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The effect of simulation-based education on nursing students' knowledge and performance of adult basic cardiopulmonary resuscitation: A randomized clinical trial

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ABSTRACT

Background & Aim: Cardiopulmonary arrest as a life-threatening condition needs urgent interventions to protect individuals' life and prevent irreversible damages to vital organs. This study aimed to investigate the effect of simulation-based education on the knowledge and performance of nursing students of adult essential life support cardiopulmonary resuscitation (BLS-CPR).
Methods & Materials: This study used a pretest-posttest study with a control group. It was conducted at Iran University of medical sciences, Tehran, Iran, in 2017. In this study, 49 nursing students at the sixth education semester were assigned using the simple random allocation into two groups of intervention (n=28) and control (n=21). Initially, the conventional BLS education was provided to the two groups of intervention and control using the conventional method. Next, the intervention group received a simulation-based education. The knowledge and performance of the students before, immediately after, and three months after the intervention was assessed using a modified knowledge assessment questionnaire and a modified performance evaluation checklist about BLS in adults.
Results: The students' knowledge in the intervention group immediately after ($p<0.001$) and three months after the intervention ($p<0.05$) were significantly higher than the control group. The mean scores of performance immediately after ($p<0.001$) and three months after the intervention ($p<0.001$) were significantly higher than the control group.
Conclusion: Simulation-based education increased the knowledge and performance of nursing students in the field of BLS-CPR. According to the results, integrating conventional training with simulation-based education can be effective in learning BLS among nursing students.

Introduction

Cardiopulmonary arrest is one of the leading causes of death out of the hospital (1). According to the American Heart Association (AHA), in the United States in 2011, 326,000 people have received emergency medical services (EMS) for cardiac arrest out of the hospital. Also, 209,000 people with in-hospital cardiac arrest receive cardiopulmonary resuscitation (CPR) annually. The prevalence of death in patients with cardiac arrest is about 90% (2). Education plays an essential role in learning CPR principles.

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Through education, nurses are known to perform CPR, and also it can be helpful to stabilize their learning (3). To improve the quality of CPR education, different educational methods are used, including both direct and indirect methods such as workshops, lectures, movies, leaflets, booklets, e-learning, and multimedia software (4).

According to the European Resuscitation Council, considering the survival chain, updating related guidelines, and educating critical skills are factors to improve survival rate (5). The regular education of technical skills are essential factors in CPR, and lack of education cause inappropriate CPR performance and poor clinical outcomes (6). Currently, the lecture is a conventional method of teaching health education to

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students, but proper and adequate education needs other complementary methods to increase the quality of education (7). Even short-time practices that happen in the clinical skill centers are not enough to learn all related skills. Little is known about the best method of education for this critical and essential skill (8).

Simulation is one of the best learning methodologies in the clinical nursing educational program (9). Simulation is different from conventional teaching methods such as lectures, in which the learner is passive (10). Simulation can improve patient safety by creating a safe and controlled environment (11). Also, the use of the simulation approach can improve the knowledge, skills, and performance of nursing students. They can reach high levels of critical thinking and acquire new professional skills without endangering the patient's health (12).

Additionally, the use of simulation can overcome challenges such as the shortage of clinical situations and raise the number of nursing students (13). Students expect their instructors to use interactive educational methods reflecting the real clinical world (7). Nursing students as adult learners are self-directed, and internally motivated to learn those related to their social and professional roles, and they explore immediate implications for the knowledge gained. They can achieve these aims and expectations through practice in simulated environments (14).

In simulation-based education, the preparation of an educational scenario, feedback, or debriefing is necessary. Each scenario should be consistent with institutional missions and/or program goals (15). Also, CPR skills' retention is closely related to the learner, trainer, educational program, and the number of training courses (10). There are conflicting results about the impact of simulation education on the improvement of knowledge and performance in the field of CPR.

One study confirmed that 95% of students were satisfied with simulation and students learned skills faster using this method (16, 17).

