Original Article

Comparison of Mannequin-Based Simulation Training Method with Virtual Training Method on Nursing Students' Learning Cardiopulmonary Resuscitation: A Controlled Randomized Parallel Trial

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Abstract

Background: The use of different educational methods and programs, such as simulation and virtual training, plays an important role in effective Cardiopulmonary Resuscitation (CPR) learning for nursing students. This study was conducted with the aim of comparing mannequin-based simulation training with virtual training on CPR learning among nursing students. **Materials and Methods:** This parallel randomized controlled trial was conducted in 2022. We selected 73 nursing undergraduate students and randomly assigned them to two groups: mannequin-based simulation and virtual training groups. The knowledge, attitude, and performance of CPR in both groups were evaluated and compared before, immediately after, and 1 month after the intervention. Data analysis was performed using independent *t*-test and the repeated-measure analysis of variance (ANOVA) using the Statistical Package for Social Sciences (SPSS) software. **Results:** Within-group differences were significant in both mannequin-based simulation and virtual training groups in terms of knowledge, attitude, and CPR performance before and after training, as well as between before and 1 month after training ($p < 0.001$). In addition, the mean performance of simulation group students was significantly higher than the virtual group ($p < 0.001$), but no significant difference was observed between the two groups in terms of knowledge and attitude dimensions before training, after training, and 1 month after training. **Conclusions:** Both mannequin-based simulation and virtual training methods increase CPR learning. Considering that students' knowledge and attitude increase significantly using both training methods and the performance of students in the simulation group is better than in the virtual group, the use of a multimodal approach is recommended for CPR training of nursing students.

Keywords: *Cardiopulmonary resuscitation, education, nursing, simulation training*

Introduction

In most cases, nurses are the first healthcare professionals to identify cardiac and respiratory arrest.[1,2] Cardiopulmonary Resuscitation (CPR) is one of the fastest medical interventions during cardiac arrest and can significantly aid in preventing death or delaying it.[3] CPR is a series of basic actions performed by skilled and knowledgeable individuals to save patients with respiratory cardiac arrest.[2] Proper execution of CPR based on guidelines is essential for optimizing patient survival.[4] Therefore, it is crucial to educate nursing students, who may encounter cardiac arrest, about CPR. Additionally, nursing students should receive the latest and most appropriate knowledge regarding the CPR process.[5]

After conducting studies across various countries, the importance of CPR has been well established.[6-8] Keeping up-to-date with the latest methods of basic life support for CPR is one of the most important pieces of information that every individual must possess.[9] This becomes particularly crucial for healthcare workers, especially nurses.[10] Various factors contribute to effective and successful CPR, with the most significant being proper CPR training.[11,12] Choosing an appropriate method for implementing educational programs is one of the most essential steps in designing educational

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plans.[13] The results of several studies have shown that nursing students lack the necessary skills in CPR and do not follow American Heart Association (AHA) guidelines properly.[14] Thus, there is a need to improve CPR knowledge among nursing and medical students.[15,16] Nursing students should be able to commence and perform effective CPR when beginning their career.[17,18] In this regard, researchers suggest that new and alternative approaches to enhancing CPR knowledge and skills could be beneficial for students.[19]

Simulation is one of the educational methods, which can lead to the development of knowledge, skills, performance, critical thinking, and self-confidence in learners. By practicing and repeating in a secure and healthy environment without disrupting the safety and health of patients, the ability to achieve high levels of critical thinking is attainable using simulation.[20] Such an experience is possible by practicing on a mannequin, through which learners can practice clinical skills and experience patient responses to care using this method.[21] Simulation allows learners to actively participate in their learning process, provide care for patients in a controlled and safe environment,[22] and test decisions and actions in an experimental and non-risky environment.[23] Also, the effectiveness of mannequin-based simulation education in enhancing nursing and medical students' learning has been proven in multiple studies.[24,25] Another method of instruction is virtual training which is a powerful and pervasive instructional tool.[26] In this method, a greater number of learners can be trained.[27] With the increase in computer literacy, online and virtual learning have become more popular.[28] Early evidence also confirms the effectiveness of virtual interventions in medical education.[29,30] Given that virtual training is currently receiving serious attention from universities and educational centers, especially in pandemics where face-to-face education for students is restricted, it can somewhat overcome the gaps caused by the inability of learners to attend courses, but the strengths and weaknesses of this method, particularly in clinical settings, need to be evaluated. However, although simulation-based methods have shown benefits, particularly in clinical and performance-related studies, due to the complexity and cost of this method, it is less frequent; therefore, further studies are necessary to examine the effectiveness of this method.[31] Given this, this study aims to compare mannequin-based simulation training with virtual training on the learning of CPR among nursing students.

