Revista ARACÊ
ISSN: 2358-2472

PERFORMANCE OF MEDICAL STUDENTS IN THE INTERPRETATION OF THE ELECTROCARDIOGRAM: TRAINING PATHS AND COMPETENCIES

https://doi.org/10.56238/arev7n3-257

Submitted on: 02/25/2025 **Publication date:** 03/25/2025

João Victor Alcântara Pires[1] and Gleber Nelson Marques[2]

ABSTRACT

Introduction: The electrocardiogram (ECG) has established itself as one of the most important diagnostic tools in cardiology, since it is a simple and safe test to be performed, widely available and because it has a good cost-effectiveness ratio, which enables many clinical uses and makes the ability to interpret it relevant to physicians of different specialties and in different scenarios. **Objectives:** to identify the main methods and training, institutional and personal paths used by medical students that correlate with a greater ability to properly diagnose a 12-lead electrocardiogram. **Methodology:** This is a descriptive cross-sectional study, which was attended by undergraduate medical students, from the 3rd to the 6th year, of a public university in the state of Mato Grosso. The students answered a questionnaire containing 11 subjective questions to assess the population characteristics of interest regarding their previous training path and 20 electrocardiographic tracings, divided into three blocks of analysis: B1 (basic notions of ECG), B2 (life-threatening disorders) and B3 (most prevalent disorders in clinical practice). **Results**: A total of 67 medical students from one of the public universities in the state of Mato Grosso (female: n = 43; male: n = 24), aged 21-48 years (26.7 ± 4.86), answered the proposed questionnaire. The overall average performance of the students was 51.49 points, with a progressive and significant improvement in the performance of students from the 3rd to the 6th year, reaching the apex during the 5th year of graduation. **Conclusion:** The survey respondents presented a very satisfactory performance regarding the competence for the diagnosis of electrocardiographic tracings when compared to the performances of students from universities in Europe and the USA reported in the Literature. In our sample, the main factor correlated with a better performance to interpret the electrocardiogram was the individualized study of the students, which reflects a better exploration of training resources, which, in turn, results in a higher level of confidence to interpret the electrocardiogram and, consequently, in a better performance of these individuals in the domain of this competency. Among the study participants, the main strategy used to teach electrocardiography was seminars, in addition to individualized study.

Keywords: Electrocardiography. Medical education. Cardiology.

[1]Bachelor of Medicine, State University of Mato Grosso (UNEMAT)
Email: joao.pires@unemat.br
[2]Professor and Researcher, State University of Mato Grosso (UNEMAT)
Orcid: https://orcid.org/0000-0002-7604-411X
E-mail: gleber.nmarques@unemat.br

Revista ARACÊ
ISSN: 2358-2472

INTRODUCTION

Since its appearance in 1902, when it was presented by Eithoven, the electrocardiogram (ECG) has become one of the most common and important diagnostic tools for the diagnosis of heart diseases[1,16]. This procedure is simple, safe, reproducible, and relatively economical1,2. Because it is a record of the heart's electrical activity, it is a technology that provides information that is not readily obtained by other methods.

The 12-lead ECG enables many clinical uses, allowing it to be used as the standard for the non-invasive diagnosis of arrhythmias and conduction disorders, and occasionally as the sole marker of heart disease. Thus, it is imperative that physicians from different specialties[7] have sufficient knowledge to interpret it and, thus, be able to make the diagnosis and propose appropriate therapies1. Despite being the most widely performed cardiovascular procedure in the world1,3-6, interpreting the ECG is a complex task that involves knowledge about anatomy, electrophysiology, pathophysiology, as well as visual recognition of patterns and the ability to correlate them with the patient's clinical manifestations3.

In Brazil, a large portion of university graduates will have as their first workplace emergency medical care units, urgent and emergency departments and, in some cases, even intensive care centers. This is a common reality, especially in places far from large centers and that do not have high technological density and wide availability of specialized professionals8. Thus, the interpretation of the electrocardiogram is a key skill to be developed, and should be reinforced and improved during the years of residency and in the exercise of the profession.

In the emergency department, the rapid and accurate interpretation of the ECG is crucial, since admissions due to cardiac complaints are extremely frequent9. In fact, the Brazilian guidelines for ST-elevation acute myocardial infarction (STEMI)[10] and non-ST-elevation myocardial infarction (NSTEMI)[11] recommend that the electrocardiogram of all patients presenting to the emergency department with chest pain be performed and interpreted in a maximum interval of 10 minutes. Failure to recognize and treat these cases can result in negative implications for the patient16.

Incorrect interpretation of ECG findings can result in inadequate management and, in some cases, fatal outcomes for patients13,14. The literature suggests that approximately 33% of ECG interpretations have some error and approximately 11% result in inadequate management[15]. Thus, it is relevant to identify, understand and monitor the factors that

Revista ARACÊ
ISSN: 2358-2472

influence the acquisition and persistence of competence for correct interpretation of electrocardiograms.