In another study, a significant increase in the acquisition of knowledge and skills of adult BLS using the high-fidelity simulation (HFS) mannequins group compared to the low-fidelity simulation (LFS) mannequins group was reported, but three months later CPR knowledge and skill were significantly decreased in both groups (13). However, no pre-test of skills was performed in this study so that the observed improvement could be due to factors other than their interventions, such as a better performance of participants before the study.

Another study on the number of healthcare providers (HCPs) to investigate the effect of HFS on the retention of BLS knowledge score at three, six, and nine months, and two years after the intervention, indicated no significant difference in the total mean percent scores in the study intervals (10). The authors of the study stated that HFS alone was not enough to support the retention of BLS knowledge in HCPs. The limitation of this study was that knowledge acquisition, along with performance retention and acquisition, were not considered. Ackermann (18) showed that human patient simulation (HPS) cardiopulmonary arrest scenario using HFS significantly influenced the acquisition of knowledge and skills compared with the control group. Also, CPR knowledge and skills after three months from education in the simulation-based group were higher than those of the control group. Despite current studies, the effect of different scenarios in different conditions (within and outside hospital) by utilizing medium and low fidelity mannequins were not assessed.

This study aimed to investigate the effect of education on the knowledge and skills of nursing students of basic adult CPR.

Methods

Study design

This research project used a quasi-experimental study with a pretest-posttest design with a control group.

Research population and sampling

The research population of this study was nursing students in the 6th semester at Iran University of Medical Sciences, Tehran, Iran, 2017. In Iran, nursing students pass 8 semesters that the last two are an internship in the field courses. In this study, all undergraduate nursing students in the sixth education semester (including 2 classes with 22 and 30 students in each) were enrolled using the census method. In the 6th semester, nursing students learn critical care courses, and in this course, they have a session about CPR. Using a random method (draw), the two classes were classified as intervention (simulation-based education and conventional education method) and control (conventional education method) groups by an individual who was not aware of the purpose of the study.

Data collection

A demographic data form, a modified performance Checklist for adult BLS, and a modified knowledge questionnaire were used for data collection. The demographic information form was filled out by the groups before the intervention.

In this study, a modified knowledge questionnaire was used for adult BLS based on the 2015 AHA guideline. The content validity of this questionnaire was evaluated and verified by a panel of experts. It examined the diagnosis of cardiopulmonary arrest symptoms, assessment of the injured or the anesthetized person, checking the vital signs and the response level, positioning, asking for help, chest compression in terms of number and depth, essential airway management, mouth-to-mouth respiration and the use of the Automated External Defibrillator (AED) (19). This questionnaire had no items regarding the onset of recovery, assessment time, and chain of survival in cardiac arrest inside and outside the hospital, location and measurement of the patient's pulse, and proper head positioning for opening the airway in traumatic patients. Therefore, with the agreement of the research team, those six items were added to the questionnaire. Lastly, this modified questionnaire consisted of 20 questions about the principles of the BLS. For each correct answer, score 1 and for any wrong or non-response answer score zero was assigned. The total score of this questionnaire was 0 to 20, and a higher score reflected more knowledge about adults' BLS. The content validity of this modified questionnaire was evaluated and confirmed by the panel of experts, and its reliability was reported as 0.75 using the calculation of the Kuder-Richardson Coefficient test. Before the intervention, the pretest was performed. Immediately after and three months after the intervention, the posttests were taken.

A modified performance Checklist for Adult BLS was developed based on the Adult CPR and AED Skills Testing Checklist. This was a 16-item checklist that items, including artificial respiration using a bag valve mask and simultaneous pulse and breathing, were added to it based on the 2015 AHA. In accordance with the 2015 AHA and the BLS Course 2015 Interim Tool, four items were added to the checklist including putting the patient on a CPR backboard or a CPR board, not bending the elbows when compressing the chest, continuing to compress the chest during the AED connection, re-compressing the chest immediately after giving the breath and CPR discharge using AED, and proper positioning of injured head to open the airway. Finally, the modified checklist included 20 items. Each item got one score in case of correct performance, if there was a failure or mistake, zero score was. The total score of this checklist was 0-20, and a higher score indicated better performance. For reliability of this modified checklist, the interrater reliability technique was used and nine eligible students from the seventh education semester were requested to participate and two evaluators simultaneously and in a parallel manner assessed their performance. The correlation coefficient of the evaluators was calculated and reported as 0.898. The time spent on conducting the skills was measured using a calibrated chronometer. The time was taken to check the number of pulses, respiratory rate, chest compression, and their numbers by the researcher assistant.

