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Chest compression quality and retention of skills in basic life support training given to medical school year 5 students

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Abstract:

OBJECTIVES: Sudden cardiac arrest is a significant cause of cardiovascular death. Basic life support (BLS) practitioners need training to provide effective, quality interventions. This study investigates the effectiveness of curriculum-based BLS training and measures the students' performance levels before and after training and their skill retention over time.

METHODS: A total of 70 students were selected as the study population. Before their emergency medicine (EM) clerkship, participants performed BLS with 30 compressions and two rescue breaths on a simulation manikin (Measurement 1). Early posttraining skills were reassessed within the 1st week after clerkship (Measurement 2), and skill retention was evaluated after 9 months (Measurement 3). All measurements were done by a single observer using the same manikin.

RESULTS: Of the 70 enrolled students, 64 completed the study. Significant improvements were observed in overall cardiopulmonary resuscitation (CPR), compression, and ventilation scores posttraining and at 9 months ($P < 0.05$). Among 34 participants who performed ≥3 CPRs, posttraining and 9-month scores remained stable ($P = 0.238$). No significant change was found in compression scores among nonperformers ($P = 0.982$), and intergroup comparisons showed no statistical difference ($P = 0.977$; $P = 0.900$).

CONCLUSION: BLS training provided to medical faculty 5th-year students in the EM clerkship program increased the effectiveness of chest compression, and this skill did not regress within 9 months.

Keywords:

Basic life support, cardiopulmonary resuscitation quality, emergency medicine clerkship, skill retentions

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Introduction

Sudden cardiac arrest and death account for an important common cause of all deaths from cardiovascular causes of death.[1] Sudden cardiac arrests can occur in hospital or out of hospital. Despite advances in resuscitation, only approximately 8.2%–9.4% of all cardiac arrest victims survive to leave the hospital.[2] A recent multicenter study from Türkiye indicates that bystander cardiopulmonary resuscitation (CPR) rates remain low, that only 2.9% of out-of-hospital cardiac arrest cases received CPR from nonhealthcare providers, while emergency medical services performed CPR in 86.5% of cases.[3] Each minute that a patient remains in cardiac arrest, the probability of survival decreases, and the functions of the organs, particularly the brain, might be permanently lost. Therefore, early and correctly provided basic life support (BLS)

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Box-ED section

What is already known on the study topic?

- Sudden cardiac arrest is a leading cause of death, and effective basic life support (BLS) training significantly improves survival rates. High-quality chest compressions and ventilation are a key for effective cardiopulmonary resuscitation (CPR), but the retention of these skills over time remains a debated issue.

What is the conflict on the issue? Has it importance for readers?

- The primary conflict lies in determining the optimal frequency and content of BLS retraining to maintain skill effectiveness. This is crucial for readers as it addresses the real-world challenge of ensuring that healthcare professionals are consistently prepared for life-saving interventions.

How is this study structured?

- This prospective controlled, before-and-after study used simulation models to evaluate the BLS skills of medical students before, immediately after, and 9 months after training. Statistical analyses were conducted to assess skill retention and effectiveness.

What does this study tell us?

- BLS training improved medical students' CPR performance, particularly their effectiveness in chest compression. Skills remained relatively stable over 9 months, suggesting the curriculum's value in long-term skill retention.

significantly impacts survival regardless of whether the practitioner is a healthcare professional.[4] All BLS practitioners must receive training to perform effective and qualified interventions.

There are different levels of performing BLS skills. Since they are life-saving critical interventions, the performance levels of healthcare professionals are expected to be high in BLS skills. To perform effective skills demonstrating benefit with minimal risk, BLS training courses and retraining at appropriate intervals must be carried out using equipped simulation models. There are also different views regarding the content and frequency of retraining.[5-7]

The present study investigated the effectiveness of curriculum-based BLS training given to medical faculty year 5 students in an academic university's emergency medicine (EM) department during their clerkship rotations. It measured the students' performance levels before and after training and their skill retention over time.

