Karya J Health Sci. 2022; 3(3): 182-186
ARAŞTIRMA MAKALESİ/RESEARCH ARTICLE doi: 10.52831/kjhs.1117060 e-ISSN:2717-9540

KARYA JOURNAL OF HEALTH SCIENCE

journal homepage: www.dergipark.org.tr/kjhs

THE EFFECT OF USING WEB-BASED ELECTROCARDIOGRAPHY SIMULATION ON RHYTHM DIAGNOSTIC SKILLS OF PARAMEDIC STUDENTS

WEB TABANLI ELEKTROKARDİYOGRAFİ SİMÜLASYONU KULLANIMININ PARAMEDİK ÖĞRENCİLERİNİN RİTİM TANILAMA BECERİLERİNE ETKİSİ

Aslı Kurtgöz[1*], Selin Keskin Kızıltepe[2]

[1]Department of Therapy and Rehabilitation, Sabuncuoğlu Şerefeddin Health Services Vocational School, Amasya University, Amasya, Turkey

[2]Department of Nursing, Faculty of Health Sciences, Düzce University, Düzce, Turkey

ABSTRACT

Objective: This study was conducted to determine the effect of the use of web-based electrocardiography (ECG) simulation on paramedic students' rhythm diagnostic skills.

Method: The study was conducted as a single-group pretest-posttest design study between 02.05.2021-01.09.2021. The study group of the research consisted of students studying in the last year in the paramedical department of a university in Turkey. The data of the study were collected person-to-person using the information form and the Basic ECG Rhythm Diagnosis Form. Participants were provided online ECG training for 3 hours per week over the course of 8 weeks. One month after the training, the participants were pre-tested. After the pretest, the participants used a web-based ECG simulator for 4 weeks. Posttest was applied to the participants at the end of four weeks.

Results: It was found that the rate of correct diagnosis of all rhythms in the Diagnosis of Basic ECG Rhythms Form of the students increased after the use of a web-based simulator. It was determined that there was a significant statistical difference between the pre-test and post-test scores of the students (t:-7.476, p<0.001).

Conclusion: ECG is one of the subjects that individuals have difficulty in learning. Therefore, using different teaching methods in addition to the traditional teaching method can help facilitate ECG teaching. In this study, it was determined that the use of web-based electrocardiography simulation improved the rhythm diagnostic skills of paramedical students.

Key Words: Electrocardiography, Learning, Paramedic, Students

ÖZ

Amaç: Bu çalışma web tabanlı elektrokardiyografi (EKG) simülasyonu kullanımının paramedik öğrencilerinin ritim tanılama becerisi üzerindeki etkisi belirlemek amacıyla yapıldı.

Yöntem: Araştırma, 02.05.2021-01.09.2021 tarihleri arasında tek gruplu ön test-son test desenli çalışma olarak yürütüldü. Araştırmanın çalışma grubunu Türkiye'de bir üniversitenin paramedik bölümünde son sınıfta öğrenim gören öğrenciler oluşturdu. Araştırmanın verileri bireyi tanıtıcı bilgi formu ve Temel EKG Ritimlerini Tanılama Formu kullanılarak yüz yüze toplandı. Katılımcılara 8 hafta boyunca haftada 3 saat olmak üzere online EKG eğitimi verildi. Eğitimi takiben bir ay sonra katılımcılara ön test uygulandı. Ön test sonrası katılımcılar bir web tabanlı EKG simülatörünü 4 hafta süresince kullandı. Dört hafta sonunda katılımcılara son test uygulandı.

Bulgular: Öğrencilerin Temel EKG Ritimlerini Tanılama Formunda yer alan tüm ritimleri doğru tanılama oranlarının web tabanlı simülatör kullanımından sonra arttığı bulundu. Öğrencilerin ön test ve son test puanları arasında anlamlı düzeyde istatistiksel fark olduğu belirlendi (t:-7.476 p<0.001).