The students' performance was examined before, immediately after, and three months after the intervention in the groups. Using one of the two clinical scenarios (different from the items in education and practice in the intervention group), the type of scenario (hospital and pre-hospital) was determined for the first group through a random method. In the next groups, the test was conducted alternately based on the hospital or pre-hospital scenario. Four clinical scenarios of cardiac arrest inside and outside of the hospital were organized using the literature review. The content validity of these scenarios was evaluated and confirmed by the panel of experts.

Educational intervention

In both groups, the conventional adult BLS training was conducted by researcher assistants using Power-Point presentations, movies, and practical exercises on CPR mannequins at the clinical skills center. The conventional adult BLS training was done in two hours for each group. In the intervention group, in addition to receiving conventional education, clinical skills were taught on CPR mannequins for 30 minutes by the researcher and researcher assistant. Education was performed inside (clinical skills center) and outside the hospital as a simulated cardiopulmonary event. The different rooms (environment) were simulated for each scenario. Also, some co-researchers (as actors) played roles in those scenarios. After demonstrating each scenario of cardiopulmonary arrest for the students, the BLS was performed on CPR mannequins. Afterward, using the same scenarios, the students practiced the BLS in three-member groups under the supervision of a researcher at the clinical skills center. The students continued to practice various BLS roles, including heart compression, artificial respiration, and the use of AED. Each student practiced BLS steps for 5 minutes and a total of 15 minutes in each group. After practicing on mannequins, students' debriefing under the guidance of the researcher was performed for 5-10 minutes.

Ethical considerations

It was carried out in 2017 after obtaining permission from the Ethics Committee affiliated with Iran University of Medical Sciences (IR.IUMS.FMD.REC1396.9411706005) and the clinical trial registration code (IRCT2017102436974N1). The researcher initially provided the students with a complete explanation of the research and its objectives, and the volunteer students signed the written informed consent form. None of the participants were lecturers on the subject in the research zone.

Data analysis

The normal distribution of variables was performed using the Kolmogorov-Smirnov (KS) test. To compare quantitative variables between the two groups, the independent t or Mann-Whitney U test was used. The homogeneity of qualitative variables between two groups was performed using the Chi-square and Fisher's exact test. To compare the mean scores of knowledge and performance over time, a one-way repeated measures ANOVA and Bonferroni post-hoc test were used, respectively. Statistical analysis was conducted using the SPSS V.16 software program. The significance level was set as $P<0.05$.

Results

In this study, data from 49 undergraduate nursing students were analyzed (Figure 1). During the study, two students from the intervention group and one student from the control group were excluded due to the inability to participate in the practical training sessions. Finally, the data from 21 students in the control group and 28 students in the intervention group were used for analysis.

There was no statistically significant difference between the two groups in terms of demographic variables indicating their homogeneity (Table 1).