Methods

Setting and participants

This prospective controlled, before-and-after study was conducted in a tertiary care university hospital's emergency department between March 2019 and February 2020, with Akdeniz University's Clinical Research Ethics Committee approval (approval date: February 20, 2019 and approval number: 193) by the Declaration of Helsinki. Seventy students from the year 5 students who will receive EM clerkship as per the regular medical education curriculum were selected as the study population. Written informed consent forms were obtained from all students participating in the study. The student group participating in the study was evaluated by testing with the same method at different times.

Study design

The gender and age of all participating students were recorded. A structured questionnaire assessed students' baseline knowledge levels before their EM clerkship and their previous BLS training status. Before starting the EM clerkship, participants were required to perform a 2-min BLS procedure on a simulation manikin. This included 30 chest compressions, followed by two rescue breaths using mouth-to-mouth ventilation using a single-use sterile drape (Measurement 1).

Measurement 1 was conducted before the students received a standardized 3-h BLS training session. This session comprised a 1-h theoretical lecture and a 2-h practical session, designed according to the National Core Education Program (NCEP) curriculum. The training was delivered by a single instructor, who also supervised the practical BLS performance assessments to ensure consistency.

One week after completing the standardized BLS training, participants underwent a reassessment of their BLS skills using the same simulation manikin to evaluate their immediate posttraining proficiency (Measurement 2). To assess skill retention over time, their BLS performance was reevaluated using the same simulation manikin and feedback device approximately 9 months later (Measurement 3). Students continued their final-year (year 6) internship program during these 9 months.

Given the potential impact of real-life experience on BLS performance, participants were asked the following question before the 9-month follow-up assessment: "During your internship, have you performed CPR in a clinical setting?" Based on their responses, participants were categorized into two groups: those who had performed CPR at least three times and those who had not. The potential difference in BLS performance scores between these two groups was then analyzed.

Measurements

Resusci Anne QCPR (Laerdal Medical, Stavanger, Norway) simulation manikin and Laerdal SimPad PLUS (Stavanger, Norway) device were used as equipment for the practices in the study. Participants' BLS performance was measured and recorded using the SimPad PLUS device, which provides detailed quantitative feedback on various CPR parameters; these parameters are shown in Appendix 1.

CPR performance scores and CPR quality parameters were analyzed, as recorded by the SimPad PLUS device, with the chest compression score as the primary outcome measure. The Laerdal Resusci Anne QCPR manikin, combined with the SimPad PLUS device, calculates CPR performance scores based on CPR quality parameters, as per the guidelines recommended by the American Heart Association (AHA).[8] Measurements were performed in the simulation laboratory of the EM department. Only one participant was present in the room with the same observer during the measurement, while other participants were kept in the waiting room, so they could not see the previous practice. A single observer performed all measurements. The participant was not given any positive or negative feedback during or after the measurement, and they were asked to perform the practice they learned as they remembered it.

Statistical analysis

The study data were analyzed using SPSS version 23 (SPSS Inc., Chicago, IL, USA). The study data were expressed as mean ± standard deviation for normally distributed continuous variables and as a percentage (%) for categorical variables; median values and interquartile ranges were evaluated for data that did not conform to the normal distribution. The Kolmogorov–Smirnov test and Shapiro–Wilk test were used for normality analysis. Since the data were not normally distributed, Friedman analysis was used for dependent variables to compare the groups. Bonferroni correction was performed to determine those significant among dependent variables and $P < 0.05$; $P < 0.017$ was considered statistically significant. The Wilcoxon analysis and Mann–Whitney *U*-test were performed to evaluate the difference between the group that performed CPR and the other that did not before the last measurement. The Akdeniz University's Statistical Consulting, Application, and Research Center supported statistical analysis for this study.

Results

The study included 70 students. Six students who could not complete the study for various reasons were excluded from the analysis, which was completed with the remaining 64 students [Figure 1].

Table 1 presents the demographics of the participants and the percentage of correct answers to the prestudy questionnaire, which evaluated their level of BLS knowledge.