Materials and Methods

This study was a controlled randomized parallel-group trial that aimed to compare the effectiveness of simulation and virtual learning approaches on the knowledge of nursing students regarding CPR. The study was registered in the Iranian Registry of Clinical Trials with the registration number IRCT20210804052074N1.

The population under study consisted of third-year nursing students (semesters 5 and 6) from Shahroud University of Medical Sciences (SHMU) which it conducted within the timeframe spanning from October 10, 2022, to November 21, 2022. After obtaining the necessary permissions from the educational department of the university and the faculty, we recruited participants and randomly assigned them to two groups: mannequin-based simulation training group and virtual training group. Inclusion criteria required that participants were from the same university, did not pass conditionally the previous semester, did not have any work experience or a nursing diploma, had not participated in CPR training courses previously, and had no relevant work experience. The criteria for exclusion from the study were lack of satisfaction and the failure to complete all required training sessions. It should be noted that three participants in the simulation group did not attend any training sessions and were excluded from the study, resulting in a total of 73 students for final evaluation.

A research assistant who was not involved in the intervention or evaluation process allocated participants into two groups using random assignment, with one group receiving virtual training and the other group receiving mannequin-based simulation, in such a way that each participant chose a closed letter containing the names of the groups that were prepared according to the sample size and then that participant was randomly placed in that group.

The sample size was calculated using the G*power 3.1.7 program.[32] With an effect size of 0.50, a significance level of 0.05 (α), and a power of 0.80 (1-β), the calculated sample size was 33 participants per group. With an additional 10% for potential dropouts, it resulted in a total of 38 participants per group.

The instruments utilized in this study consisted of a demographic questionnaire containing information pertaining to age, gender, and on-campus residency (yes/no), and the knowledge and attitude questionnaire and the researcher-created performance checklist were constructed after reviewing previous studies and questionnaires in this field and taking into account the educational content. After being validated for both reliability and validity, we used these instruments in the study.

A knowledge assessment questionnaire was created to evaluate CPR knowledge for this study, consisting of 24 multiple-choice questions. Scores ranged from 0 to 24, with higher scores indicating greater levels of knowledge. Additionally, an attitude measurement questionnaire was designed with 18 questions related to students' attitudes toward CPR actions, validated through content validity, and reliability through retesting. The questionnaire consisted of three options: incorrect, correct, and I don't know, which were equivalent to zero, one, and two points, respectively. Scores ranged from 0 to 18, with higher scores indicating greater levels of attitude. Pearson's correlation coefficient

was used to determine reliability through retesting of the knowledge and attitude questionnaires, resulting in 0.88 and 0.84, respectively, indicating the strength of the relationship between the measures over time. Internal consistency was determined using Kuder-Richardson 20 (KR-20), resulting in a KR-20 score of 0.94 for the knowledge questionnaire and 0.91 for the attitude questionnaire.

The CPR performance recording checklist includes 20 items that assess the practical performance of students. To this end, two research assistants who were trained in CPR and evaluation were employed. The validity of the tool was acquired by obtaining the opinions and suggestions of 10 faculty members and experts about the study topic, and the reliability between the evaluators for the performance assessment checklist was determined using Cohen's kappa coefficient and was agreed upon to be 0.92. Additionally, the reliability of this checklist was 0.82 using Pearson's correlation coefficient and 0.89 using KR-20 for internal consistency. Each item on this checklist included three options: not executed (0), partially executed (1), and fully and correctly executed (2). The overall score ranged from 0 to 60. The knowledge and attitude questionnaire and performance checklist were used as pre- and post-tests for both groups. The pre-test was conducted 30 minutes before the intervention, and the post-tests were conducted immediately after and 1 month after the education.

After determining the educational needs and objectives, the content was prepared in two sections, basic and advanced cardiac resuscitation, based on the AHA (2020) guidelines.[2,3] The content was prepared according to educational needs, facilities, and necessary tools for education, such as pictures, videos, whiteboard, advanced simulator mannequins, and other necessary equipment. Before the education, learners became familiar with the learning materials, tools, simulators, and how to use them, which reduced the potential learner's frustration due to unfamiliarity with educational tools. The educational program and content were developed using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model[33] [Figure 1]. After extensive literature review, the authors conducted a Delphi consensus-based survey for developing the educational program (educational content and scenarios).

