Healthcare Professionals' Electroencephalography Competency: A Disconnect Between Self-Assessment and Objective Testing

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ABSTRACT

BACKGROUND: The role of the healthcare professional (HCP) in performing high-quality electroencephalography (EEG) is critical to ensuring accurate results. This study analyzes HCPs' subjectively and objectively assessed EEG competence to provide information on their EEG competence and competence needs for the development of their education and training. **METHODS:** The study was a descriptive cross-sectional study. The target group of the study was HCPs working in the clinical neurophysiology departments of university hospitals in Finland. The research data were collected using the EEG Competence instrument created for this research. The instrument consisted of a self-assessment section and a knowledge test component. **RESULTS:** The participants (N = 65; response rate, 81%) consisted of 34 registered nurses and 31 laboratory technologists. In the self-assessment section, the highest mean score was in patient observation (mean, 4.6) and the lowest was in EEG theoretical knowledge (mean, 3.9). In the test section, most of the respondents (73.8%) answered all questions correctly (maximum, 6 points). There was a positive correlation between age, work experience, own satisfaction with EEG competence, and subjective self-assessment. Those familiar with EEG guidelines and who participated in training days assessed their competence as significantly better ($P < .05$). Respondents who read EEG-related literature on their own identified artifacts better ($P = .005$). **CONCLUSIONS:** Laboratory technologists' and registered nurses' subjectively and objectively assessed EEG competence was high. In the future, the EEG competence instrument should be developed further, and more research is needed to assess its psychometric properties to provide more information on HCPs' competence in the diagnostic process.

Keywords: biomedical laboratory scientist, competence, EEG, healthcare professional, laboratory technologist, registered nurse

Healthcare professionals' (HCPs') electroencephalography (EEG) competence is fundamental for accurate test results[1,2] and for the correct diagnosis of patients with neurological disorders.[3] Correct and timely diagnosis is essential in healthcare to guide patient care. However, diagnostic error has been reported as a common patient safety issue.[4] Electroencephalography is a diagnostic test with specific importance for the diagnostic process of epilepsy[5] and for assessing prolonged epileptic seizures in critically ill patients.[6] The professional titles and education of persons performing EEG vary. Usually, EEG is performed by technicians or technologists (EEG tech).[7] However, more recently, nurses are expected to be competent in EEG to improve patient outcomes and safe practices.[8,9]

In Finland, the specialty of clinical neurophysiology is part of the biomedical laboratory science bachelor's degree program (210 European Credit Transfer and Accumulation System, 3.5 years; the title "biomedical laboratory scientist" is also known as laboratory technologist). Education is given in universities of applied sciences.[10] However, clinical neurophysiology departments also employ registered nurses with no formal EEG training in nursing school; in their case, familiarization in the field only takes place in the workplace. In this study, "HCP" refers to nurses and technologists.

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Background

Competence can be defined as "functional adequacy and capacity to integrate knowledge and skills to attitudes and values into specific contextual situations of practice."[11] In the diagnostic process, HCPs' competence can be divided into individual, team-based, and system-related competencies.[12] In this study, the focus is on the individual EEG competence of HCPs. EEG competence is defined as knowledge and skills that are essential for performing the diagnostic test, EEG.

To maintain the quality of EEG, the American Clinical Neurophysiology Society, the International Federation of Clinical Neurophysiology, the American Society of Electroencephalographic Technicians, and the International Organization of Societies for Electrophysiological Technology have developed EEG guidelines and competency requirements. According to these, performing EEG includes, for example, electrode application, patient observation, recognition of different waveforms, and elimination of artifacts. However, it is unclear how EEG competence can be measured. In this study, EEG competence consists of 6 components formed by grouping EEG guidelines and competence requirements (Figure 1).