Participants' skill levels according to their performance in the overall CPR score, compression score, and ventilation score in three separate measurements were grouped as "basic level" (0%–49%), "intermediate level" (50%–74%), and "advanced level" (75%–100%), as determined by the measuring device. The distribution of the study group according to this classification is shown in Figure 2. CPR quality parameters recorded by SimPad PLUS were evaluated using the Friedman test. As a result of the Friedman test, significant differences

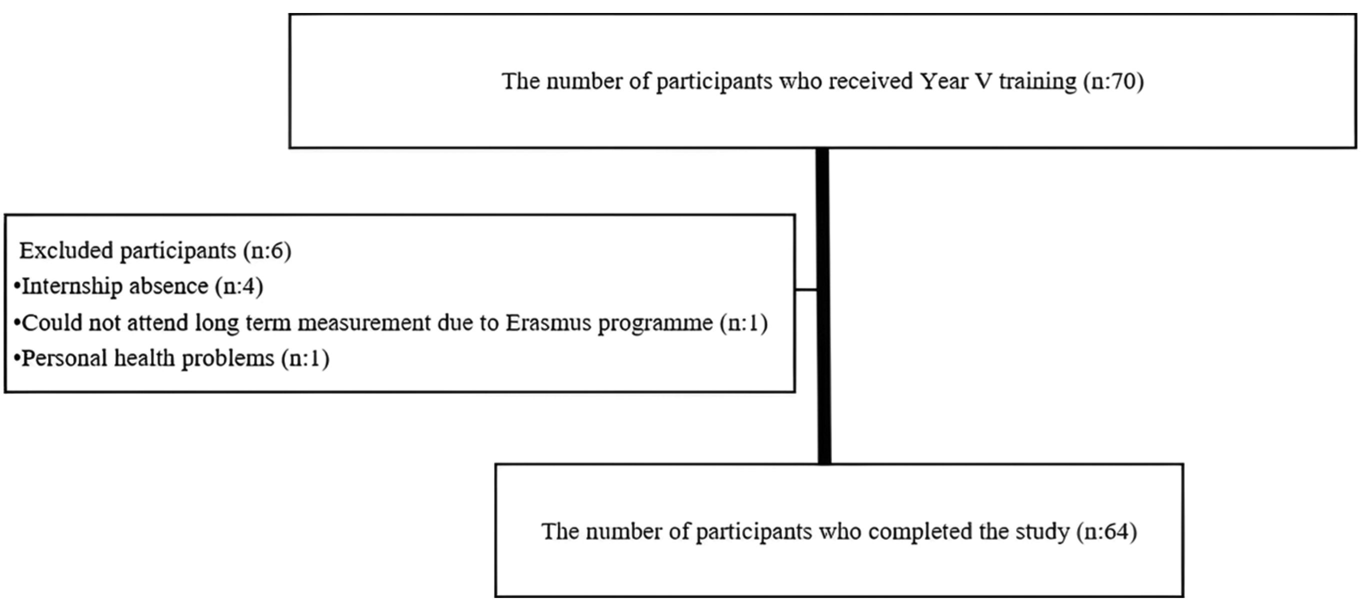

Figure 1: Study flowchart

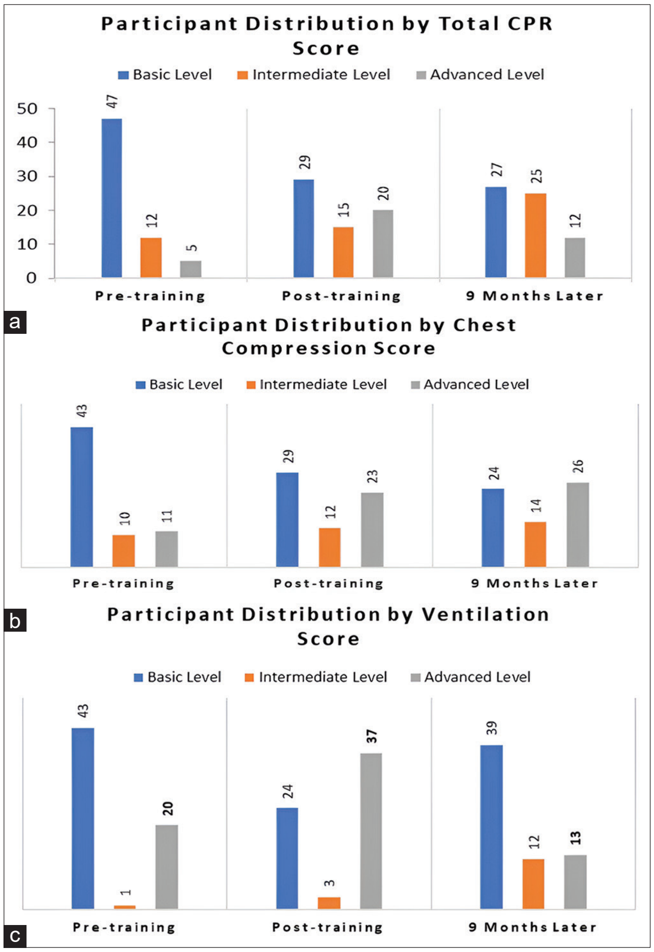

Figure 2: Distribution of the participants' skill levels according to their performances. (a) Overall cardiopulmonary resuscitation score, (b) chest compression score, (c) ventilation score. CPR: Cardiopulmonary resuscitation

Table 1: Demographic data and ratios of correct answers

Demographic data	Values
Age, mean±SD	23.55±8.76
Gender, *n* (%)	
Male	28 (43.8)
Female	36 (56.2)
Questions in the Questionnaire	**Ratios of correct answers (%)**
What should be the compression-to-ventilation ratio while you are alone during BLS?	98.4
Where should chest compression be applied?	98.4
What should be the rate of chest compression per minute?	81.3
How much force should be applied during chest compression? (depth)	78.1

BLS: Basic life support, SD: Standard deviation

were found in the overall CPR score, ventilation score, and compression score across the different time points of the training sessions. The medians of the overall CPR score, chest compression score, and ventilation score parameters obtained as a result of the measurements of the participants are given in Table 2.

Subsequently, the Wilcoxon subgroup analyses were performed for these three parameters to determine specific pairwise differences. In the parameters of overall CPR score, compression scores, and ventilation scores, a statistically significant difference was found between the pretraining and posttraining measurements and the measurements that took place 9 months later [Table 3].