Sonuç: EKG, bireylerin öğrenmekte zorlandıkları konulardan biridir. Bu nedenle geleneksel öğretim yöntemine ek olarak farklı öğretim yöntemlerinin kullanılması EKG öğretiminin kolaylaştırılmasına yardımcı olabilir. Bu çalışmada web tabanlı elektrokardiyografi simülasyonu kullanımının paramedik öğrencilerinin ritim tanılama becerisini geliştirdiği belirlendi.

Anahtar Kelimeler: Elektrokardiyografi, Öğrenme, Paramedik, Öğrenci

INTRODUCTION

Cardiovascular diseases (CVDs) are among the leading causes of death in the world and approximately 17.9 million deaths occur every year due to CVDs [1]. In addition, some diseases constitute risk factors for arrhythmias [2,3]. Electrocardiography (ECG) is one of the diagnostic tools frequently used in the diagnosis of many cardiovascular diseases and in the detection of arrhythmias. However, it is necessary to have sufficient knowledge and skills to interpret the ECG correctly and quickly for diagnosis.

For timely and accurate diagnosis, not only physicians but also nurses, paramedics and other healthcare professionals should have the ability to diagnose basic ECG rhythms [4]. The diagnosis of cardiac rhythms and initiation of appropriate treatment and intervention in the early period by paramedics, especially those providing service in the pre-hospital field, has an important position in reducing morbidity and mortality [5]. At the same time, correct interpretation of ECG can prevent unnecessary medical interventions [6].

Makale Bilgisi/Article Info

Yükleme tarihi/Submitted: 15.05.2022, **Revizyon isteği/Revision requested:** 05.09.2022, **Son düzenleme tarihi/Last revision received:** 06.09.2022, **Kabul/Accepted:** 11.09.2022

***Sorumlu yazar/Corresponding author:** Amasya University, Sabuncuoğlu Şerefeddin Health Services Vocational School, İpekköy, Amasya, Turkey
[1*]Email: asli.aydogan@amasya.edu.tr, [2]Email: selinkeskinkeskin@gmail.com

Accordingly, in order to prevent delays in the diagnosis of cardiac rhythm disorders, it is necessary to develop the skills of healthcare professionals serving in the pre-hospital field to diagnose cardiac rhythms and interpret ECG [7]. The nature and timing of emergency treatment and intervention provided by paramedics is a critical determinant of survival in non-hospital cardiac arrests [8]. It has been reported that defibrillation performed within 3-5 minutes after collapse provides a survival rate of up to 50-70%; every minute that defibrillation is delayed reduces the survival probability of patients by 10-12% [9]. In this context, it is an important requirement for paramedics working in the pre-hospital field to be able to diagnose cardiac rhythms quickly and accurately.

Serious training should be provided to improve the ability to interpret ECG [4]. ECG is known as one of the skills that are difficult to teach due to its abstract nature, complex mechanism, and scattered content. Therefore, the use of various teaching methods in the education of students and health professionals can facilitate ECG teaching [6]. Students are unlikely to receive adequate bedside training on ECG interpretation in cardiology services or intensive care units. Therefore, ECG trainings should be provided to the students before clinical practice [10]. A single teaching method may not be sufficient for training all students. Therefore, in addition to the traditional teaching method, an effective learning environment should be created by using different methods such as role-play, model use, case discussion, web-based training, and simulation use [11]. The use of these methods in ECG teaching may also support students' ability to interpret ECG. In a study examining the effect of the web-based teaching method on students' ECG learning compared to the traditional narrative method, it was detected that the ECG interpretation skills of the students in the web-based group were significantly better than the other group [12]. In a pre-test / post-test study conducted with medical students, it was detected that a web-based ECG training program increased students' ability to interpret ECG [13]. In another study, it was reported that training software developed for ECG teaching positively affected ECG teaching [14].

The use of simulators in health education has been one of the most prominent teaching approaches in recent days. The use of simulators in ECG teaching is effective in acquiring and maintaining students' ECG interpretation skills and improving students' self-confidence and critical thinking skills [15]. In a study conducted on this subject, it was determined that the use of software-based simulators for cardiac arrhythmias was effective in the ECG learning of the participants [6]. In this context, it is thought that the use of various teaching methods such as the use of simulators before clinical practice will both improve students' ability to interpret ECG and facilitate ECG teaching. This study was conducted to determine the effect of the use of web-based electrocardiography simulation on the rhythm diagnostic skills of paramedic students.

