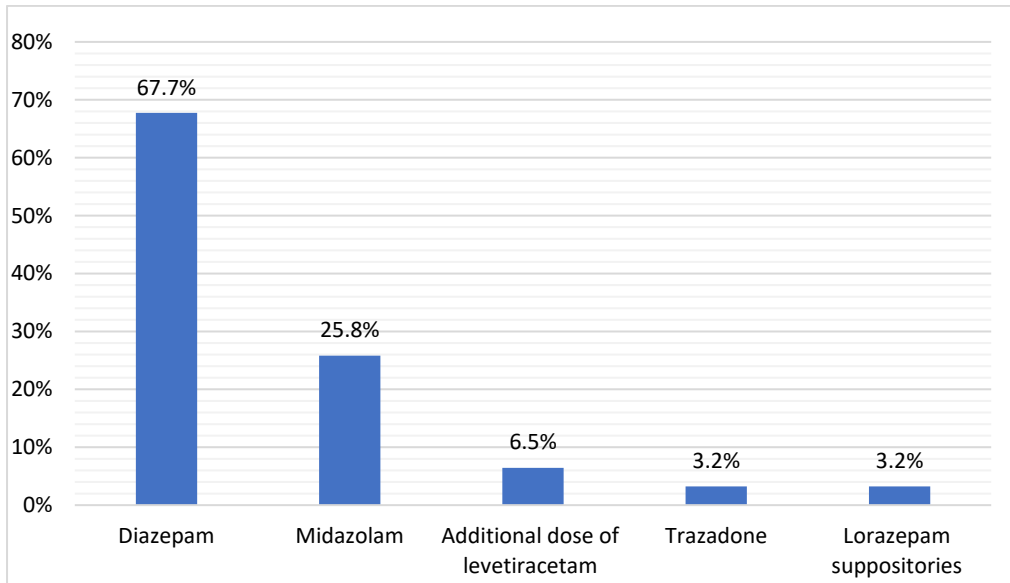


Figure 10. The percentage of dogs that were being treated with respective acute medication among the dogs where owners use acute medication to stop a seizure at home (n=31) of this study.

The most common length of the postictal phase among the study population of this study was 30-60 minutes (28.2%, n=11), followed by 15-30 minutes (25.6%, n=10), 5-15 minutes and >2 h (both 15.4%, n=6 each), 1-2h (10.3%, n=4) and <5 minutes (5.1%, n=2) (Figure 11).

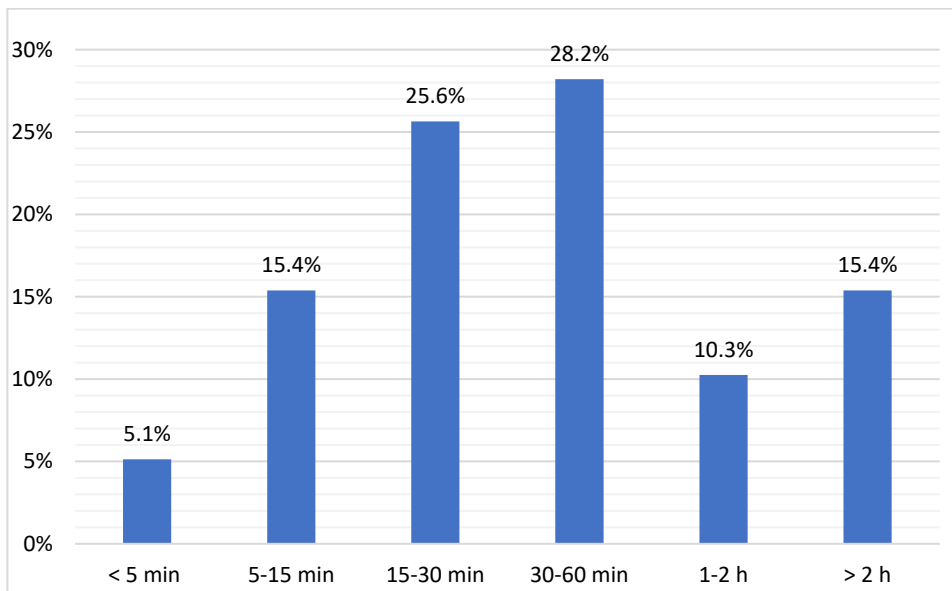


Figure 11. The length of the postictal phase within the study population (n=39) of this study.

In total 26 different categories were created based on the owners' answers from the open text box asking them to describe what changes they see in their dogs during the postictal phase (Figure 12). Restlessness was found to be the most common behavioral change (38.5%, n=15) among the study population, followed by

blindness (35.9%, n=14), compulsive behavior (including compulsive pacing and circling) (30.8%, n=12), confusion (30.8%, n=12), lack of coordination (30.8%, n=12) and tired (25.6%, n=10). The least common behaviors and symptoms reported by the owners were sweating, thirst, head tick, running, whimpering, and trembling, with only 2.6% (n=1) of dogs showing each respective behavior.