Participants who performed at least three or more CPR were classified in one group, with 34 participants in this group. The remaining 30 had fewer or no CPR attempts. In the first group with three or more CPR performances, no significant difference was found between the posttraining score and 9 months after measurements ($P = 0.238$). Furthermore, there was no significant difference in the chest compression score for the second group without CPR performance ($P = 0.982$).

No statistically significant difference was found between the mean and median chest compression scores of both groups measured after the training and in the 9th month ($P = 0.977$ and $P = 0.900$) [Table 4].

Discussion

Our study demonstrated that BLS training provided to 5th-year medical students during their EM clerkship enhanced the effectiveness of chest compressions, with this skill being retained for at least 9 months. The results indicated that, before training, chest compression and overall CPR scores calculated by the device based on specific parameters were primarily at a basic level. However, these scores significantly improved following the training, reaching intermediate and advanced levels. In addition, a statistically significant difference was observed between pre- and posttraining measurements for the ventilation score. In AHA guidelines, it is stated that high-quality CPR increases the survival rate in resuscitation.[9] In the questionnaire participants took before the training, about 80% or more correct answers were given to questions about CPR quality parameters. Our faculty applies a horizontal

Table 2: Median CPR performance scores across measurements and their statistical comparison using the friedman test

Parameters	Median value (25%–75%)			P*
	Measurement 1 (pretraining)	Measurement 2 (posttraining)	Measurement 3 (9 months later)	
Overall CPR score (%)	29.5 (16–52)	55 (28–79)	53.5 (32–70)	<0.001
Chest compression score (%)	36.5 (10–54)	51.5 (20–82)	62.5 (26–85)	<0.001
Ventilation score (%)	0 (0–83)	86.5 (8–96)	13 (0–72)	<0.001

*P<0.05 was considered statistically significant. CPR: Cardiopulmonary resuscitation

Table 3: Comparison of CPR performance scores across measurements using the wilcoxon test following the friedman test