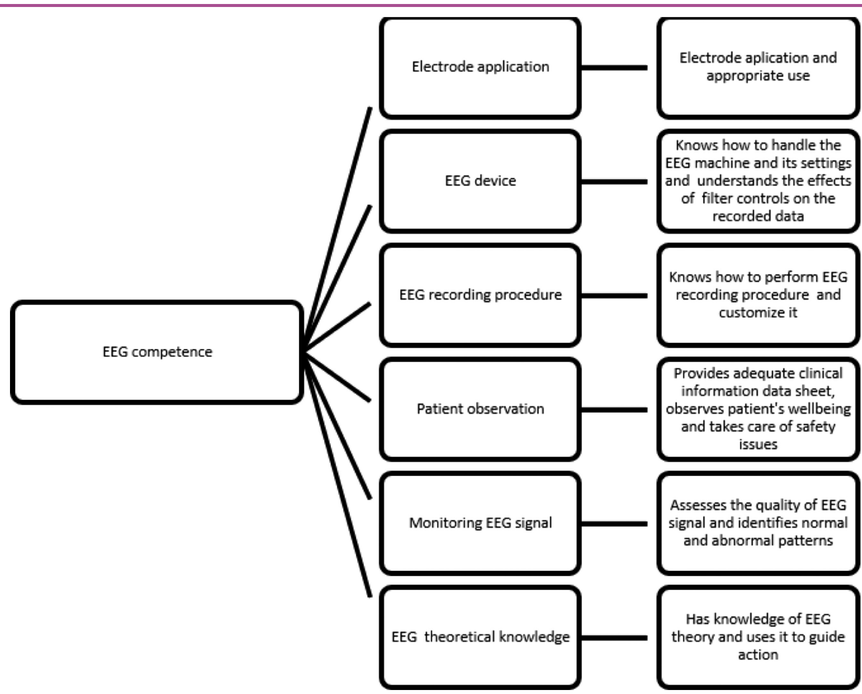
There are a limited number of studies on EEG competence.[13–18] Most often, research has focused on the knowledge and skills of nurses to perform continuous EEG monitoring[12–16] because its use has increased especially in intensive care units and there is a lack of trained EEG professionals to be available 24/7.[17,18] There is a lack of studies focusing on, for example, routine standard EEG, which is the most basic EEG method.[3] As a result, the overall EEG competence of HCPs is unclear.

Electroencephalography competence has been evaluated using various instruments developed for single studies,[13–18] and the focus of the instruments varies. Images of EEG tracings are used to assess HCPs' skills to identify different EEG patterns.[13–18] Knowledge test is used to assess nurses' knowledge of EEG fundamentals.[17,18] Subjective self-assessment of EEG competence has been used only rarely in instruments, with questions relating to the participants' current level of comfort with EEG on a scale of 1 to 10.[17,18] Studies on EEG competence focusing on, for example, electrode application, patient observation, or handling of the EEG recording device are limited.

Electroencephalography competence associates with educational background. Electroencephalography tech interrater agreement was moderate.[13] However, individual results varied widely.[13] The test scores of certificated EEG techs were higher than those of EEG techs not having certification.[13] Nurses' ability to interpret the EEG signal was weak before training,[16–18] and most participants' EEG knowledge remained under passing grade in the test.[17,18] However, studies have proved that additional training can influence the development of competence.[14–18]

The purpose of this study was to analyze HCPs' subjectively and objectively assessed EEG competence. The aim is to provide information on the EEG

FIGURE 1 Components of electroencephalography (EEG) competence based on previous literature.



competence and competence needs of HCPs for the development of their education and training. The study also provides a new assessment method of EEG competence evaluation. The research questions were as follows: What is the level of EEG competence of HCPs? What background factors, if any, associate with the EEG competence of HCPs? What is the association between the subjective and objective assessment of HCPs' EEG competence?

Methods

A descriptive cross-sectional study design was applied. Data were collected in October to November 2020 at 5 clinical neurophysiology wards of 4 university hospitals in Finland. The target group was HCPs working in these wards (N = 80). The data were collected using a paper questionnaire including background information and the EEG Competence instrument (EEGcomp) created for this study. The EEGcomp measures HCPs' EEG competence based on international EEG guidelines and competence requirements (American Clinical Neurophysiology Society, American Society of Electroencephalographic Technicians, International Federation of Clinical Neurophysiology, International Organization of Societies for Electrophysiological Technology) consisting of 2 sections: self-assessed EEG competence (54 items) and the knowledge test component (6 items) to supplement the self-assessment and to objectively test participants' knowledge to name electrodes and identify artifacts.