In view of the above, this study analyzed the degree of competence of medical students from a public university in the state of Mato Grosso to interpret and properly diagnose the tracings presented in 12-lead electrocardiograms.

METHODOLOGY

This is a cross-sectional descriptive study, which had as its study population students from the medical course of a public university in the state of Mato Grosso, in their clinical years, that is, from the 3rd to the 6th year of the undergraduate course. The research began from a simple review of the specialized literature in order to identify the main variables related to the performance of the students for the interpretation of the 12-lead electrocardiogram already observed in previous studies to enable comparisons, safeguarding the due differences.

To participate in the study, the students fully answered the proposed questionnaire and agreed to sign the informed consent form (ICF). Individuals who were attending the basic cycle of medical school, students who did not fully answer the proposed questionnaire, and those who did not agree to sign the informed consent form were excluded from the study.

STUDY DESIGN

Following established approaches19,22,35,36 in the literature, the questionnaire containing 31 questions was organized into two large sections:

In the first stage of the questionnaire, participants were asked to answer 11 subjective questions that corresponded to the population data of the study. The questions were as follows: what is the gender of the participants; their age; in which year of the undergraduate course is this individual; what is the degree of importance attributed by the participants to electrocardiography for their training; what is the degree of confidence of the participants to interpret the ECG; if these students participated in academic cardiology leagues; if they were exposed to classes on ECG during the undergraduate course; if the participants consider that the ECG teaching they received throughout their undergraduate studies was sufficient; whether the student studied electrocardiogram on his own; what are

Revista ARACÊ
ISSN: 2358-2472

the main methods of teaching ECG promoted at the university and what medical specialty the participant intends to follow.

In the second stage of the questionnaire, the students were asked to interpret the electrocardiographic tracings. A total of 20 tracings were selected and submitted to independent analysis by 3 cardiologists, who agreed to participate in the study as consultants. All the tracings used in the study were considered unequivocal examples of the pathology that was intended to be evaluated7,13. The ECG tracings were kindly provided by the team of the national Telediagnosis ECG project of the Ministry of Health. Only 2 tracings could not be found in the database of the aforementioned project: ventricular fibrillation (VF) and NSTEMI. In both cases, the tracings were obtained through consultation of the specialized literature33,34.

In the construction of the questionnaire, the 20 electrocardiographic tracings selected contained only information on the patient's age and gender, without more relevant clinical data, since providing a clinical history improves the accuracy of the participants by 4-12% when compared to not providing a clinical history, with a significantly greater influence on the target audience of this research, professionals with a lower level of training4,18,22,31,32.

Electrocardiographic tracings were divided into three subgroups7:

1. B1 - Basics of ECG: 1. Recognize a normal ECG; 2. Determine the electrical axis of the QRS complexes; 3. Determine heart rate.
2. B2 - Life-threatening disorders: 1. Polymorphic ventricular tachycardia (DVT); 2. Ventricular Fibrillation (VF); 3. ST-segment elevation myocardial infarction (STEMI); 4. Non-ST-elevation acute myocardial infarction (NSTEMI); 5. Total Atrioventricular Block (CAVB).
3. B3 - Disorders common to clinical practice: 1. Hyperkalemia; 2. Atrial fibrillation (AF); 3. Atrial flutter; 4. Supraventricular tachycardia; 5. Sinus bradycardia; 6. Pacemaker rhythm; 7. Right bundle branch block (RBD); 8. Left bundle branch block (LBB); 9. Left ventricular overload (LVS); 10. 2nd degree atrioventricular block (2:1); 11. Ventricular pre-excitation (Wolf-Parkinson-White pattern) and 12. Pericarditis.

MATERIALS AND METHODS

All data were collected through an online form created on the *Google Forms*® platform. The form was programmed not to record information that could be used as a

Revista ARACÊ
ISSN: 2358-2472

means of personal identification of the participant, such as name, personal documents and academic records. In addition, the form was also programmed to allow only one access/response for each participant and to inform them about their performance in the test, through the number of correct answers. Participants had 2 hours to fully answer the questionnaire. All participants were instructed not to use external consultation materials while answering the questionnaire. The present study was approved by the Research Ethics Committee of the State University of Mato Grosso under opinion No. 5,982,013.

STATISTICAL ANALYSIS

To evaluate the performance of the students in the interpretation of the electrocardiogram, 5 points were assigned for each adequate response in each of the twenty tracings used in the study. Thus, the range of participants' scores can range from 0-100 points.

For data analysis, the two-tailed *Student T Test* model was used to compare continuous, mean and standard deviation variables, correlating them with population characteristics of each sample studied. A P value < 0.05 was established as the parameter to determine statistical significance. All statistical analyses, as well as the construction of graphs and tables, were performed using Microsoft *Excel*®, v.365.

RESULTS

POPULATION CHARACTERISTICS

A total of 67 medical students (female: n = 43; 64.18%, male: n = 24; 35.82%), between 21 and 48 years old (26.7 ± 4.86), answered the proposed questionnaire, as shown in Table 1.