METHOD

Research Type

The study was conducted as a single-group pre-test/post-test study between 02.05.2021 and 01.09.2021.

Research Population and Sample

The population of the study consisted of students (N=103) studying in their last year in the paramedical department of a university. In the study, it was aimed to reach the entire population without choosing a sample. The study was completed with a total of 81 (participation rate: 78.6%) students who voluntarily participated in the study.

Data Collection

In the study, the data were collected face-to-face using the information form prepared by the researchers by reviewing the literature and the Basic ECG Rhythms Diagnosis Form [16,17]. Online ECG training was provided to the participants by the researcher (A.K.) for 3 hours a week over the course of 8 weeks. One month after the training, data collection tools were applied to the participants for pre-testing purposes. After the pre-test application, the participants were asked to use a web-based ECG simulator called The Six-Second ECG for 4 weeks. The Six-Second ECG is a free web simulator that includes 27 basic heart rhythms [18]. In the 'Explore Review' section under the 'Learn' tab in the simulator, you can click on any rhythm name and view the software rhythm and the features of rhythm. In the 'Explore Review Play' section under the 'Game' tab, users have the opportunity to evaluate their rhythm diagnostic skills by identifying randomly introduced rhythms. The students were reminded about the use of the ECG simulator three times a week over the course of 4 weeks via text messages and e-mail. The reminder e-mail and messages were sent by the researcher A.K. At the end of four weeks, the Basic ECG Rhythm Diagnosis Form was re-applied to the participants for post-test purposes. Nine students who completed the pre-test but did not complete the post-test were excluded from the study. The study was completed with 81 students who filled out the pre-test and post-test completely.

Data Collection Tools

The Participant Information Form: The participant information form included questions about the descriptive characteristics (age, gender, etc.) of the participants.

The Basic ECG Rhythms Diagnosis Form: The Basic ECG Rhythms Diagnosis Form consists of 14 basic ECG rhythms (Normal Sinus Rhythm, Sinus Bradycardia, Sinus Tachycardia, Sinus Arrhythmia, Atrial Tachycardia, Atrial Fibrillation, Atrial Flutter, 1st Degree AV Block, 2nd Degree AV Block Type 1, 2nd Degree AV Block Type 2, 3rd Degree AV Block, Ventricular Tachycardia and Ventricular Fibrillation). The rhythms that the participants answered correctly were calculated as 1 point and the rhythms that they answered incorrectly were calculated as 0 point. Accordingly, the highest score that those who answered all questions correctly can get from the form is 14. The Cronbach Alpha Reliability Coefficient of the Basic ECG Rhythms Diagnosis Form was found to be 0.68.

Statistical Analysis

The data obtained from the study were assessed in the IBM SPSS V20 package program setting. The Kolmogorov Smirnov test was used to determine the suitability for normal distribution. Mann-Whitney U test and Kruskall-Wallis test were used for the comparison between the groups in the analysis of the data not demonstrating normal distribution. Wilcoxon Signed Rank Test was used to compare the pre-test and post-test scores of the participants. Analysis results are expressed as mean±standard deviation, median (min-max) and frequency (percentage). In the study, the significance level was taken as 0.05.

Ethical Approval

Before starting the study, a study permit was obtained from the relevant institution and approval from The Clinical Research Ethics Committee of Ondokuz Mayıs University (No: B.30.2.ODM.0.20.08/510) in order to conduct the study. Permission was obtained from the institution where the study was conducted (No:15386878-044). In addition, the participants were informed about the purpose and process of the study with a volunteering form before the questionnaire forms were applied, and their written and verbal consents were obtained.

RESULTS

It was determined that the average age of the students participating in the study was 20.19±1.18; 71.6% (n=58) were female, 63.0% (n=51) were Vocational Health High School graduates, and 93.8% (n=76) were satisfied with studying in the paramedic department. The answers given by the students to the questions about ECG diagnosis are given in Table 1.