Parameters	*P**		
	Analysis of Measurement 1–2	Analysis of Measurement 1–3	Analysis of Measurement 2–3
Overall CPR score (%)	<0.001	<0.001	0.089
Chest compression score (%)	0.003	<0.001	0.377
Ventilation score (%)	<0.001	0.739	<0.001

**P*<0.017 was considered statistically significant after Bonferroni correction. CPR: Cardiopulmonary resuscitation

Table 4: Comparison of chest compression scores based on participants' CPR experience

	Median value of chest compression score (%)		*P**
	Second measurement	Third measurement	
CPR ≥3	51.5	61	0.238
CPR <3	53	66.5	0.982
*P***	0.977	0.900	

*Comparisons of posttraining and the 9th-month measurements of the groups within themselves with the Wilcoxon test (*P*<0.05 was considered significant), **Comparison of the measurements between the groups with the Mann–Whitney *U*-test (*P*<0.05 was considered significant). CPR: Cardiopulmonary resuscitation

and vertical integrated training model based on the SPICES training model developed by Harden. With this model, students receive BLS education in 3 different classes (1st, 3rd, 5th grades). The survey's high rate of correct answers suggests that this is due to the participants' BLS training in previous years. Since our study mainly aimed to evaluate skill levels, especially chest compression skills, rather than investigating theoretical knowledge about CPR, the survey was not repeated in posttraining measurements, and theoretical knowledge levels were not measured. This survey, which questions the most fundamental theoretical knowledge beforehand, was implemented to test the group's status regarding essential knowledge and to see whether it was distributed homogeneously. Since the primary purpose was to evaluate BLS application performance, repeated measurements were not made.

Education in the school of medicine in our country is carried out by NCEP and is constantly renewed by the needs and recommendations brought by the changing and developing world.[10] Accordingly, it is aimed that each graduated physician performs BLS completely and appropriately when necessary.[11] To achieve this goal, rather than theoretical weighted training, practical training is preferred, where simulation models, which have an essential place in integrated education, are utilized. With this hands-on training using simulation models that allow chest compression and airway practice, students can practice BLS intervention most realistically. The measurements performed during the practices and their instant evaluation with feedback also contribute positively to the learning process. It is also essential to evaluate the retention of the skills gained in practical training. The results of these evaluations will guide us on when and in what content retraining should be provided.

Our study found no significant difference between posttraining measurements and those that took place 9 months later. There are studies evaluating the effectiveness of BLS training in the literature. In a study that measured the efficacy of 150-min long BLS training and its retention 8 months later, no significant difference was found regarding the retention of the training.[12] While a significant difference was found between pre- and posttraining measurements for chest compression scores in another study evaluating CPR parameters before, after, and 6 months after a 45-min long BLS training, no significant difference was found between posttraining measurements and the measurements that took place 6 months later.[13] The results of these studies are consistent with our results. Our study indicates that the EM clerkship training significantly improves CPR performance and that this improvement is retained for at least 9 months. One possible explanation for the sustained skill retention observed in our study could be the practical nature of the training, which enhances muscle memory and procedural fluency. However, despite this retention, the lack of a statistically significant increase in chest compression scores over time suggests that skill levels do not spontaneously improve without additional reinforcement. This finding highlights the potential need for periodic refresher training to maintain or further enhance CPR performance.

Another result of our study was that the level of the participants on ventilation was very low before the training. The measurements showed a significant difference between pre- and posttraining median values regarding ventilation scores. It is seen that the training also creates a positive awareness of proper breathing. The ventilation score decreased again in the measurements performed 9 months later. Based on this, it can be concluded that training also creates awareness about proper ventilation, but this awareness gained cannot be maintained and regressed again at the end of 9 months.