Table 1. Population characteristics

	Total	%	Average (Points)	DP	P Value
Gender					
Female	43	64,18%	53,26	20,87	0,581964847
Male	24	35,82%	47,92	20,43	0,400264238
Age (mean + SD)	26,7 ± 4,86	-			
Year of study					
Year 3	9	13,43%	30,56	9,17	0,00013082*
4th year	12	17,91%	44,17	19,75	0,225410119
Year 5	28	41,49%	59,46	18,73	0,032557339*
Year 6	18	26,87%	53,89	20,9	0,63254626
Attended ECG classes					
Yes	55	82,09%	52,82	19,57	0,616842624
No	12	17,91%	44,58	25,18	0,36238582

Revista ARACÊ
ISSN: 2358-2472

Studied on his own					
Yes	62	92,54%	52,82	20,62	0,61264856
No	5	7,46%	33,00	12,04	0,026450511*
Participates/Participated in Academic Leagues of Cardiology					
Yes	11	16,42%	61,82	24,32	0,189273501
No	56	83,58%	49,29	19,53	0,401909051

Considers ECG teaching important					
Yes	66	98,51%	-		
No	1	1,49%	-		
Considers that the ECG teaching she received was sufficient					
Yes	0	-	-		
No	67	100%	-		
Confidence to interpret the ECG					
Very confident	0	-	-		
Confident	7	10,45%	72,14	10,35	0,001867103*
Not very confident	43	64,18%	54,3	20,14	0,364969265
I don't have confidence	17	25,37%	35,29	13,4	0,000240759*

Source: authors.

PERFORMANCE ANALYSIS

The overall average performance of the students was 51.49 points. The comparison between these results shows that, as expected, the performance of students in the 3rd year is statistically lower than the performance of students in the other clinical years, as well as the general performance of the participants (3rd year vs. 4th year, P = 0.036; 3rd year vs. 5th year, P < 0.0001; 3rd year vs. 6th year, P = 0.00019; 3rd year vs. overall average, P = 0.00013). The performance of the 4th year students was significantly higher than that of the 3rd year students and significantly lower than the performance of the 5th year students (4th year vs. 5th year, P = 0.00018), but without statistical difference when compared to the 6th year students and the overall average (4th year vs. 6th year, P = 0.065; 4th year vs. Overall average, P = 0.225). On the other hand, the performance of 5th year students was substantially higher than that of 3rd and 4th year students, as well as the overall average (5th year vs. general average, P = 0.0325) as expected, since in this phase the clinical cardiology outpatient clinic takes place, however, there was no significant difference in the comparison of performance of 5th and 6th year students (5th year vs. 6th year, P = 0.273). Finally, the average of the 6th year students was higher than that of the 3rd year, but did not present statistical relevance when compared to the average of the 4th and 5th year students, as well as in relation to the general average (6th year vs. general average, P = 0.632), these data are illustrated in Table 2.

Revista ARACÊ
ISSN: 2358-2472

Table 2 – Year-to-year performance of medical students at the university analyzed.

Year of study	Total	%	Average (Points)	P Value
Year 3	9	13,43%	30,56	< 0,0001*
4th year	12	17,91%	44,17	0.00019*
Year 5	28	41,49%	59,46	-
Year 6	18	26,87%	53,89	0,273

% - Proportion of the sample of respondents in relation to the total population; P-value – sample vs. Average 5th grade (59.46 points); * - statistically relevant based on the *two-tailed Student T Test*. Source: authors.

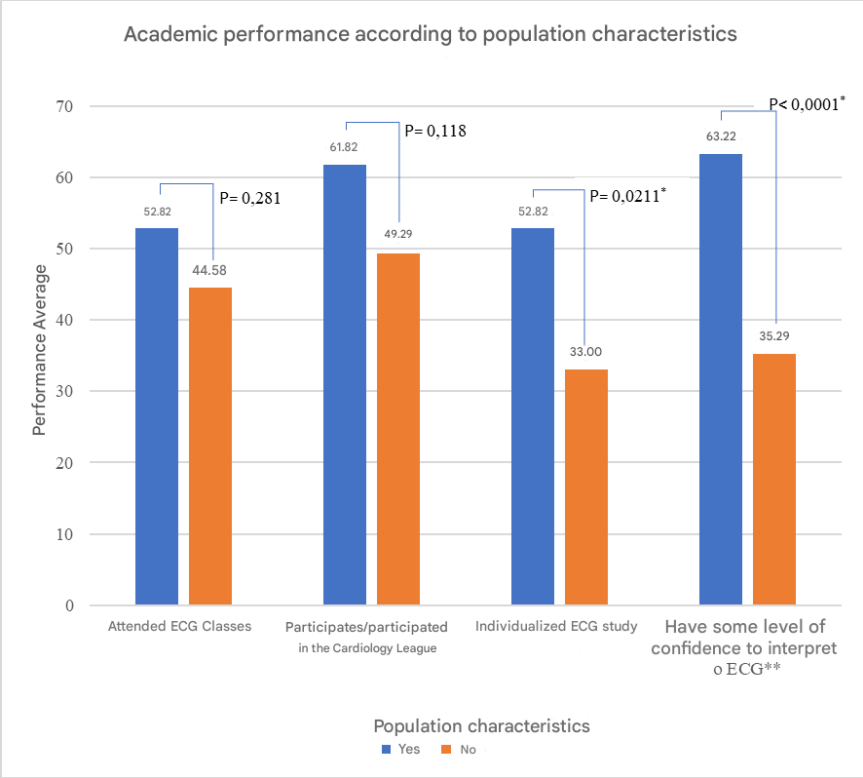
When comparing the performance of male and female participants, there was no statistically significant difference (M: 47.92 points; F: 53.26 points, P = 0.212). Likewise, no statistically relevant disparities were identified when comparing the performance of students who attended or did not attend ECG classes during their undergraduate studies (attended ECC classes: 52.82 points vs. did not attend ECG classes: 44.58 points, P = 0.281).