When comparing the sex distribution within the reported behaviors, there were three behaviors reported only in females (“sweating”, “thirst” and “trembling”) and three behaviors reported only in males (“head tick”, “running” and “whimpering”). “Restlessness”, “compulsive behavior”, “confusion”, “lack of coordination”, “tired”, “fear” and “disorientation” were most frequently reported among males, while “attention seeking”, “anxiety”, “reactive” and “wants to be alone” was most frequently reported in females. Behaviors and symptoms “blindness”, “hunger”, “growling”, “barking”, “panting”, “urination”, “screaming” and “defecation” had a distribution of 50% males and 50% females. See details in Figure 13. No statistically significant behavioral difference was found when comparing male and female dogs in the postictal phase.

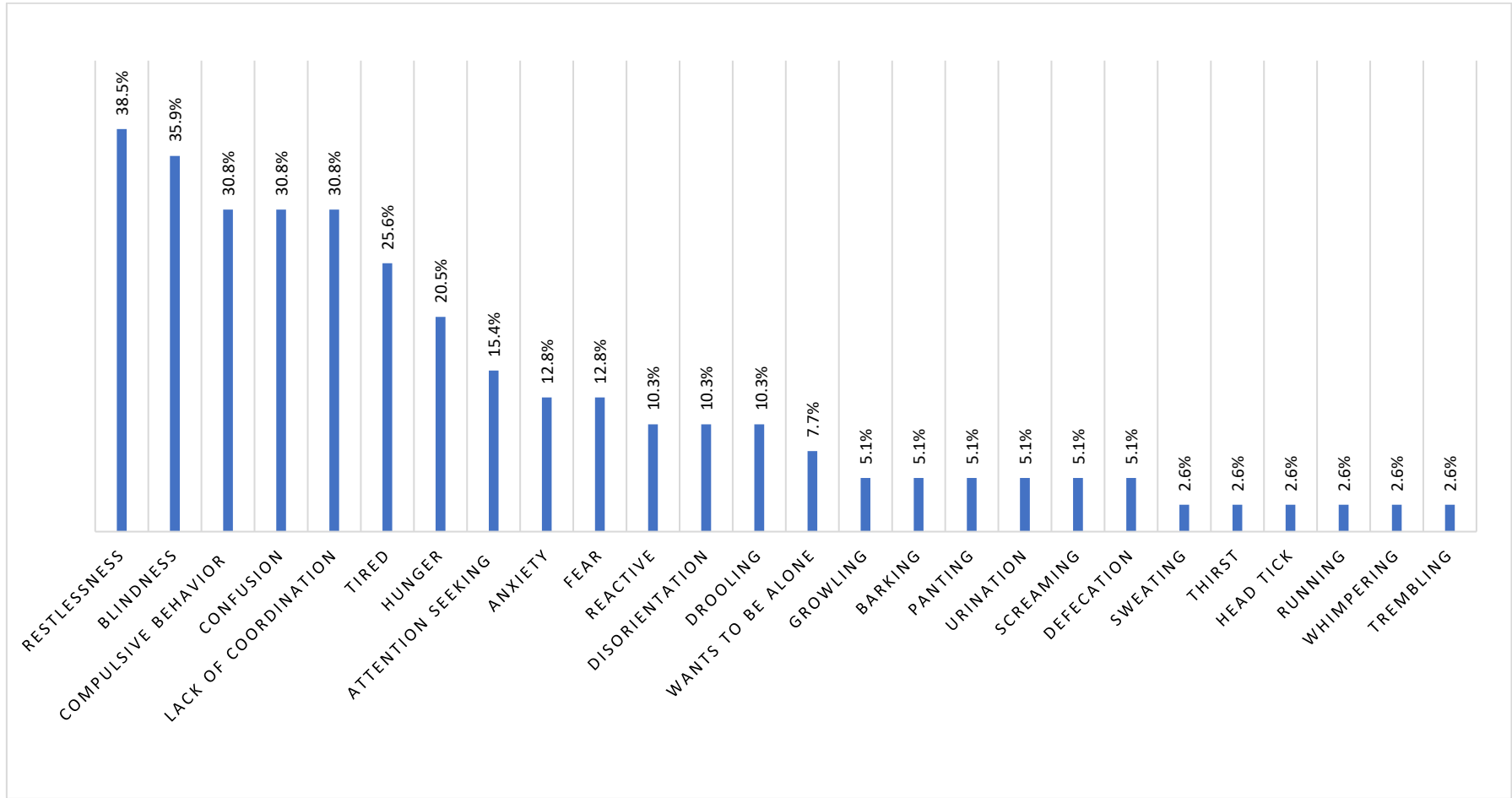


Figure 12. The percentage of dogs exhibiting respective behavior/symptom based on the owners open text box answers within the study population (n=39) of this study.