It was found that 44.4% of the students considered the ECG diagnostic skill insufficient, 51.9% thought that ECG diagnosis was difficult but enjoyable, and 60.5% stated that conducting case studies related to ECG in the classroom environment was a method that would facilitate ECG diagnostic skill (Table 1).

Table 1. Distribution of the answers given by the students to the questions related to ECG

Question	Answers	n	%
How s/he evaluates the ECG diagnostic skill	Highly insufficient	28	34.6
	Insufficient	36	44.4
	Neither good nor bad	17	21.0
His/her thoughts on ECG diagnosis	I think it is enjoyable to diagnose ECG.	7	8.7
	I think ECG diagnosis is difficult but enjoyable.	42	51.9
	I think it is difficult to diagnose ECG.	32	39.5
His/her opinions on methods to facilitate ECG diagnostic skills **	By listening to the lesson and participating in the lesson	25	30.9
	By watching videos about ECG	17	21.0
	By studying books related to ECG	9	11.1
	By observing from the monitor at the bedside	47	58.0
	By using computer-aided simulation programs related to ECG	33	40.7
	By performing case studies related to ECG in the classroom	49	60.5

***More than one answer was given, ECG: Electrocardiography*

When the answers of the ECG rhythms diagnostic form applied to the students before and after the use of web-based simulator were examined, it was found that the correct diagnostic rates of all rhythms of the students increased after the use of web-based simulator (Table 2). A statistically significant difference was found between the pre-test and post-test scores of the students (t:-7.476 p<0.001).

When the pre-test / post-test scores and descriptive data of the students were compared, a statistically significant difference was found between the pre-test scores and the status of evaluating gender and ECG diagnostic skills (Table 3).

DISCUSSION

Electrocardiography is one of the most widely used and important diagnostic tests, and specialization in its interpretation requires considerable time and effort. It is important to provide ECG competence to healthcare professionals through training so as to meet their needs. This training begins during undergraduate education and should continue with vocational training [19]. The complex structure of ECG can force students to understand and interpret ECG. This situation can also reduce students' self-confidence in rhythm diagnostic skills. As a matter of fact, in our study, it was determined that 44.4% of the students evaluated their ECG diagnostic skills to be insufficient and 51.9% stated that ECG diagnosis was difficult but enjoyable. Similar to our study findings, in a study conducted by Viljoen et al. (2020) 53.7% of the students who received traditional education stated that ECG evaluation and interpretation were difficult [20]. In a study conducted in Australia, it was found that 96% of the students thought that ECG knowledge was useful in their future careers; only 15% trusted their knowledge about ECG rhythm interpretation; 73% stated that it was difficult to understand ECG [21]. It is thought that using the teaching methods that students are interested in will be effective in changing the students' views that ECG is difficult and their feelings of insufficiency in their ability to interpret ECG.

In our study, the majority of the students defined the methods to facilitate ECG diagnostic skills as that "conducting case studies on ECG, making bedside observations and using computer-aided simulation programs on ECG". It was found that students expressed approaches such as "listening to the lesson/attending the lesson, watching videos about ECG and studying books about ECG" as facilitating methods to a lesser extent. This finding reveals that students prefer methods such as case studies, clinical practice, and simulation use, in addition to traditional education in ECG learning. When educators are aware of the various learning styles of the students and act in this direction in ECG teaching, it can be ensured that both an efficient learning environment is created, and their students are motivated to achieve academic success [11].

ECG is a diagnostic tool frequently used in the pre-hospital field and its interpretation is an important skill for paramedics [16,22]. Immediate diagnosis and treatment of cardiac arrest rhythms (ventricular fibrillation, pulseless ventricular tachycardia, etc.), critical arrhythmias (sinus bradycardia, AV blocks, etc.) and ischemic changes (acute inferior myocardial infarction, etc.) in the pre-hospital field can significantly and rapidly affect patient results [16].