Equally, the performance of students who participate/participated in the academic league of cardiology (mean: 61.82 points) was not higher than that of students who did not participate/participated (mean: 49.29 points, P = 0.118). There was also no significant difference between the means of students who intend to specialize in any of the areas in which electrocardiogram interpretation is considered a vital skill (G1 – specialty group 1) – cardiology, cardiovascular surgery, anesthesiology, internal medicine, emergency medicine, intensive care medicine, and family and community medicine – compared to those who do not intend to specialize in these areas at the time of the research (G2 – group specialties 2) (G1: 61.82 points; G2: 49.29 points, P = 0.394).

On the other hand, the degree of confidence that the students declare to have has a statistically significant relationship with their performance. The students who claimed to be "confident" obtained an average of 72.14 points, a result significantly higher than those who claimed to be "not very confident", average: 54.30 points (P = 0.0038) and those who reported "not having confidence", average: 35.29 points (P < 0.0001). Similarly, individuals who reported having studied individually, with an average of 52.82 points, also had a statistically higher performance than those who did not, with an average of 33.00 points (P= 0.021), as shown in Figure 1.

Revista ARACÊ
ISSN: 2358-2472

Figure 1: Average performance of students according to population characteristics. P – P value, according to *the two-tailed* Student T Test.*- Statistically significant in the *two-tailed* Student T Test.**- Given "Yes" obtained through the average of the results of the students who declared to be confident and those who declared to be somewhat confident. Source: authors.



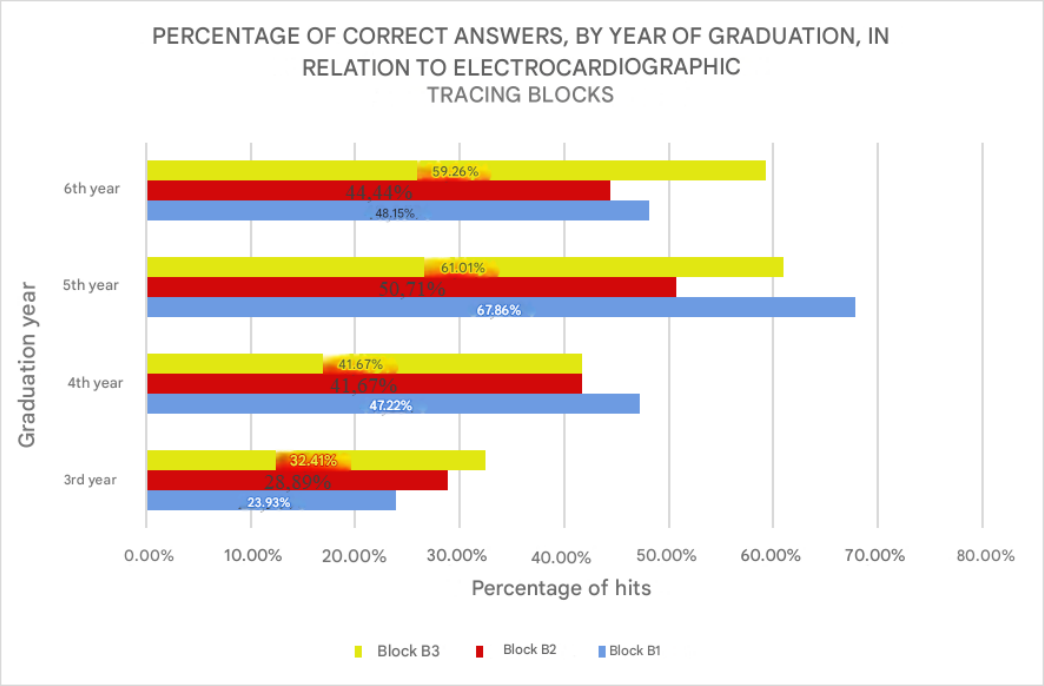
COMPETENCE IN THE INTERPRETATION OF THE ROUTES

Figure 2 illustrates the performance of the research participants, year-over-year, in relation to each of the three blocks of electrocardiographic tracings used in the study. In our study, on average, 53.73% of the participants were able to determine the basic characteristics of an electrocardiographic tracing (B1). The average number of correct answers regarding the tracings that posed threats to the patients' lives (B2) was 45.07%. In the group of tracings that represent common pathologies in the urgency and emergency scenario (B3), the average performance was 54.35%. However, no statistically significant differences were observed in the performance of the students to interpret the tracings of the three blocks (B2 vs. B1, P = 0.138; B2 vs. B3, P = 0.0996).