The information related to CPR education was made available to students in two groups of mannequin-based simulation and virtual training with the same educational content, under the precise supervision of a researcher and the assistance of two specialist panel members (an emergency medicine specialist and a pre-hospital emergency medicine instructor). After preparing the training materials, we assigned each part of the training to one person. The educational content in both groups was identical, and the only difference was the method of training in the two groups, where in the virtual training

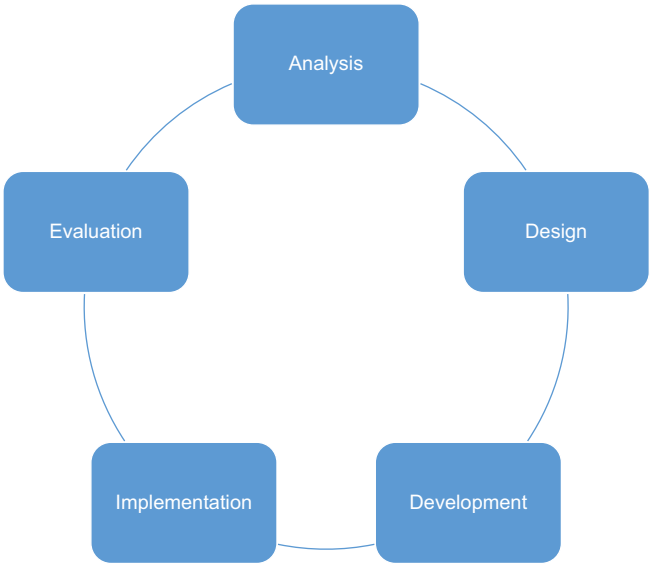

Figure 1: ADDIE model

group, images were displayed through slides, and question and answer sessions were used to clarify any ambiguities or resolve potential issues. Then, on the second day, relevant videos were shown that demonstrated the necessary skills, such as chest compression, ventilation, defibrillation, and intubation in different conditions (basic and advanced CPR), and if any questions or ambiguities arose for the students, the researchers provided them with answers to completely clarify the topics for the students.

In the simulation group, on the first day, information related to the knowledge of CPR was taught to students for 1 hour using a mannequin. Then, on the second day, a hypothetical patient scenario was designed for the students in different conditions (basic and advanced CPR) and with all the necessary facilities and equipment. The scenario was conducted, and the students in groups of 5–7 people were engaged in discussion and resuscitation performance on the mannequin in simulated conditions. After the scenario was completed, we asked the students to present the actions taken along with the instructor in the group discussion. Throughout this process, the instructor acted as a facilitator and, in the end, to make the simulation process and training based on scientific principles, the instructor tried to raise any remaining or additional details in the group with the help of other students to provide effective training. The study process is illustrated in Figure 2.

Data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 22 software, with a 0.05 significance level. In order to compare the difference between the mean scores of two groups using independent *t*-test and to examine the scores before and after the intervention, and 1 month after the intervention, an analysis of variance (ANOVA) with repeated measures was used.