The self-assessed EEG competence section consists of 6 areas, namely, electrodes (11 items), EEG device (9 items), EEG recording procedure (13 items), patient observation (10 items), monitoring the EEG signal (7 items), and EEG theoretical knowledge (4 items), where participants assess their EEG competence using a 5-point Likert scale (1, very poor; 2, poor; 3, neither poorly nor well; 4, well; and 5, very well). The knowledge test section consists of 2 areas: naming electrodes (3 items) by filling in the blank with the correct name of the indicated electrodes from the standardized 10–20 system image presented (3 items) and identification of artifacts (3 items) from 3 different images of EEG tracings using multiple-choice questions. Each correct answer scores 1 point, so the highest possible score is 6 points.

When using a new instrument, it is important to evaluate its validity and reliability.[19] Content validity of the EEGcomp was assessed with 6 content experts for each item's relevance, importance, and clarity. The experts were a nurse and 5 technologists who worked as practitioners, specialists, or supervisors or in education in the field of clinical neurophysiology and had knowledge of EEG. Seven items were clarified and modified based on the feedback and suggestions provided by the experts. As for reliability, the internal consistency of the EEGcomp was examined with Cronbach α coefficient, which varied between 0.829 and 0.956. Preliminary piloting was conducted with the target group (n = 3) to test the instrument's usability and completion time. No modifications based on this were done.

The data were analyzed using the IBM SPSS v26.0 for Windows (IBM Corp). Data are presented using percentage, mean (SD), and median. A total of 10 sum variables were formed from the self-assessment section by calculating the averages (means) of items while maintaining the original scale of 1 to 5 and from the test section where each correct answer scored 1 point. The association between the background variables and the sum variables was examined based on the distribution of the variable using the Mann-Whitney *U* test or 2-sample *t* test. The associations between the numerical variables were calculated using a Pearson or Spearman correlation coefficient. Statistical tests' significance level was set at $P = .05$. The study followed good scientific practice,[20] and permission for the study was obtained from each of the 4 Finnish university hospitals.

Results

Of 80 surveys distributed, 65 responses (81%) came from registered nurses (34) and laboratory technologists (31), with a mean age of 41 (9.3) years and a median of 8 (range, 0.2-30) years of work experience with EEG. Only 26% of participants had completed optional clinical neurophysiology courses in a university of applied sciences. However, most of the participants reported receiving EEG training in the workplace, on average, 2 times a year (82%) and participating in out-of-work training once a year (85%). Approximately half of the participants were familiar with EEG recommendations and guidelines (54%) and reported sometimes reading EEG literature independently (58%). The median of participants' satisfaction with their own EEG skills was 8 (range, 5–10).

Self-assessed EEG competence mean (SD) was 4.5 (0.5). On sum variable level, the highest mean (SD) score was in patient observation (4.6 [0.5]) and the lowest was in EEG theoretical knowledge (3.9 [0.6]). In the test section, the median of the total test score was 6 points, with a range of 4 to 6 points. Most of the participants (73.8%) named all the electrodes and identified all the artifacts correctly (Table 1). There was no correlation between subjectively and objectively assessed EEG competence ($P = .812$).

Of the background factors, participation in out-of-work training ($P = .011$) and familiarization with EEG recommendations ($P = .002$) associated with higher self-assessed EEG competence. In addition, among numerical background variables, age ($P < .001$), work experience ($P < .001$), and own satisfaction with EEG

TABLE 1. Participants' (N = 65) Level of Subjectively and Objectively Assessed EEG Competence

Sum Variable (No. Items)	Range	Mean (SD)	Median (IQR)	α
Overall self-assessed EEG competence (54-item Likert range, 1–5)	3.2–5	4.5 (0.5)	4.6 (0.7)	0.98
Electrode application (11 items)	3.1–5	4.5 (0.5)	4.7 (0.9)	0.901
EEG device (9 items)	2.9–5	4.4 (0.6)	4.4 (1.0)	0.868
EEG recording procedure (13 items)	3.5–5	4.5 (0.5)	4.7 (0.7)	0.912
Patient observation (10 items)	3.3–5	4.6 (0.5)	4.8 (0.7)	0.933
Monitoring EEG signal (7 items)	2.9–5	4.4 (0.6)	4.4 (1.1)	0.956
EEG theoretical knowledge (4 items)	2.5–5	3.9 (0.6)	4.0 (0.9)	0.829
Overall objectively assessed EEG competence (6 items; 0–6 points)	4–6	5.67 (0.62)	6 (0)	
Naming electrodes (3 items)	1–3	2.91 (0.42)	3 (0)	
Identify artifacts (3 items)	1–3	2.76 (0.50)	3 (1)	

Abbreviations: EEG, electroencephalography; IQR, interquartile range; α, Cronbach alpha.

recording skills ($P < .001$) correlated positively with self-assessed EEG competence. In the objective test section, participants reading EEG literature on their own sometimes or often ($P = .005$) received higher scores for identifying artifacts than others.