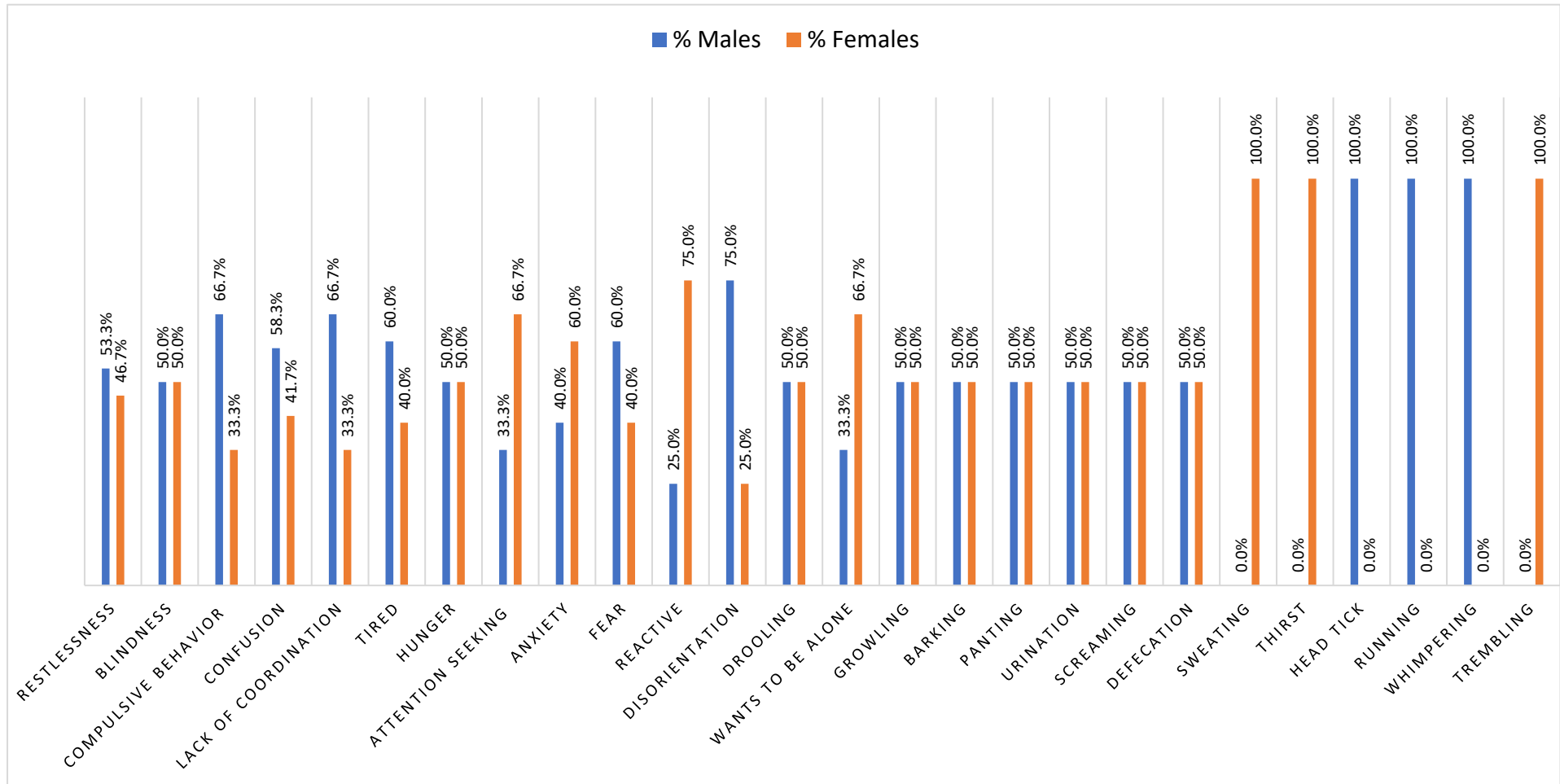


Figure 13. The dogs' sex distribution (de-sexed dogs included in each category) in percent within the respective behavior/symptom.

4.2 Video analysis and follow up questionnaire

Invitation for further participation was sent to 29 owners. 44.8% (n=13) owners gave their consent for further participation in the study. One video was obtained during this study's course with a total length of 30 min 12 s. (1814 s.). In total two behavioral events and six behavioral states were observed in the video analysis. "Owner proximity" was the behavior state with the longest total duration time (1375.1 s), followed by "resting" (1296.9 s), "ears back" (1178.8 s), "wide eyes" (873.6 s) and "trembling" (306.7 s). The behavior with the shortest total duration time was "tail wag" (3.2 s). The dog was out of sight for a total of 57.3 s. (Figure 14).