Among the teaching and learning resources of electrocardiogram, the most used by the participants were: study through seminars (46 votes), internship practices (24 votes), classes with specialists (10 votes) and online software (7 votes).

Revista ARACÊ
ISSN: 2358-2472

Figure 2: Proportional performance of the study participants, by year of graduation, in relation to each block of electrocardiographic tracing.



Source: authors.

DISCUSSION

According to a meta-analysis conducted in the United States by Cook, Oh, and Pusic in 2020[3], the average proficiency of American medical students to interpret the electrocardiogram is 42%. While the study conducted Kopec *el at*[7], evaluating the performance of medical students from all medical schools in Poland, showed an average performance of 66%. The analysis of our data shows that the average performance of the participants to interpret the electrocardiogram was 51.49 points. This mean is higher than that reported by the North American study3, but lower than that presented by the Polish study7.

In our study, 53.73% of the participants were able to adequately recognize basic electrocardiographic features, tracings that made up block B1. This average is lower than that obtained by Polish students (86%)[7] in the analysis of these same characteristics, and not available in the North American study.

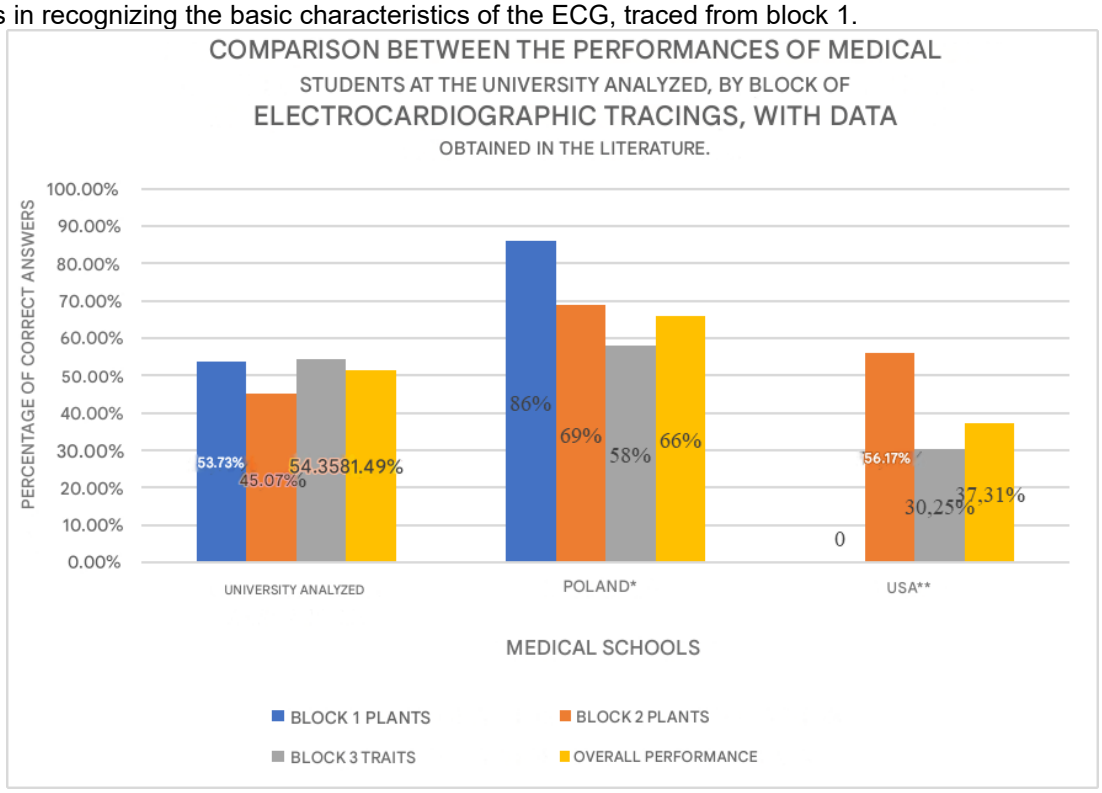
When we turn our attention to the B2 block tracings, which represented pathologies that directly threaten the lives of patients, that is, medical emergencies, we can observe that, on average, 45.07% of the participants were able to adequately recognize these tracings. In their study comparing the performance of medical students at the George Washington University School of Medicine with the performance of residents, Jablonover *et*

Revista ARACÊ
ISSN: 2358-2472

al.[13] showed an overall average of correct answers of 56.17% among the six routes that they considered critical in their study13. These data indicate that, although there are occasional differences in some traces, when we compare the general averages of correct answers, the performance of the medical students who participated in our study is not far from that observed among the students of George Washington University. However, a greater difference can be observed in relation to the results found in the study by Kopec *et al.*[7], where Polish students obtained an average of 69% of correct answers.

