



# Electroencephalographic Abnormalities in the Screening for Pilot Applicants in Korea

Dan A Oh<sup>a\*</sup>

Hyeyun Kim<sup>b\*</sup>

Eun-Kee Bae<sup>a</sup>

<sup>a</sup>Department of Neurology,  
Inha University Hospital, Incheon, Korea

<sup>b</sup>Department of Neurology,  
International St. Mary Hospital,  
Catholic Kwandong Medical School,  
Incheon, Korea

**Background and Purpose** Electroencephalography (EEG) is often used as a screening tool for selecting pilots despite controversy regarding its contribution to aviation safety. We investigated EEG abnormalities in Korean commercial pilot applicants in order to identify the usefulness of EEG screening in this population.

**Methods** We retrospectively analyzed the EEG results of 740 unselected pilot applicants who underwent waking EEG at Inha University Hospital from January 2013 to May 2017. EEG recording was performed for 30 minutes, which included 3 minutes of hyperventilation and intermittent photic stimulation.

**Results** The pilot applicants were predominantly male (95.3%) and had a mean age of 27.8 years (range: 16–40 years). Nine of them (1.2%) exhibited EEG abnormalities; the most common abnormality (six applicants) was a small amount of generalized irregular slow activities, while the other three applicants (0.4%) exhibited epileptiform discharges, with two showing generalized spike-and-wave complexes and one showing a few spike-and-wave complexes in the left fronto-temporal area. The two applicants with generalized spike-and-wave complexes were found to have experienced clinical seizures by a neurologist during detailed history-taking.

**Conclusions** This study found that 2 of 740 pilot applicants (0.3%) were diagnosed with epilepsy by routine EEG screening in an unselected population. Considering the low predictive value of EEG without the relevant clinical history in an unselected healthy young population, our findings raise questions regarding the cost-effectiveness of the current EEG screening protocol applied to pilot applicants. We suggest that a more-targeted and standardized EEG screening approach be applied to pilot applicants with epilepsy risk factors or a seizure history as determined by thorough medical history-taking.

**Key Words** electroencephalography, screening, seizure, epilepsy, pilots.

## INTRODUCTION

Electroencephalography (EEG) is widely used as a health screening test among pilot applicants in many countries, including Korea. This is based on the belief that excluding pilot applicants with certain EEG abnormalities will prevent in-flight seizures by eliminating applicants at a significantly higher risk of having seizures.<sup>1</sup> However, no definite evidence has been presented that indicates EEG screening can improve aviation safety. Accordingly, the current EEG screening method needs to be thoroughly evaluated, including due to a lack of evidence regarding its merits and the application of a standardized protocol.

In this study we investigated EEG abnormalities and their clinical significance in Korean commercial pilot applicants to evaluate the usefulness of EEG screening in this population.

**Received** July 12, 2017  
**Revised** November 26, 2017  
**Accepted** November 29, 2017

### Correspondence

Eun-Kee Bae, MD, PhD  
Department of Neurology,  
Inha University Hospital,  
27 Inhang-ro, Jung-gu,  
Incheon 22332, Korea  
**Tel** +82-32-890-3860  
**Fax** +82-32-890-3099

**E-mail** [alchemist0210@gmail.com](mailto:alchemist0210@gmail.com)

\*These authors contributed equally to this work.

© This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

## METHODS

We retrospectively analyzed the EEG health-screening results of 740 unselected pilot applicants who underwent waking EEG from January 2013 to May 2017 at Inha University Hospital, Incheon, Korea. Twenty-one scalp electrodes were applied according to the international 10-20 system. Electrocardiography and electrooculography were recorded in separate channels. EEG recordings were performing using a Comet<sup>®</sup> EEG machine (Grass-Telefactor, West Warwick, RI, USA) for 30 minutes, which included 3 minutes of hyperventilation and intermittent photic stimulation. Photic stimulation was performed using the Grass PS 60/LED photic stimulator (Grass-Telefactor) following the international protocol.<sup>2</sup> The EEG results were interpreted by a single epileptologist (E.K. Bae). The study was approved by the Inha University Hospital Institutional Review Board (IRB No. 2017-11-007).