Our study, different from other studies, aimed to measure the effectiveness of the ongoing curriculum education as a side goal. Since the participating students continued their education as part of their routine clinical training, controlling their exposure to various factors during the 9 months between the posttraining and follow-up assessments was impossible. Specifically, participants may have encountered cardiac arrest cases in their clinical practice, requiring them to perform CPR at varying frequencies. As a result, differences in real-life exposure and hands-on experience could have contributed to variability in skill retention and performance outcomes. Before the last measurements, participants were asked if they had performed CPR on an actual patient. This variable, which was not detected in the initial design of the study, would have had an effect on our results. However, there was no significant difference in the results of the compression scores between the group that performed CPR twice or more (n = 42) and the other group (n = 22). When we classified the participants as having three or more CRP performance (n = 34) and others (n = 18), the result remains the same, and there was no significant difference. Since the CPR practice conducted in in-hospital areas generally involves an advanced airway practice or the use of bag valve mask, only the chest compression scores of the participants were evaluated.

Limitations

The study was conducted in a single center with limited participants. Since the study group consisted of fifth-grade students, the BLS training that they received before may have caused the group's initial knowledge level to be unstable and not remain at the same level. However, the high correct answer rates in the survey suggest that the difference is not too much. In addition, the fact that theoretical knowledge was not reevaluated at the second and third measurement times may be considered among the study's limitations. Although having only one instructor and observer throughout the study was seen as a limitation, it helps mitigate potential biases in skill assessment. Since all measurements were performed by the same individual using a standardized evaluation device, variability in data collection was minimized. In addition, the study primarily focused on assessing skill changes immediately after training and again 9 months later, ensuring a consistent and controlled evaluation process. Therefore, this limitation is not expected to have significantly impacted our results.

Conclusion

BLS training provided to medical faculty year 5 students in the EM clerkship program increased the effectiveness of chest compression, and this skill did not regress within 9 months.

Author contributions

- Ramazan Sivil: Conceptualization, data curation, investigation, methodology, project administration, validation, visualization, roles/writing – original draft, writing – review and editing, revision
- Ozlem Yigit: Conceptualization, formal analysis, investigation, methodology, project administration, validation, roles/writing – original draft, writing – review and editing, revision
- Suleyman Ibze: Data curation, investigation, project administration, roles/writing – original draft, writing – review and editing, revision
- Erkan Goksu: Conceptualization, formal analysis, supervision, roles/writing – original draft, writing – review and editing, revision
- Yesim Senol: Conceptualization, formal analysis, methodology, supervision, roles/writing – original draft, writing – review and editing.

Conflicts of interest

There are no conflicts of interest.

Ethical approval

The study was authorized, and the need for informed permission was exempted by the Akdeniz University Faculty of Medicine Clinical Research Ethics Committee, Decision Date: February 20, 2019 and Decision No.: 193.

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Appendix 1: Cardiopulmonary resuscitation quality parameters recorded by SimPad PLUS

Parameter	Explanation
Overall CPR score	Percentage-based score representing CPR performance (0%–49%: Basic, 50%–74%: Intermediate, 75%–100%: Advanced)
Total compression score	Percentage score indicating the quality of chest compressions
Total ventilation score	Percentage score reflecting the effectiveness of ventilations
Flow fraction (compression fraction)	The proportion of CPR time spent on chest compressions
Hand position accuracy	The percentage of compressions performed with correct hand placement
Mean no-flow time	The average pause duration during CPR (time without chest compressions)
Total number of compressions	The total number of compressions performed during the measurement period
Mean compression depth	The average depth achieved during chest compressions
Percentage of correct compressions	The proportion of compressions performed at the correct rate and depth
Mean compression rate	The average number of compressions per minute
Recoil percentage	The percentage of compressions allowing full chest recoil
Adequate depth compressions	The percentage of compressions reaching the target depth
Total number of ventilations	The total number of ventilations delivered (expected: 10–12 per min)
Mean ventilation volume	The average volume of air delivered per breath (mL)
Mean ventilation rate	The average number of ventilations per minute
Adequate ventilation percentage	The percentage of ventilations delivering 500–600 mL of air
Excessive ventilation percentage	The percentage of breaths exceeding 600 mL
Inadequate-ventilation percentage	The percentage of breaths delivering<500 mL
Overall CPR score	Percentage-based score representing CPR performance (0%–49%: Basic, 50%–74%: Intermediate, 75%–100%: Advanced)
Total compression score	Percentage score indicating the quality of chest compressions

CPR: Cardiopulmonary resuscitation