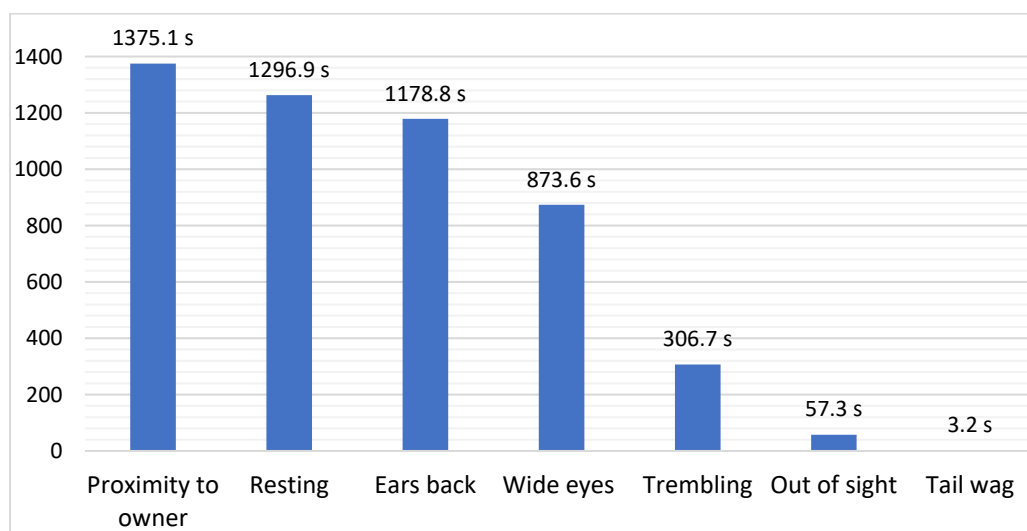


Figure 14. Total duration in seconds (s) for the respective behavioral state registered during the video analysis.

The most common behavioral event observed was "sham chewing" with a total of 71 occurrences, followed by "lip licking" with a total of 70 occurrences.

When asked in the follow up questionnaire if their dog always showed the same behavioral changes and symptoms during the postictal phase, the owner who provided the video material answered "yes". The owner then described the behavioral changes and symptoms including the word "shaking" and the phrase "wants to be close to me". This description of the dog's postictal phase falls under the categories "trembling" and "proximity to owner". This answer is consistent with the previously given description by the owner in the initial questionnaire, with the exception of the word "tired" which was included in the initial questionnaire but not in the follow-up survey.

When asked to choose what behaviors and symptoms the owner had observed in their dog during the postictal phase from a list of behaviors and symptoms, the owner chose “lack of coordination”, “attention seeking”, “resting” and “trembling”.

5 Discussion

5.1 General results

Generalized seizures was the most common seizure type in this study population based on the initial questionnaire, which supports the results from Heynold et al. (1997). However, these results are contradicting several other studies showing that focal seizures with secondary generalization is the most common type of seizure in dogs with IE (Berendt & Gram 1999; Berendt et al. 2002, 2004, 2008; Licht et al. 2002). This could be due to the fact that the focal onset is often very short and can therefore be missed by the owners (Berendt et al. 2015). Furthermore, a study conducted by Packer et al. (2017) shows that focal seizures are often being under-reported due to owners having better understanding of generalized seizures than focal. It has also been shown that focal seizures are the least agreed upon seizure type among veterinarians, which may be due to the large variety of motor, autonomic and behavioral signs that may be reported during a focal seizure (Packer et al. 2015). It is possible to assume that the results of this study would be different if practicing veterinarians had a consensus regarding what characterizes a focal seizure, thus giving the owners clear advice and tools to improve owners' ability to recognize focal seizures at home.

When looking at the diagnostic methods used to obtain a diagnosis of IE, a clear majority of owners whose dog underwent a CSF analysis completed the questionnaire in English. While it is unknown if dogs to these English-speaking owners obtained a diagnosis in Sweden or abroad, it is possible to assume the latter. If the use of CSF analysis as a routine part of the diagnostic work up when investigating IE is more common outside of Sweden is unknown, as to the authors knowledge no studies investigating this question have been published at the time of writing (2023). However a study conducted by Erlen et al. (2020) has shown that dogs under primary veterinary care in the UK that present with seizures, are more likely to receive advanced diagnostic evaluation if the dog is <12 years old or if the dog is insured. This suggests that the financial aspect of the owner influence case management. A study published by the Swedish insurance company Agria (Heske et al. 2014a) has reviewed the diagnostic work-up for 163 randomly selected

insured dogs that have been diagnosed with epilepsy, none of which underwent CSF analysis. Their report states that the number of clinical tests included in the diagnostic-work up for each individual case reflects the veterinarian's experience, the owner's economy, and the diagnostic equipment available. Further studies should be conducted to properly evaluate the availability of CSF analysis as a diagnostic method across Sweden, both practical availability at veterinary practices and financial availability of the owners and insurance companies, to be able to draw any conclusions surrounding the difference of diagnostic methods found between Swedish- and English-speaking owners.