As for the performance in the 12 routes that represented common scenarios to be found in urgent and emergency environments, block B3, the average performance of the students was 54.35%. In this group of traces, the average performance of Polish students7 was 58%, very close to the value observed in our study. When compared with the performance of students at George Washington University (30.25%)[13], we can highlight a better performance of the participants in our research (54.33%). Figure 3 summarizes the comparisons between our results and those of the Polish and American schools.

Figure 3: Comparison between the performance of medical students to interpret the electrocardiogram, based on the tracing blocks, with data from the literature. * - Data extracted from the study conducted by Kopec *et al7* in all medical schools in Poland. ** - Data extracted from the study conducted by Jablonover *et al13* at George Washington University.0 - The study by Jablonover *et al13* did not evaluate the performance of the students in recognizing the basic characteristics of the ECG, traced from block 1.



Source: authors.

Revista ARACÊ
ISSN: 2358-2472

Among the medical students who participated in our research, the performance to interpret the ECG increased as the students progressed in their undergraduate studies, reaching the apex during the 5th year of the course, figure 5, unlike other groups analyzed in Brazil19. These data suggest that among the students participating in the study, the teaching of electrocardiography has been effective, since these students not only improved their performance progressively throughout their undergraduate studies, but also retained what they learned for periods longer than 6 to 12 months, a parameter widely consolidated in medical education21. The significantly higher performance of 5th year students is partly explained by the fact that it is during the first year of internship that these students have greater contact with the practical internships of cardiology, intensive care medicine and emergency medicine and, therefore, are more exposed to electrocardiographic tracings, which tends to favor student performance4, 13.

The self-reported confidence level, as well as the fact that they conducted studies on an individualized basis, are factors that correlated with a significant improvement in performance among the research participants, which can also be verified in several other articles in the specialized literature3,7,13,21.

In their study Jablonover *et al*.[13] evaluated the correlation between the future choice of specialization of the students of George Washington University with a possible increase in the performance of the participants. However, the study did not show a significant difference between participants who intended to specialize in areas where this skill is frequently requested and those who intended to specialize in other areas (P = 0.24)[13]. Similarly, in our study, the choice of specialization in areas where ECG interpretation is a vital skill7,17 was not reflected in a significant improvement in performance (53.80 points vs. 49.88 points; P = 0.394). This suggests that the competence to correctly interpret the ECG is perceived by medical students as an essential competence for every physician.

The teaching modalities used by the students who answered the questionnaire are similar to the learning resources found in many other [articles,21,24,26,27,28]. Based on the specialized literature, the only thing that can be said about the teaching methodologies of electrocardiography is that no teaching method was able to prove to be more efficient than the other25. Thus, the individualization of learning methods has been shown to be the preponderant factor in the acquisition of competencies, since learning styles vary widely among medical students and direct the choice and use of available learning resources[26].

Revista ARACÊ
ISSN: 2358-2472

CONCLUSION

The analysis of the data allows us to conclude that although there are important points to be considered for continuous improvement in the performance for the interpretation of the electrocardiogram, the results obtained are very close to those presented by the national and international literature, satisfactorily positioning the research participants. In general, our sample of students showed a similar performance, with certain nuances, to that of other American and European students in recognizing the basic characteristics of the ECG, the tracings that represented emergency scenarios, as well as the pathologies that are more common in urgent and emergency environments.

Our results indicate that, for the sample analyzed, The main factor that correlated with a higher performance to interpret the electrocardiogram was the individualized study of the students, which is reflected in a better exploration of training resources such as teachers, seminars, textbooks, practices in the outpatient clinics and participation in study groups, which consequently result in a higher level of confidence to interpret the electrocardiogram and in the better performance of these individuals. Which, on the other hand, was not true for the fact that they had or had not attended classes on the ECG during their undergraduate studies or that they had participated or not in the academic league of cardiology. According to the answers to the questionnaire, the main teaching-learning methodology of electrocardiography used by the participants was seminars and individual studies.

As favorable points, we were able to highlight aspects to be improved in the training path of the research participants regarding the teaching and learning of electrocardiography. In addition, the methodological design and research instruments are replicable and can be a means of longitudinally monitoring the performance of students for this medical competence, guiding training strategies for the course project.

As limiting factors to our study, regarding the initial general objective, we highlight the fact that the participation of the students took place voluntarily by only one of the medical teaching institutions in the state, which ended up limiting the possible variety of some variables examined in the research, such as the predominant methods in the training path, as well as the sample size. In addition, although the students were not supervised while answering the questionnaire, the ECG traits chosen are authentic (real clinical cases) and are not included in textbooks or medical compendiums, in addition to the fact that no

Revista ARACÊ
ISSN: 2358-2472

biases were identified when we analyzed the data obtained in comparison with other international studies.