## RESULTS

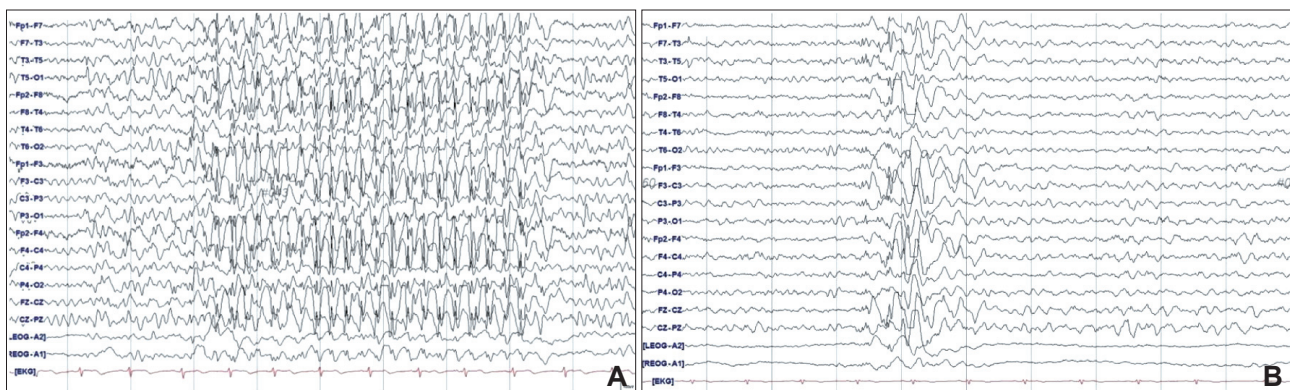
The pilot applicants were predominantly male (95.3%) and had a mean age of 27.8 years (range: 16–40 years). Nine of them (1.2%; all males) showed EEG abnormalities, with the most common abnormality (present in six applicants) being a small amount of generalized irregular slow activities. These six applicants had no history of seizure or loss of consciousness, and no applicant showed any neurologic symptom or sign at the time of evaluation. The remaining three applicants (0.4%) exhibited epileptiform discharges, with two showing generalized spike-and-wave complexes and one showing a few spike-and-wave complexes in the left fronto-temporal area. Two of these three applicants (aged 17 and 18 years) (Fig. 1) with generalized spike-and-wave complexes were found to have a history of recurrent clinical seizures with brief lapses of awareness and vacant staring, which appeared to be an absence or focal-impaired-awareness seizure type as

determined by detailed history-taking by a neurologist. One applicant with a few spike-and-wave complexes in the left fronto-temporal area did not have a history of seizure or loss of consciousness and showed no evidence of any neurologic symptom or sign at time of evaluation. His brain MRI findings were also normal, and thus there was no evidence for this EEG abnormality being clinically significant at the time of evaluation.

## DISCUSSION

This study diagnosed 2 of 740 pilot applicants (0.3%) with epilepsy based on the routine EEG screening of an unselected population. In addition, one applicant showed temporal spike-and-wave complexes and six applicants showed generalized irregular slow activities. Although a long-term follow-up is necessary, none of these seven cases appeared to be clinically significant at the time of evaluation.

It is acceptable to exclude patients with clinical epilepsy from the commercial pilot physical examination with the aim of preventing air accidents. However, should we disqualify all the applicants with EEG abnormalities without diagnostic relevance? This might unnecessarily exclude healthy applicants who would never have a seizure in their lives. In general, some individuals who do not have epilepsy can experience interictal epileptic discharges (IEDs); IEDs are rarely seen in normal children (1.9–3.5%) and adults (0.2–0.5%).<sup>3</sup> To be more specific, 3 studies of asymptomatic flight candidates with epileptiform activity on EEG who were followed for 2 to 15 years found that 1 of 31 (3.2%), 1 of 30 (3.3%), and 0 of 14 (0%) developed a seizure, giving a cumulative risk of an individual with an epileptiform EEG developing a seizure of 2.67% (2 in 75), based on US navy data from 1961 to 1981.<sup>4</sup> In other words, most of the asymptomatic candidates with IEDs remained seizure-free over a considerable period. Furthermore, individuals with normal EEG findings can subsequently develop seizures; the sensitivity of a single EEG