5.2 Postictal changes based on owners' descriptions

"Fatigue" has been reported to be the most common postictal change in previous studies (Jaggy & Bernardini 1998; Berendt & Gram 1999). This, however, was not the case in the study population of this study. "Tired" was found to be the sixth most common postictal change, which is not in agreement with the hypothesis or previously published reports. The reason for this could stem from the design chosen for this study and previous studies. Previous reports have also been acquiring information about the postictal phase through a detailed description of postictal changes from the owners as a part of a questionnaire. The issue with this method is that there are various ways to describe one as "tired" or "fatigued", including different synonyms of the words and seemingly unrelated words that in certain context could still be interpreted as a description of one being tired or fatigued. As the questionnaire in this study included open textbox answers from the owners, each researcher could therefore make different assumptions and interpretations from the owners' descriptions if the words or synonyms of the words are not expressly present in the description, leading to a biased reporting. Whether the results of this study would be different if a follow-up interview with the owners was conducted, giving the author a chance to confirm the interpretations of the descriptions, cannot be told with a certainty but is something that is recommended for future studies to minimise reporting bias.

Several behavioral changes and symptoms were found during the course of this study that have not previously been reported, such as the dog being "reactive" and "anxious". As previous studies have shown that dogs with IE exhibit behavioral changes related to anxiety, compared to healthy dogs and dogs with other medical conditions (Shihab et al. 2011; Levitin et al. 2019; Watson et al. 2020), it is not surprising that the owners in this study have described their dog as "anxious". It is however important to remember that these results are based only on the owners' own perception of their dogs. It has been shown that when describing a dog's behavior, people often use emotional labels instead of objectively describing the

dog's body language or what the dog is doing (Tami & Gallagher 2009), thus making the categories "reactive" and "anxiety" (which have not been previously reported in those terms) very subjective. For example, restlessness, compulsive pacing and barking (all of which have been reported in previous studies), are common signs of anxiety in dogs (Flannigan & Dodman 2001; Storengen et al. 2014; Tiira et al. 2016). It would therefore be beneficial in future studies to conduct follow-up interviews with owners who are using emotion to describe their dog's behavior, asking for clarifications about how the dog is acting when the owner perceives the dog as "anxious" or "reactive", thus painting a more objective picture of the dog's behavior. Other signs that have not been previously reported but found in the current study, such as "drooling", "urination", "defecation", "panting" and "sweating", are on the other hand not emotional states, giving these descriptions of the postictal phase little room, if any, for different interpretations.

There was a numerical difference in sex distribution when looking at some of the behaviors that the owners have described. However, no statistically significant difference has been found. This could be due to the relatively small study population resulting in few individuals exhibiting each behavior. This question could be further investigated in future studies with a bigger study population. Furthermore, as have been mentioned before, these results are based solely on the owners' own perception of the dog. Conducting a behavioral observation study with an ethogram and follow-up interviews with the owners would give the researcher data with clearly defined behavioral states and events thus making it possible to compare the difference in sex while minimizing reporting bias. Although this was one of the aims in the current study, unfortunately time did not allow for such collection of data.

5.3 Video analysis

The hypothesis was that "resting" or "resting with eyes closed" would be the most exhibited behavior in the video analysis. This hypothesis was however not true as "proximity to owner" was the behavior with the longest duration, followed by "resting". It is however important to remember that only one video was obtained during the course of this study. More research is therefore needed to further investigate this hypothesis as no conclusions can be drawn based solely on one individual.