Revista ARACÊ
ISSN: 2358-2472

REFERENCES

1. Aimoli, U. S., & Miranda, C. H. (2020). Competência clínica no manejo do infarto agudo do miocárdio com supradesnível do segmento ST por médico recém-formado candidato à residência médica. Arquivos Brasileiros de Cardiologia, 114(1), 35–44. https://doi.org/10.36660/abc.20180309

2. Barthelemy, F. X., Segard, J., Fradin, P., Hourdin, N., Batard, E., Pottier, P., Potel, G., & Montassier, E. (2017). ECG interpretation in emergency department residents. European Journal of Emergency Medicine, 24(2), 149–156. https://doi.org/10.1097/MEJ.0000000000000312

3. Berger, J. S., Eisen, L., Nozad, V., D'Angelo, J., Calderon, Y., Brown, D. L., & Schweitzer, P. (2005). Competency in electrocardiogram interpretation among internal medicine and emergency medicine residents. The American Journal of Medicine, 118(8), 873–880. https://doi.org/10.1016/j.amjmed.2004.12.004

4. Brasil, Ministério da Educação. (2022). Cadastro nacional de cursos e instituições de educação superior: Cadastro e-MEC. https://emec.mec.gov.br/

5. Breen, C. J., Kelly, G. P., & Kernohan, W. G. (2019). ECG interpretation skill acquisition: A review of learning, teaching and assessment. Journal of Electrocardiology, 1(1), 1–4. https://doi.org/10.1016/j.jelectrocard.2019.03.010

6. Cook, D. A., Oh, S.-Y., & Pusic, M. V. (2020). Accuracy of physicians' electrocardiogram interpretations. JAMA Internal Medicine, 180(11), 1461. https://doi.org/10.1001/jamainternmed.2020.3989

7. Diogo, M. A., Ferreira, D., Batista, A. J., & Braga, F. C. (2024). As tecnologias digitais de comunicação e informação: Uma discussão considerando as diretrizes nacionais curriculares do curso de medicina. Aracê, 6(3), 10066–10074. https://doi.org/10.56238/arev6n3-341

8. Eslava, D., Dhillon, S., Berger, J., Homel, P., & Bergmann, S. (2009). Interpretation of electrocardiograms by first-year residents: The need for change. Journal of Electrocardiology, 42(6), 693–697. https://doi.org/10.1016/j.jelectrocard.2009.07.020

9. Fent, G., Gosai, J., & Purva, M. (2015). Teaching the interpretation of electrocardiograms: Which method is best? Journal of Electrocardiology, 48(2), 190–193. https://doi.org/10.1016/j.jelectrocard.2014.12.014

10. Hatala, R. M., Brooks, L. R., & Norman, G. R. (2003). Practice makes perfect: The critical role of mixed practice in the acquisition of ECG interpretation skills. Advances in Health Sciences Education, 1(1), 17–26.

11. Hatala, R. M., Norman, G. R., & Brooks, L. R. (1999). Impact of clinical scenario on accuracy of electrocardiogram interpretation. Journal of Internal Medicine, 14(1), 126–129.

Revista ARACÊ
ISSN: 2358-2472

12. Jablonover, R. S., Lundberg, E., Zhang, Y., & Stagnaro-Green, A. (2014). Competency in electrocardiogram interpretation among graduating medical students. Teaching and Learning in Medicine, 26(3), 279–284. https://doi.org/10.1080/10401334.2014.918882

13. Kopeć, G., Magoń, W., Hołda, M., & Podolec, P. (2015). Competency in ECG interpretation among medical students. Medical Science Monitor, 21, 3386–3394. https://doi.org/10.12659/MSM.895129

14. Mahler, S. A., Wolcott, C. J., Swoboda, T. K., Wang, H., & Arnold, T. C. (2011). Techniques for teaching electrocardiogram interpretation: Self-directed learning is less effective than a workshop or lecture. Medical Education, 45(4), 347–353. https://doi.org/10.1111/j.1365-2923.2010.03891.x

15. Masoudi, F. A., Magid, D. J., Vinson, D. R., Tricomi, A. J., Lyons, E. E., Crounse, L., Ho, P. M., Peterson, P. N., & Rumsfeld, J. S. (2006). Implications of the failure to identify high-risk electrocardiogram findings for the quality of care of patients with acute myocardial infarction. Circulation, 114(15), 1565–1571. https://doi.org/10.1161/CIRCULATIONAHA.106.623652

16. Mele, P. F. (2008). The ECG dilemma: Guidelines on improving interpretation. Journal of Healthcare Risk Management, 28(2), 27–31. https://doi.org/10.1002/jhrm.5600280205