**Fig. 1.** Electroencephalography (EEG) recordings of two male applicants diagnosed with epilepsy. EEG demonstrated generalized spike-and-wave complexes in the applicants who were aged 17 years (A) and 18 years (B).

record for an epileptic abnormality may be no more than 50% in people with epilepsy.<sup>5</sup> Therefore, the risk of future seizures cannot be based solely on EEG findings. In the case of the present applicants who were diagnosed with epilepsy, an experienced physician could have found this clinically by thorough history-taking without EEG; EEG is a supporting tool in the diagnosis of epilepsy. One particular precaution in medical history-taking is that absence and focal impaired awareness seizures may go unnoticed in daily life, with the subject often not being aware of these episodes.<sup>6</sup> Accordingly, we suggest that detailed and effective medical history-taking techniques for discriminating seizures should be developed and standardized. In addition, a countermeasure for identifying unreliable applicants should also be prepared.

Current diagnostic EEG investigations conducted during pilot selection and certification lack both standardization and reference to universally applicable criteria for their effective use.<sup>7</sup> Moreover, the supporting literature is strikingly scarce. A typical EEG recording technique used to target patients in hospitals might be unsuitable for screening healthy populations. For example, because pilots have high probability of being exposed to seizure-provoking factors, such as sleep deprivation and strong visual stimuli such as sunlight, standardized activation procedures are required rather than the currently applied routine protocols. Besides, EEG as a technique for long-term monitoring of brain dynamics has advanced without its benefiting pilot selection.<sup>7</sup> These advances in digital long-term video-EEG technology might provide new information and insight for developing more effective ways to ensure aviation safety.

The present study is inherently limited by its retrospective single-center design. Furthermore, we were not able to determine the long-term clinical consequences of the EEG abnormalities detected during screening. Nevertheless, this study augments the scarce data and evidence on this subject in Ko-

rea, and hopefully its data will act as a baseline for future studies.

In conclusion, considering the low predictive value of EEG without the relevant clinical history in an unselected healthy young population, our findings raise questions regarding the cost-effectiveness of the current EEG screening protocol applied to pilot applicants. Future studies are needed to evaluate and standardize the EEG screening methods in this population. We suggest that a more-targeted and standardized EEG screening approach be adopted for pilot applicants with an epilepsy risk factor or a seizure history as determined by thorough medical history-taking.

#### Conflicts of Interest

The authors have no financial conflicts of interest.

#### Acknowledgements

This work was supported by INHA UNIVERSITY Research Grant (INHA-56992).

#### REFERENCES

1. Zifkin BG. The electroencephalogram as a screening tool in pilot applicants. *Epilepsy Behav* 2005;6:17-20.
2. Kasteleijn-Nolst Trenité D, Rubboli G, Hirsch E, Martins da Silva A, Seri S, Wilkins A, et al. Methodology of photic stimulation revisited: updated European algorithm for visual stimulation in the EEG laboratory. *Epilepsia* 2012;53:16-24.
3. Pillai J, Sperling MR. Interictal EEG and the diagnosis of epilepsy. *Epilepsia* 2006;47 Suppl 1:14-22.
4. Clark JB, Riley TL. Screening EEG in aircrew selection: clinical aerospace neurology perspective. *Aviat Space Environ Med* 2001;72:1034-1036.
5. St Louis EK, Cascino GD. Diagnosis of epilepsy and related episodic disorders. *Continuum (Minneapolis)* 2016;22(1 Epilepsy):15-37.
6. Kasteleijn-Nolst Trenité DG, Vermeiren R. The impact of subclinical epileptiform discharges on complex tasks and cognition: relevance for aircrew and air traffic controllers. *Epilepsy Behav* 2005;6:31-34.
7. Velis DN. Proposal for electroencephalogram standardization in aircrew selection. *Epilepsy Behav* 2005;6:27-30.