Discussion

Healthcare professionals' self-assessed EEG competence was very close to the maximum of the scale. However, participants experienced some shortcomings in their EEG theoretical knowledge. In the objective test section, most of the participants answered all questions correctly. There was no correlation between self-assessment and test assessment.

The level of EEG competence has varied from weak to good in previous studies.[13–18] The results of this study are better in terms of satisfaction with one's own EEG competence and identifying artifacts. However, it should be noted that, in some previous studies, nurses had only little or no previous work experience in EEG and it was not part of their everyday job description.[14–18] Previous studies also found partial deficiencies in EEG theoretical knowledge, but skills improved significantly after training.[17,18] The results of this study cannot be compared with previous results in all areas. In this study, the test section did not include the identification of different waveforms or a theoretical knowledge test. However, the instrument has items not included in previous studies, such as patient observation. Agostini and Bonner[1] have described the role of the EEG performer in patient observation as "functioning as eyes and ears for the interpreting physician." Healthcare professionals have an important role in monitoring the patient's condition and reporting changes as members of the diagnostic team.[21] In the future, it may be necessary to take a closer look at the role of the EEG performer in patient observation.

In this study, the factors associating with EEG competence differed slightly from the results of previous studies. Educational background[13] and some education programs[14–18] have been found to improve EEG knowledge and skills. Similarly, in this study, participation in out-of-work training significantly improved the level of self-assessed EEG competence, and supervisors should understand the benefits of these trainings and enable their employees to participate in them equally. However, in this study, educational background was not related to participants' EEG competence. It should be noted that, internationally, EEG techs' and laboratory technologists' educations are not directly comparable because, in Finland, EEG education is included in only a few credits in the biomedical laboratory science curriculum. Work experience has been reported to relate to EEG knowledge and skills,[18] which was also the case in this study. However, after an education program, there was no longer any correlation in previous studies.[18] Ahrens et al[13] point out that the predictive value of work experience is often impaired by variability. In the test section of this study, participants who read EEG-related literature on their own were better able to identify artifacts. It is therefore important to consider employees' own activity and willingness to develop professionally.

The results of the self-assessment section and knowledge test section were inconsistent. In the future, the psychometric properties of the instrument should be further assessed for interrater reliability, construct validity, translational validity, and criterion validity.[19] The instrument's objective test section should be extended to include, for example, a theoretical knowledge test and seizure identification.

The limitations of the study focus on generalizability, data collection, and instrumentation. This study was conducted in 4 university hospitals in Finland, which limits the generalizability of these findings to other countries. In addition, one limitation of the study relates to the subjectivity of self-assessment. Although self-assessment is one of the most widely used methods and an important part of competence assessment,[22] there is variation between self-assessment and other assessment methods.[23] Internal consistency of the instrument was high (Cronbach $\alpha = 0.98$). This may mean that there are redundant items or that the content of the items is too similar.[19,24] In this study, the aim was to assess EEG competence with 6 areas through self-assessment, and 2 of the 6 areas were supplemented with a knowledge test. The amount of knowledge test items was relatively low. To ensure that the EEGcomp instrument assesses the comprehension of the 6 competency criteria, future revisions could be beneficial. In addition, EEG competence was defined as knowledge and skills that are essential for performing a diagnostic test, and the instrument consists mainly of technical skills. In the future, it could be beneficial to assess EEG competence from a broader point of view and add nontechnical skills to the instrument that are needed in the diagnostic process.

Conclusions

Laboratory technologists' and registered nurses' overall subjectively and objectively assessed EEG competence was high. However, participants self-assessed some shortcomings in their EEG theoretical knowledge. To increase the EEG competence in the future, development of targeted educational interventions could be beneficial. For example, different online learning platforms could provide possibilities for innovative learning. This study provided new insights into the assessment of HCPs' EEG competence. However, EEGcomp needs further development to meet the competence required in the diagnostic process to provide more detailed information on HCPs' competence in the diagnostic process and ensure reliable diagnosis of patients.

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