Table 2. Frequency distributions of students' pre-test and post-test answers to the Basic ECG Rhythms Diagnosis Form

ECG Rhythm		Pre-test answers		Post-test answers	
		n	%	n	%
Normal Sinus Rhythm	Incorrect	26	32.1	18	22.2
	Correct	55	67.9	63	77.8
Sinus Arrhythmia	Incorrect	59	72.8	53	65.4
	Correct	22	27.2	28	34.6
Atrial Flutter	Incorrect	52	64.2	19	23.4
	Correct	29	35.8	62	76.5
Atrial Tachycardia	Incorrect	64	79.0	45	55.6
	Correct	17	21.0	36	44.4
Atrial Fibrillation	Incorrect	55	67.9	30	37.0
	Correct	26	32.1	51	63.0
Ventricular Tachycardia	Incorrect	58	71.6	15	18.5
	Correct	23	28.4	66	81.5
Sinus Bradycardia	Incorrect	50	61.7	22	27.2
	Correct	31	38.3	59	72.8
Sinus Tachycardia	Incorrect	69	85.2	27	33.3
	Correct	12	14.8	54	66.7
Sinus Arrest	Incorrect	43	53.1	15	18.5
	Correct	38	46.9	66	81.5
Ventricular Fibrillation	Incorrect	57	70.4	16	19.8
	Correct	24	29.6	65	80.2
1st Degree AV Block	Incorrect	70	86.4	52	64.2
	Correct	11	13.6	29	35.8
2nd Degree AV Block Type 2	Incorrect	72	88.9	49	60.5
	Correct	9	11.1	32	39.5
2nd Degree AV Block Type 1	Incorrect	76	93.8	60	74.1
	Correct	5	6.2	21	25.9
3rd Degree AV Block	Incorrect	71	87.7	46	56.8
	Correct	10	12.3	35	43.2
Total		81	100.0	81	100.0

ECG: Electrocardiography, AV Block: Atrioventricular Block

Table 3. Comparison of students' descriptive characteristics and pretest-posttest scores

		Pre-test Mean±SD	Pre-test Median (Min-Max)	Post-test Mean±SD	Post-test Median (Min-max)
Age group	18-20	3.88±2.72	3 (0-11)	8.28 ±3.18	8 (1-14)
	21-26	3.79±2.25	3 (0-9)	8.21±2.70	8 (3-14)
Test value			U=664.500 p=0.839		U=655.00 p=0.763
Gender	Male	2.57±1.90	2 (0-8)	7.96 ±2.72	8 (3-12)
	Female	4.36±2.64	4 (1-11)	8.38 ±3.16	9 (1-14)
Test value			U=392.500 **p=0.004**		U=593.500 p=0.438
Satisfaction with studying in the department	Satisfied	3.97±2.63	3 (0-11)	8.34±2.99	8 (1-14)
	Dissatisfied	3.22±2.05	3 (1-7)	8.44 ± 2.51	9 (4-11)
Test value			U=134.500 p=0.271		U=136.000 p=0.286
How s/he evaluates the ECG diagnostic skill	Highly insufficient	2.89±2.13	2 (0-9) [a]	7.43±3.18	8 (1-12)
	Insufficient	4.28±2.74	4 (1-10) [ab]	8.53±2.83	9 (2-12)
	I'm undecided	4.53±2.55	4 (0-11) [b]	9.06±3.03	9 (3-14)
Test value			X^2=7.483 **p=0.024**		X^2=3.184 p=0.204

Mean: Average, SD: Standard deviation, U: Mann Whitney U test, X^2: Kruskall Wallis Test, ECG: Electrocardiography, a-b: No difference between groups with the same letter