When comparing the dog owner's answers in the follow-up questionnaire to the registered behaviors in the video it became apparent that some behaviors were not recognized by the owner. "Ears back", "wide eyes", "lip licking" and "sham chewing" were not present in the owner's own description and were not selected

from the list of behaviors. These behavioral cues have indeed been shown to be used less frequently when describing and interpretation a dog's behavior among dog owners (Tami & Gallagher 2009; Lakestani et al. 2014; Demirbas et al. 2016). One could argue that "proximity to owner", "trembling" and "resting" are less subtle behaviors and therefore were recognized by the owner. The fact that some behavioral cues can be missed by the owner can affect a veterinarian's ability to gather a complete anamnesis to determine how the dog in question is being affected during the postictal phase. A practicing veterinarian rarely has the chance to see the postictal phase in their patients so the ability to obtain a complete anamnesis from the owner is critical when trying to assess a patient's welfare after a seizure. If a dog for example is only using the position of its ears and eyes for conveying distress and the owner does not recognize those behavioral cues, the dog in question could falsely be considered unaffected or the true length of the postictal phase underestimated. This could be problematic as treatment with AEMs should be considered when the postictal changes are lasting over 24h, which may lead to some dogs falling out from that category due to the owner's inability to correctly assess their dog's behavior. As the primary goal with AEMs are to decrease the seizure frequency, it also indirectly decreases the times the dog is experiencing the postictal changes thus decreasing the patients suffering if the postictal changes are long lasting or considered severe. These aspects should be considered by the veterinarian when presented with patients with IE, making it possible to decide on a care that is sustainable both for the patient and the owner and to decrease the patients suffering during the postictal phase. These results are however based on data collected only from one owner and whether other owners also don't recognize the more subtle behavioral cues cannot be said with a certainty.

"Lack of coordination" was not observed during the video analysis but chosen by the owner as one of the behavioral changes/symptoms. This could stem from the fact that the dog was out of sight for parts of the video, and the lack of coordination was therefore missed by the author. Furthermore, the dog was out of sight when the dog was on the move, highlighting the importance of a correctly placed video camera or the use of more than one camera for future studies to lower the risk of missing a certain behavior.

5.4 Ethical and societal aspects of this study

The methods used were assessed by the author and supervisors as harmless to the animals included in this study and no ethical review was therefore conducted. A reason for this was the direct communication per email between the author and the owners and clear instructions about the filming process. The owners were asked to place the camera in the room and to interact with their dogs as they would normally

do. This made it possible for the dogs to seek out comfort from the owner (if the individual in question needed comfort from the owner) thus not contributing to potential emotional distress if that comfort had not been given. In this author's opinion the study design chosen therefore had no negative consequences on the dogs' welfare.

During contact with some of the owners they have expressed how stressful and traumatic IE have been for them, both the seizures themselves but also the symptoms during the postictal phase. Other owners have expressed how important they think this research is as it gives them more knowledge about situations where they feel helpless. Having knowledge of these behavioral changes as a practicing veterinarian makes it possible to prepare the owners for the different manifestations of the postictal phase. It is possible to assume that this can contribute to a better wellbeing for the owners, as they feel more prepared in a situation they otherwise know little about.

5.5 Limitations of this study and future research

This study did not include videos of the seizures themselves, which may have resulted in misleading results regarding the seizure type that the dogs are exhibiting. Future studies should include videos of the ictus if the researcher's aim is to investigate what seizure type is the most common among dogs with IE. Combining video analysis with a questionnaire or interviews with the owners would also give the researcher a possibility to investigate if focal seizures are indeed easily missed by the owners as the previous literature have been suggesting.

Another limitation to this study was that only one video was obtained due to the relatively short amount of time that was available for data collection. Future research should strive to continue analyzing video material to get an objective understanding of how dogs with IE are affected by the postictal phase and if some behaviors may be missed or misinterpreted by the owners. Furthermore, a future research direction could investigate what postictal changes the owners themselves perceive as "severe", giving veterinarians a perspective from the owners that should be considered when deciding on the right care that is sustainable both for the patient and for the owner.

6 Conclusion

In conclusion this study found that “restlessness” was the most frequently described postictal change by the owners’ themselves. Owners also included emotional states (such as “afraid” and “anxious”) as part of the descriptions. Future studies would benefit from conducting follow-up interviews with the owners to clarify what specific behaviors their dog is exhibiting to avoid misinterpretation of the data. This study also found “proximity to owner” to be the behavior with the longest total duration during the video analysis. The one owner who provided the video material and completed the follow up questionnaire recognized the more obvious behaviors (“proximity to owner”, “resting” and “trembling”) but did not acknowledge the more subtle behavioral cues, such as the position of the ears, eye size, “lip licking” and “sham chewing”, which may be indicative of that owners often use emotional states for describing their dog’s behavior. Further observational behavioral studies should be conducted to properly investigate what behaviors dogs may exhibit during the postictal phase and which behaviors are more likely to be missed by the owners.

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Popular scientific summary

Seizures are believed to be the most common chronic neurological conditions in dogs, with the estimate that between 0.5% and 5.7% of dogs suffer from seizures. One of the many reasons for seizures is epilepsy. Epilepsy is however not one disease, but a group of disorders that increase the risk of epileptic seizures. Idiopathic epilepsy (IE) is epilepsy where no underlying cause for the seizures can be found, except for a genetic background. Many terms are used when talking about seizures, for example *ictus* which is a word used to refer to the seizure itself. The *postictal phase* is the time period after a seizure when the brain function is restoring itself.