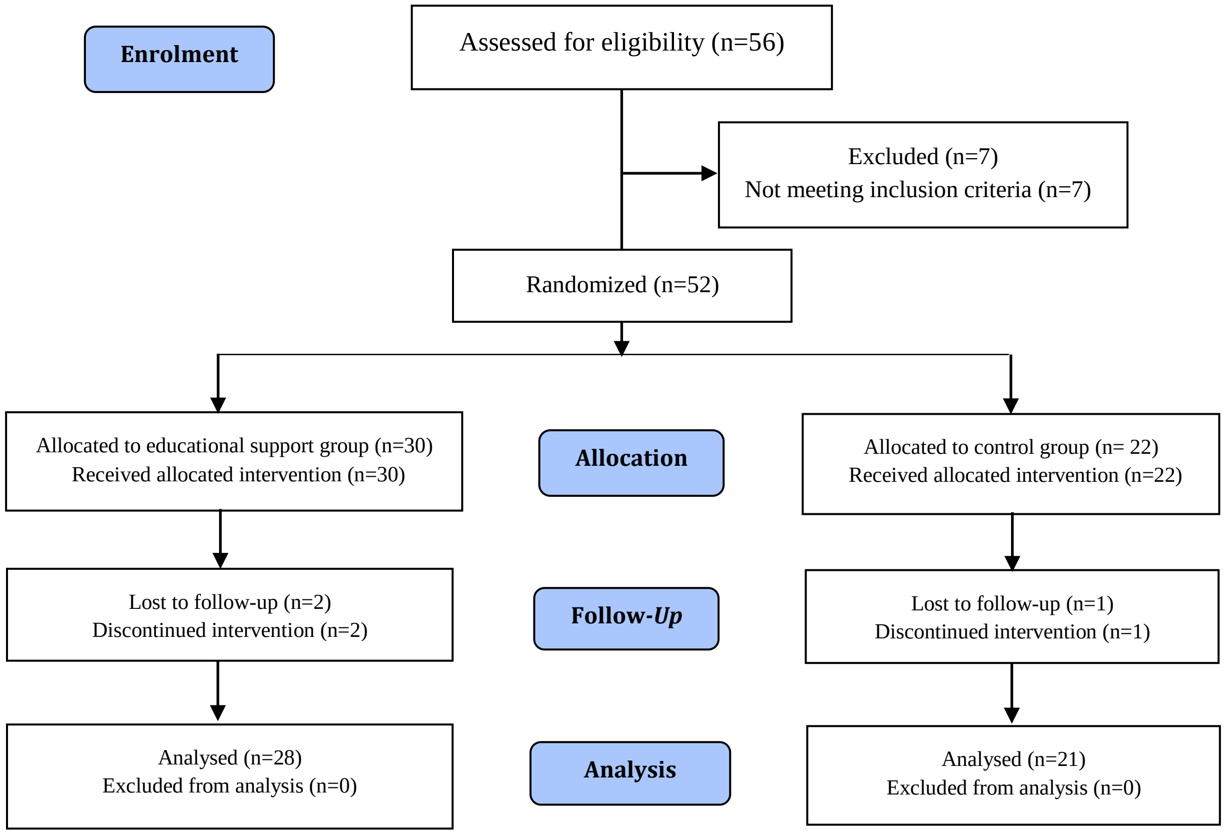

Figure 1. The research process

Table 1. Demographic characteristics of the students in the groups

Variable	Variable levels	Control group (n=21)	Intervention group (n=28)	Test result/ p-value
Age (year)	20-21	6(28.6)	9(32.1)	*z= 0.281 p=0.779
	22-24	12(57.1)	15(53.6)	
	≥25	3(14.3)	4(14.3)	
	Mean±SD	22.71±2.61	22.82 ± 3.03	
Gender	Female	2(9.5)	5(17.9)	$^{**}\chi^2 = 1.87$ P= 0.17
	Male	10(47.6)	23(82.1)	
Marital status	Married	2(9.5)	5(17.9)	***P=0.863
	Single	19(90.5)	23(82.2)	
History of participation in basic CPR	Yes	8(38.1)	6(21.4)	$^{**}\chi^2 = 1.63$ P= 0.2
	No	13(61.9)	22(78.6)	
Work experience in the hospital	Yes	6(28.6)	7(25)	$^{**}\chi^2 = 0.07$ P= 0.77
	No	15(71.4)	21(75)	
Experience of basic CPR	Yes	7(33.3)	11(39.3)	$^{**}\chi^2 = 0.18$ P= 0.66
	No	14(66.7)	17(60.7)	

* Mann-Whitney test, ** Chi-square test ***, Fisher's exact test

There were no statistically significant differences between the level of knowledge of nursing students in the intervention and control groups before education (p=0.86) (Table 2).