In a study conducted by Drew et al. (2011) it was reported that the duration of hospitalization decreased with the increase in the use of ECGs by paramedics in the treatment of patients with acute coronary syndrome (ACS) [23]. However, some studies in the literature emphasize that health-care personnel who serve in the pre-hospital field have low ECG usage and ECG interpretation competencies. In a retrospective study conducted on this subject, it was found that only 1.941 of 7.098 patients with ACS who were transferred to the hospital by ambulance had their ECG taken before the hospital [24]. In a study conducted by Rahimpour et al. (2021) 41.5% of those working in the pre-hospital field stated their ECG interpretation competence as medium level [25]. In a study conducted in Sweden by Werner et al. (2016) it was found that only 35% of the health-care personnel working in the ambulance were able to diagnose ventricular tachycardia; 14% were unable to identify ventricular fibrillation [26]. Poor ECG interpretation skills of health-care personnel providing services in the pre-hospital field may cause misinterpretation of ECG, thus, improper planning and delay of treatment, and worsening of patient prognosis. In this context, it is vital to develop the ECG interpretation skills of paramedics and other health-care personnel starting from undergraduate education. The use of different teaching methods may be effective in improving students' ability to interpret ECG. It has been reported in the literature that the use of web-based ECG simulators is effective in developing students' active and self-reflective learning styles and increasing their motivation [15]. In this study, it was found that the correct diagnostic rates of the students increased in all ECG rhythms after the use of web-based simulators; and there was a significant statistical difference between the pre-test and post-test scores. Similar to our study finding, it was determined that the ECG competencies of the students who took the courses supported by an ECG web application showed a significant improvement compared to the students who only took traditional education [20]. In this context, in addition to the traditional ECG teaching method, the use of web-based simulators can positively affect ECG teaching.

Study Limitations

Research results are limited to the sample studied, cultural and geographical changes may produce different results. It cannot be generalized.

CONCLUSION

In order to detect cardiac rhythm disorders and acute changes, it will be appropriate to improve the ECG usage and ECG interpretation skills of the people who will provide services in pre-hospital field starting from undergraduate education. In the development of ECG skills, the use of teaching strategies suitable for the learning style of the learner and the reinforcement of their knowledge-skills with rich teaching content may be effective. In this study, the use of web-based electrocardiography simulation improved rhythm diagnostic skills of the paramedic students who received ECG training with the traditional teaching method. In line with our study results, we think that the use of web-based ECG simulator in ECG training can provide benefits such as enriching the training content and facilitating ECG learning.

Ethical Approval: *2020/B.30.2.ODM.0.20.08/510, Clinical Research Ethics Committee of Ondokuz Mayıs University*

Conflict of Interest: *The authors have no conflicts of interest to declare.*

Funding: *None.*

Acknowledgements: *The authors would like to thank all participants.*

Author Contribution: Concept: *AK, SKK;* ***Desing:*** *AK, SKK;* ***Data collecting:*** *AK, SKK;* ***Statistical analysis:*** *AK,SKK;* ***Literature review:*** *AK, SKK;* ***Writing:*** *AK, SKK;* ***Critical review:*** *AK,SKK.*

REFERENCES

1. World Health Organization (WHO). Cardiovascular diseases. https://www.who.int/health-topics/cardiovascular-diseases#tab=tab_1. Accessed: December 30 2021.
2. Ardahanli I, Celik M. Comparison of Tp-e interval, QTc interval and Tp-e/QTc ratios between non-diabetic and prediabetic population. Annals of Medical Research. 2021;27(12):3117-3122.
3. Ardahanlı İ, Akyüz O. The effect of hemodialysis treatment on ventricular arrhythmogenesis parameters in electrocardiography. Selcuk Med J. 2021;37(1):5-10.
4. Akgun T, Karabay CY, Kocabay G, Kalayci A, Oduncu V, Guler A, Pala S, Kirma C. Learning electrocardiogram on YouTube: how useful is it. J Electrocardiol. 2014;47(1):113-117.
5. Hale P, Lowe R, Seamon JP, Jenkins JJ. Paramedic electrocardiogram and rhythm identification: a convenient training device. Prehosp Disaster Med. 2011;26(5):342-345.