Many different symptoms and behavioral changes have been described during the postictal phase, some examples are hunger, thirst, fatigue, and restlessness. These symptoms and behavioral changes vary largely from dog to dog. The International veterinary epilepsy task force (IVETF) is currently recommending starting medical treatment for IE when the postictal changes are considered severe or lasting over 24 hours. However, there is still many things that are unknown about the postictal phase. Already existing studies only briefly describe the symptoms and behaviors during the postictal phase, and no behavioral studies have yet been published.

The objective of this study is to investigate what symptoms and behaviors dogs may exhibit in the postictal phase, besides the ones already mentioned in previous studies. This study will also investigate if there are some behaviors and symptoms that the owners may miss. The purpose of this is to increase the knowledge about canine epilepsy and to assist veterinarians when working with dogs with IE.

The hypothesis “and” was that the owners would most frequently describe their dog as “tired”. The hypothesis was also that “resting” and “resting with eyes closed” would be the most registered behavior from the video analysis.

A questionnaire was distributed to owners to epileptic dogs through social media, gathering information about their dog’s epilepsy including questions about how the diagnosis was made, what medication their dog is being treated with, how the epileptic seizures look like in their dog and what postictal changes they see in their

dog. Dogs that were diagnosed based only on a normal clinical examination were excluded from this study. Owners whose dogs exhibited postictal changes no longer than 60 minutes were invited to further participate in this study and to film their dog's postictal phase. An ethogram was made containing different behaviors and detailed descriptions of each behavior and used to analyze the video material. After the video analysis, the owner received a follow-up questionnaire asking the owner to choose the behaviors they see in their dog from a list based on the ethogram.

The most described behavior based on the owners' answers was "restlessness", thus rejecting the hypothesis that "tired" was the most described postictal change. Numerous behaviors were described by the owners that have not been previously reported. No statistically significant difference was found when comparing the sex distribution within every described behavior.

"Proximity to owner" was found to be the behavior with the longest duration based on the video analysis, closely followed by "resting" and "ears back". When comparing the owner's answers on the follow-up questionnaire with the registered behaviors, the more subtle behaviors ("ears back", "wide eyes", "lip licking" and "sham chewing") were not recognized by the owner. In contrast, the more distinct behaviors ("proximity to owner", "resting" and "trembling") were correctly recognized and acknowledged by the owner. Further studies are required to investigate what behaviors dogs exhibit during the postictal phase and if some of these behaviors are harder to recognize by the owner.

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At last, but not least, this thesis wouldn't even exist without my dog (and partner in crime) Legoshi. The unfortune of him having epilepsy pushed me in the direction of small animal neurology. He is one of the biggest reasons why I now want to increase the knowledge about canine epilepsy and hopefully help other dogs and owners who struggle with it every day.

Appendix 1 – Initial questionnaire

Thank you for your interest in participating in this study about the postictal phase in dogs with epilepsy!

This questionnaire is a part of an independent project at the Swedish University of Agricultural Sciences. The purpose is to examine what behaviors and symptoms are present in dogs with epilepsy during the postictal phase. The postictal phase is the period right after an epileptic seizure when some dogs are not "themselves". The duration of this phase and what behaviors and symptoms the dogs exhibit can differ between individuals.

I am looking for owners to dogs that have an established diagnosis of epilepsy and that exhibit postictal symptoms.

This questionnaire is a notice of interest, if your dog is evaluated to fit the project's design you will be contacted for further participation. The participating owners will be asked to film their dog during a postictal period and send in the video material of 30 minutes for analysis. The participating owners will then get a follow-up questionnaire about what behaviors and symptoms they see in their dog.

You and your dog will be completely anonymous in this study as all material will be coded and presented in a way that makes it impossible for the reader to identify the owner and dog.

This questionnaire takes about 10 minutes to complete. It will be open until 13/10.

Don't hesitate to contact me if you have any questions!

Veterinary student: Katerina Krupko

Contact: kako0006@stud.slu.se

Project supervisor: Else Verbeek, Associate Professor of animal welfare with the Swedish University of Agricultural Sciences

Assistant project supervisor: Emil Olsen, specialist in neurology

1. Contact information

Please begin with filling out your contact information so that we can reach out to you.
You and your dog will be completely anonymous when the study is presented.

First name:

Last name:

E-mail adress for contact about further participation in this study:

Your phone number:

2. General information about your dog

How old is your dog? Please write in half-years

Your dog's breed (if your dog has different breeds, please write "mixed breed")

Your dog's sex

Female, intact

Female, spayed

Male, intact

Male, castrated

3. Diagnosis

The following questions are about your dogs diagnosis

Does your dog suffer from seizures?