17. Mitchell, L. B. (2021). Ventricular fibrillation. MSD Manuals. https://www.msdmanuals.com/pt-br/profissional/doen%C3%A7as-cardiovasculares/arritmias-card%C3%ADacas-espec%C3%ADficas/fibrila%C3%A7%C3%A3o-ventricular-fv

18. Nicolau, J. C., Feitosa, G. S., Petriz, J. L., Furtado, R. H. M., Précoma, D. B., Lemke, W., Lopes, R. D., Timerman, A., Marin, J. A., & Bezerra, L. (2021). Diretrizes da Sociedade Brasileira de Cardiologia sobre angina instável e infarto agudo do miocárdio sem supradesnível do segmento ST – 2021. Arquivos Brasileiros de Cardiologia, 117(1), 181–264. https://doi.org/10.36660/abc.20210180

19. Nilsson, M., Bolinder, G., Held, C., Johansson, B.-L., Fors, U., & Östergren, J. (2008). Evaluation of a web-based ECG-interpretation programme for undergraduate medical students. BMC Medical Education, 8(1), 1–7. https://doi.org/10.1186/1472-6920-8-25

20. Pastore, C., Piegas, L. S., & Sociedade Brasileira de Cardiologia. (2016). III Diretriz da Sociedade Brasileira de Cardiologia sobre análise e emissão de laudos eletrocardiográficos (3rd ed.). Sociedade Brasileira de Cardiologia.

21. Patocka, C., Turner, J., & Wiseman, J. (2015). What adult electrocardiogram (ECG) diagnoses and/or findings do residents in emergency medicine need to know? CJEM, 17(6), 601–608. https://doi.org/10.1017/cem.2014.58

Revista ARACÊ
ISSN: 2358-2472

22. Piegas, L. S., & Sociedade Brasileira de Cardiologia. (2015). V Diretriz da Sociedade Brasileira de Cardiologia sobre tratamento do infarto agudo do miocárdio com supradesnível do segmento ST. Arquivos Brasileiros de Cardiologia, 105(2), 1–121.

23. Rubinstein, J., Dhoble, A., & Ferenchick, G. (2009). Puzzle based teaching versus traditional instruction in electrocardiogram interpretation for medical students – A pilot study. BMC Medical Education, 9(1), 1–7. https://doi.org/10.1186/1472-6920-9-4

24. Salaermo, S. M., Alguire, P. C., & Waxman, H. S. (2003a). Competency in interpretation of 12-lead electrocardiograms: A summary and appraisal of published evidence. Annals of Internal Medicine, 138(9), 751–760.

25. Salaermo, S. M., Alguire, P. C., & Waxman, H. S. (2003b). Training and competency evaluation for interpretation of 12-lead electrocardiograms: Recommendations from the American College of Physicians. Annals of Internal Medicine, 138(9), 747–750.

26. Santos, E. C. L., Figuinha, F. C. R., & Mastrocola, F. (2017). Manual de eletrocardiografia: Cardiopapers. Atheneu.

27. Santos, L. S. V., de Azevedo, M. C., de Almeida, L. H., Turci, M. A., & Toledo Jr., A. (2025). Desafios e oportunidades na avaliação on-line de habilidades clínicas: Uma revisão sistemática da literatura. Aracê, 7(2), 9512–9528. https://doi.org/10.56238/arev7n2-284

28. Schläpfer, J., & Wellens, H. J. (2017). Computer-interpreted electrocardiograms. Journal of the American College of Cardiology, 70(9), 1183–1192. https://doi.org/10.1016/j.jacc.2017.07.723

29. Silva, G. S., Moraes, E. C. S., Magno, I. M. N., Neves, D. O., Souza, F. P., & Melo, G. N. (2020). Uma avaliação dos conhecimentos básicos sobre eletrocardiografia de discentes do curso de medicina. Pará Research Medical Journal, 4(26), 1–8. https://doi.org/10.4322/prmj.2019.026

30. Thach, T. H., Blissett, S., & Sibbald, M. (2020). Worked examples for teaching electrocardiogram interpretation: Salient or discriminatory features? Medical Education, 54(8), 720–726. https://doi.org/10.1111/medu.14066

31. Velasco, I. T., & Sociedade Brasileira de Medicina de Emergência. (2021). Medicina de emergência: Abordagem prática (15th ed.). Manole.

32. Viljoen, C. A., Millar, R. S., Manning, K., Hoevelmann, J., & Burch, V. C. (2021). Clinically contextualised ECG interpretation: The impact of prior clinical exposure and case vignettes on ECG diagnostic accuracy. BMC Medical Education, 21(1), 1–13. https://doi.org/10.1186/s12909-021-02854-x

33. White, T., Woodmansey, P., Ferguson, D. G., & Channer, K. S. (1995). Improving the interpretation of electrocardiographs in an accident and emergency department. Postgraduate Medical Journal, 71(833), 132–135. https://doi.org/10.1136/pgmj.71.833.132

Revista ARACÊ
ISSN: 2358-2472

34. World Health Organization. (2021). Mortality and global health estimates. https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-leading-causes-of-death