Table 2. Comparison of the mean of knowledge in the intervention and control groups before, immediately and three months after the intervention

Timepoints	Intervention	Control
	Mean±SD	Mean±SD
Before	10.18 ± 2.61	10.05 ± 2.78
One month after	16.78 ± 1.97	14.14 ± 2.43
Three months after	15.07 ± 2.29	13.33 ± 1.93
Repeated measures ANOVA	F=101.94 p<0.001	F=21.116 p<0.001

Since the interaction between time and group was significant, within-group comparison is evaluated. The repeated measures ANOVA showed that in the intervention group, the mean of the knowledge score varied at least at one time with other times (p<0.001). The Bonferroni's test showed that in the pairwise combination of all time intervals, the mean score of students' knowledge immediately after simulation-based education was significantly higher than before the intervention (p<0.001) and three months after the intervention (p=0.001).The mean of knowledge scores three months after the intervention was significantly higher than before the intervention (p<0.001).

For the control group, a statistically significant difference at a one-time interval with the other time intervals was reported (p<0.001). There was a significant difference between the knowledge scores before the intervention and immediately after (p<0.001) and three months after the intervention (p=0.001) so that the mean score of knowledge before the intervention was less than the other two time intervals.

The mean scores of the students' performance before, immediately after, and three months after the intervention was shown in Table 3. There was no statistically significant difference between groups regarding the performance scores of the students before the intervention (p=0.32) (Table 3).

Table 3. Comparison of the mean of performance of the units in the intervention and control groups before, immediately after and three months after the intervention

Timepoints	Intervention	Control
	Mean±SD	Mean±SD
Before	5.43 ± 3.01	6.19 ± 2.13
One month after	17.78 ± 1.91	14.95 ± 2.92
Three months after	16.57 ± 2.36	14.76 ± 2.86
Repeated measures ANOVA	F=253.96 p<0.001	F=67.71 p<0.001

Since the interaction between time and group was significant, within-group comparison is evaluated. The repeated measures ANOVA in Table 3 showed that the mean score of performance in the intervention group at least at the one-time interval was different from the other time intervals (p<0.001).

Bonferroni's test showed that in pairwise combination of all time intervals, the students' performance scores immediately after the intervention (p<0.001) and three months after the intervention (p<0.001) were significantly higher than before the intervention. In the control group, the result showed a significant difference at least at one time with the other time intervals (p<0.001). The results of the Bonferroni's test showed that the mean score of performance before the intervention was significantly lower than that immediately after the intervention (p<0.001) and three months after the intervention (p<0.001).

According to table 4, there was only a statistically significant difference between groups regarding the difference in knowledge scores before and immediately after the intervention. Furthermore, there were significant differences between groups regarding the difference in performance scores before and immediately after the intervention, and also before and three months after the intervention.

Table 4. Comparison of change scores of knowledge and performance over three-time points

Variables	Timepoints	Score differences		T-test result
		Mean±SD (Intervention)	**Mean±SD (Control)**	
Knowledge	Before-immediately after intervention	6.61±2.59	4.09±3.14	P= 0.004
	Immediately after intervention-after 3 months	-1.71±2.21	-0.81±2.5	P=0.187
	Before- after 3 months	4.89±2.79	3.28±3.45	P=0.078
Performance	Before-immediately after intervention	12.36±2.97	8.76±3.69	P<0.001
	Immediately after intervention-after 3 months	-1.21±2.83	-0.19±4.52	P=0.369
	Before-after 3 months	11.14±3.72	8.57±3.54	P=0.018