Yes

No

Does your dog have a confirmed diagnosis of epilepsy without any signs of tumor, inflammatory disease or other brain lesions?

Yes

No

How was the diagnosis of epilepsy confirmed? You can choose multiple options

Based on age of on-set of the first epileptic seizure, the clinical manifestation and medical history

Blood analysis

Magnetic resonance imaging (MRI) of the brain

Analysis of cerebrospinal fluid (CSF)

Electroencephalography (EEG)

Dont know/not sure

4. Information about your dog's seizures

The following questions are about how the seizures are manifesting in your dog

How old was your dog when it got it's first seizure? Please write in half-years

Type your answer...

How does the seizures look like in your dog? You can choose multiple options

- A seizure that involves the whole body, the dog collapses and is non responsive to stimuli ("Generalized seizure" or "grand mal")
- A seizure that involves one or several parts of the body, for example twitching of ears, lips or eyelids, the dog is responsive to stimuli ("focal seizure" or "petit mal")
- A seizure that starts in one or several parts of the body and the dog responds to stimuli, to later evolve into a seizure that involves the whole body and the dog is no longer responsive to stimuli (Focal seizures that evolve in to generalized seizures)
- Don't know

Does your dog defecate or urinate during/at the end of a seizure?

- Yes, always
- No, never
- It varies

For how long does your dog's seizures last on average?

- <1 minutes
- 1-3 minutes
- 3-5 minutes
- >5 minutes
- Don't know/it varies

If you ever have timed your dog's seizures, please write the time:

Type your answer...

For the past 6 months, how many times a month on average have your dog had seizures?

< 1 time a month

1-3 times a month

>3 times a month

5. Medication

The following questions are about your dog's medications

Does your dog take any anti-epileptic medications right now? Anti-epileptic medication means medication with the goal to reduce seizure frequency

Yes

No

If you chose "Yes" in the previous question, what medication/medications? You can choose multiple options

Epirepress/Epityl/Phenoleptil (Phenobarbital)

Pexion (Imepitoin)

Libromide (Potassium bromide)

Keppra (Levetiracetam)

Zonegram (Zonisamide)

Taloxa (Felbamate)

Topimax (Topiramate)

Delarit/Neurontin (Gabapentin)

Lyrica (Pregabalin)

If other medication, please specify what:

Do you use emergency medications at home to terminate an ongoing seizure? Emergency medication means medication that you as a owner give at home to terminate an ongoing seizure, besides anti-epileptic medication described in the previous question

Yes

No

If you chose "Yes" in the previous question, what medication/medications? You can choose multiple options

Midazolam

Stesolid (Diazepam)

If other medication, please specify what:

6. The postictal phase

The postictal phase is the period right after an epileptic seizure when the brain restores its normal function. Some of these symptoms may include restlessness/anxiety, barking, fatigue.

Is your dog its "normal self" directly after an epileptic seizure?

Yes

No

If your dog is not its normal self after an seizure, describe in your own words how you can see that in your dog:

Type your answer...

If your dog is not its normal self after an seizure, how long does it usually take for your dog to recover?

<5 minutes

5-15 minutes

15-30 minutes

30-60 minutes

1-2 hours

>2 hours

Thank you for answering this questionnaire!

You will be contacted through e-mail or SMS if your dog is chosen as a candidate for this study.

Appendix 2 – Follow-up questionnaire

1. The postictal phase

Your first and last name

Type your answer...

Does your dog show the same behavioral changes and symptoms after a seizure?

Yes, my dog has always the same symptoms and behavioral changes after seizures

No, the symptoms and behavioral changes can vary between seizures

Please describe in your own words what symptoms and behavioral changes you observe in your dog after a seizure

Type your answer...

Please choose the symptoms/behavioral changes you see in your dog after a seizure. You can choose multiple options.

- Hunger
- Thirst
- Wobbly/uncoordinated movements
- Seeks attention/wants to be close to the owner
- Is lying down
- Is lying down and resting with eyes closed
- Running
- Walks/trots back and forth in a compulsive manner
- Yawning

- Licking lips/nose
- Stiff/tense posture
- Barking
- Whining/whimpering
- Growling
- Screaming
- Bares teeth
- Bites
- Tries to bite
- Tries to bite/is growling while lunging

- Salivating/drooling
- Panting
- Wags tail
- The tail is held low or between the legs
- Jumping on owner/person
- Staring/intense eye contact with owner/person
- Shaking/trembling
- Peeing/uncontrolled peeing
- Pooping/uncontrolled pooping
- Sniffing on objects/people
- Big/wide eyes

- Ears are positioned back
- Chewing/making chewing motions without having food in mouth

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