6. Bazrafkan L, Hemmati M. The effect of Cardiac Arrhythmias Simulation Software on the nurses' learning and professional development. J Adv Med Educ Prof. 2018;6(2):86-91.
7. Doğan U, Atay E. Evaluation of result of basic ECG education given to student in first and emergency aid. Journal of Pre-Hospital. 2018;3(2):81-89.
8. Dyson K, Bray JE, Smith K, Bernard S, Straney L, Finn J. Paramedic resuscitation competency: a survey of Australian and New Zealand emergency medical services. Emerg Med Australas. 2017; 29(2):217-22.
9. Semeraro F, Greif R, Böttiger BW, et al. European resuscitation council guidelines 2021: systems saving lives. Resuscitation. 2021;161:80-97.
10. Yeom GJ, Yang J, Ki HS. Development and effects of supplementary textbook about ECG for nursing students. Korean Acad Fundam Nurs. 2020;27(3):268-276.
11. Kharb P, Samanta PP, Jindal M, Singh V. The learning styles and the preferred teaching-learning strategies of first year medical students. J Clin Diagn Res. 2013;7(6):1089-1092.
12. Jang KS, Hwang SY, Park SJ, Kim YM, Kim MJ. Effects of a web-based teaching method on undergraduate nursing students' learning of electrocardiography. J Nurs Educ. 2005;44(1):35-39.
13. Rolskov Bojsen S, Räder SBE, Holst AG, et al. The acquisition and retention of ECG interpretation skills after a standardized web-based ECG tutorial–a randomised study. BMC Med Educ. 2015;15:36.
14. Pontes PAI, Chaves RO, Castro RC, de Souza ÉF, Seruffo MCR, Francês CRL. Educational software applied in teaching electrocardiogram: a systematic review. Biomed Res Int. 2018;15:8203875.
15. Granero-Molina J, Fernández-Sola C, López-Domene E, Hernández-Padilla JM, Preto LS, Castro-Sánchez AM. Effects of web-based electrocardiography simulation on strategies and learning styles. Rev Esc Enferm USP. 2015;49(4):650-656.
16. Sibley A, MacLeod MH, Patocka C, Yu J, Stryhn H, Jain T. What adult electrocardiogram (ECG) diagnoses or findings are most important for advanced care paramedics to know. Cureus. 2021;13(7):e16260.
17. Hernández-Padilla JM, Granero-Molina J, Márquez-Hernández VV, Suthers F, López-Entrambasaguas OM, Fernández-Sola C. Design and validation of a three-instrument toolkit for the assessment of competence in electrocardiogram rhythm recognition. Eur J Cardiovasc Nurs. 2017;16(5):425-434.
18. SkillSTAT Learning. SS-ECG (The six second ECG) ®. North Vancouver, Canada: British Columbia; 2020.
19. Fent G, Gosai J, Purva M. Teaching the interpretation of electrocardiograms: Which method is best. J Electrocardiol. 2015;48(2):190-193.
20. Viljoen CA, Millar RS, Manning K, Burch VC. Effectiveness of blended learning versus lectures alone on ECG analysis and interpretation by medical students. BMC Med Educ. 2020;20(1):488.
21. Chen Y, Nasrawi D, Massey D, Johnston ANB, Keller K, Kunst E. Final-year nursing students' foundational knowledge and self-assessed confidence in interpreting cardiac arrhythmias: a cross-sectional study. Nurse Educ Today. 2021;97:104699.
22. Mobrad A. Electrocardiogram interpretation competency among paramedic students. J Multidiscip Healthc. 2020;13:823-828.
23. Drew BJ, Sommargren CE, Schindler DM, Benedict K, Zegre-Hemsey J, Glancy JP. A simple strategy improves prehospital electrocardiogram utilization and hospital treatment for patients with acute coronary syndrome (from the ST SMART Study). Am J Cardiol. 2011;107(3):347-352.
24. Diercks DB, Kontos MC, Chen AY, et al. Utilization and impact of pre-hospital electrocardiograms for patients with acute ST-segment elevation myocardial infarction: data from the NCDR (National Cardiovascular Data Registry) ACTION (Acute Coronary Treatment and Intervention Outcomes Network) Registry. J Am Coll Cardiol. 2009;53(2):161-166.
25. Rahimpour M, Shahbazi S, Ghafourifard M, Gilani N, Breen C. Electrocardiogram interpretation competency among emergency nurses and emergency medical service (EMS) personnel: a cross-sectional and comparative descriptive study. Nurs Open. 2021;8(4):1712-1719.
26. Werner K, Kander K, Axelsson C. Electrocardiogram interpretation skills among ambulance nurses. Eur J Cardiovasc Nurs. 2016;15(4):262-268.