Discussion

The results of this study showed that in the intervention group compared with the control group, the knowledge and performance scores were increased immediately and three months after the intervention. The results of this study can be explained based on Kolb's theory of learning. In Kolb's model, a learning cycle has a four-stage cycle, each of which shows the type of individual's perception of information. The learner performs an action (concrete experience), and thinks about that (reflective observation), follows the theory (abstract conceptualization), and ultimately experiments (active experimentation) (20). Therefore, in simulation-based education, learners' knowledge and performance can be improved in these situations. Conventional teaching takes much time for not only learners but also its complexity act as a barrier to learning, which ultimately leads to insufficient motivation for the active participation of the learner (21). Given the increasing number of nursing students, the simulation method can overcome challenges such as lack of educational facilities in clinical settings (13). Also, a specific learning environment for simulation-based education had a positive impact on students' psychological skills and emotional characteristics such as self-confidence and anxiety in the process of patient care (18). However, a study reported that students in the first sessions of simulation experienced both physiological and psychological compromised. Subsequently, they showed a positive adaptive response in the next scenarios, debriefings, and simulations (22). This can be the reason for the success of simulation in students' education.

Most studies have reported the positive effect of simulation education on nursing students (23-25). In a study by Aqel and Ahmed, the acquisition of knowledge in the HFS mannequin group was significantly higher than that of the control group (13). However, Akhu-Zaheya, Gharaibeh, and Alostaz (26) showed no statistically significant difference in knowledge acquisition between the intervention group (high-fidelity BLS simulation and conventional method of BLS) and control group (only conventional teaching of BLS). It can be attributed to the differences in the intervention protocol (27). A study reported that the use of HPS in the intervention group, in comparison with the control group, increased the level of knowledge and skills among nursing students (18). Simulation can help to indicate the knowledge-practice gap and educating high-quality CPR by creating real conditions without compromising patient safety for students in order to experience different outcomes and gaining self-confidence. However, high fidelity simulation was more effective in conducting high-quality chest compression depth and a fraction (McCoy). Another study showed that video and simulation-based education, learning and performance were similar, but they had better outcomes than conventional lecture education (28).

In this study, while knowledge and performance scores were increased significantly in both groups immediately after and three months after education, in the simulation group, it was more than the control group. The high scores of knowledge and performance three months after the intervention compared to earlier stages indicate that simulation is an aspect of reality, and is better understood, controlled, and practiced (29). On the other hand, conventional education can increase the knowledge and performance of learners about BLS immediately after the intervention, but such an increase in the intervention group was higher due to simulation-based education and reality-close experience. The level of knowledge and performance in both groups was reduced three months after the intervention, but in the intervention group, they were still higher than that of the control group; it was not significant regarding knowledge, however. Nurses may forget something after a certain period and ensuring knowledge retention is essential for proper implementation of CPR (30). A lack of repeating education on CPR as a practice-based skill can reduce students' skills over time (31). A study found that the knowledge score decreased significantly after 10 weeks from CPR education and need to review the knowledge and skills of CPR every 6-12 months was emphasized (32).

In another study, the mean performance score of nursing students was increased one month after the intervention, but it was reduced after six months (30). A study suggested that levels of skill were reduced over time. Retraining courses prevent those skills are forgotten (33).

This study has some limitations that may influence the generalizability of our findings. For instance, it was impossible to use the random allocation method, such as block randomization, because of the contamination of subjects. While retention education was performed for up to 3 months, other time intervals should be considered in future studies to examine the time needed to retrain education, especially before entering internship courses. Another suggestion of this study is to combine simulation-based education with distance learning methods to increase training retention. In this study, non-technical skills were not assessed. It is suggested that a combination of two self-centered learning strategies and inter-professional learning is used to enhance teamwork skills. Therefore, simulation-based education is suggested to be taught in the interdisciplinary and teamwork method, and their performance is examined.

In this study, the knowledge and performance were improved immediately and three months after the intervention. According to the findings, Conventional education is a practical education strategy, but its combination with simulation-based education effectively can improve the knowledge and performance of nursing students. The simulation-based CPR education, without influencing patient safety, allows subjects to experience emergencies, take necessary actions, and examine the consequences of their selections. Since nurses are at the frontline of dealing with emergencies, regular, periodic, and accessible CPR education should be provided to update their knowledge and skills on the latest CPR instructions. It is also recommended that hospital managers carry out systematic planning to improve the knowledge and performance of nurses about CPR.

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Conflict of Interest

There is no conflict of interest.

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