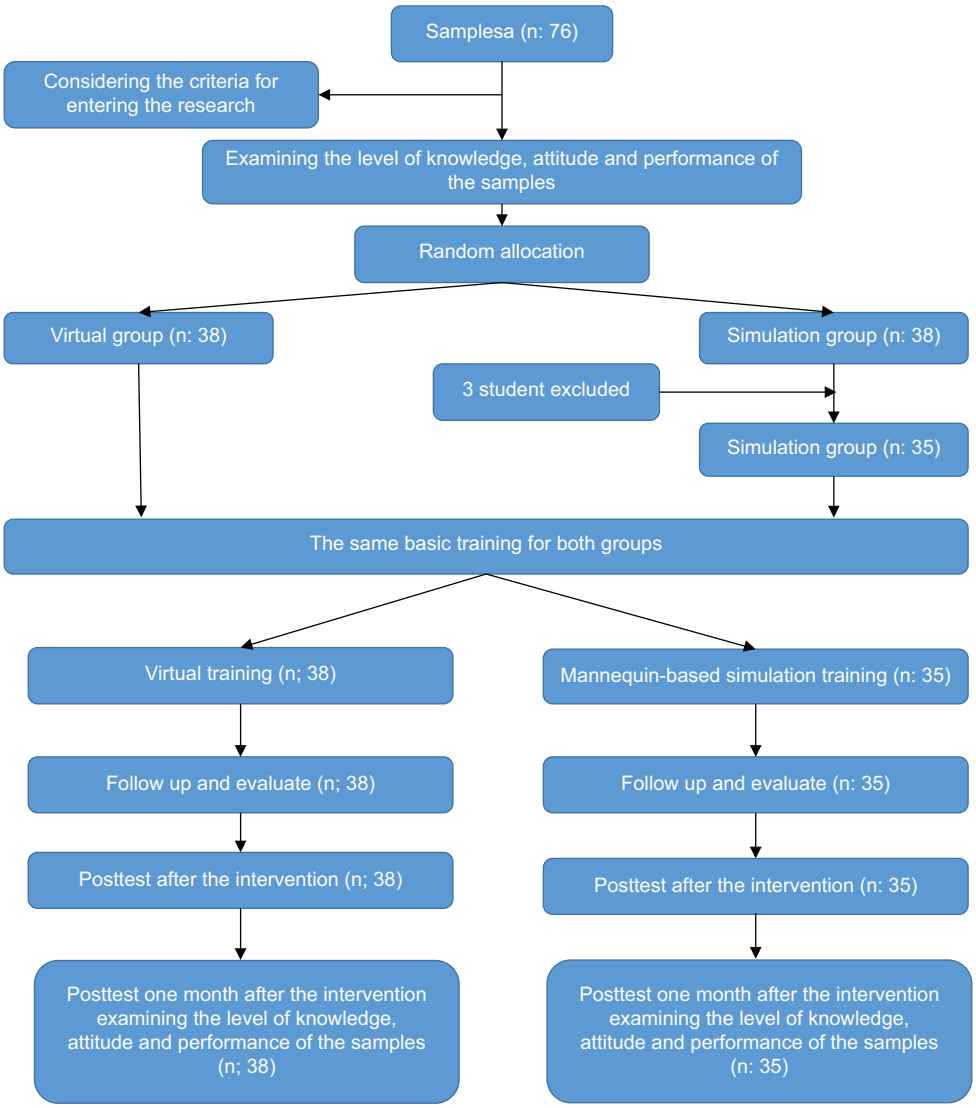

Figure 2: Flowchart of conducting the study

Ethical considerations

This study adheres to the principles of the Helsinki Declaration and has been approved by the Ethics Committee of Shahroud University of Medical Sciences with code IR.SHMU.REC.1400.037. All students were informed about the study details and provided with informed written consent. Researchers assured the students that their personal information would remain anonymous and confidential, and they were informed about their right to refuse or withdraw from the study at any time.

Results

Background and demographics

According to the results of this study, 50.7% of the study participants were male and the average age of the students was 22.45 years with a standard deviation of 0.65. Table 1 shows that there is no statistically significant difference between the two groups in terms of demographic information and basic variables before the start of the study.

Cardiopulmonary Resuscitation (CPR) knowledge

The independent *t*-test results showed that the two groups did not have a statistically significant difference before the intervention. This difference was also not statistically significant after the intervention and 1 month later. The result of the repeated-measures ANOVA indicated that the mean knowledge score in the virtual group had a statistically significant difference in at least one of the time points ($F_{2,74} = 120.831$; $p < 0.001$). Specifically, the mean score obtained after the intervention was higher than before ($p < 0.001$) and 1 month after the intervention ($p = 0.029$), and the mean score 1 month after the intervention was also higher than before ($p < 0.001$). In the simulation group, there was a statistically significant difference in at least one of the time points ($F_{2,68} = 219.941$;

Table 1: Comparison of demographic information and the initial value of the variables under investigation in the participants

Variable	Virtual group	Simulation group	Independent *t*-test	*p*
Gender				
Male *n* (%)	16 (42.10)	16 (45.70	0.10	0.756
Female *n* (%)	22 (57.90)	19 (54.30		
Age mean (SD)	22.50 (0.68)	22.40 (0.55)	0.48	0.629
Knowledge mean (SD)	11.97 (1.15)	11.71 (0.27)	0.91	0.364
Attitude mean (SD)	12.63 (0.94)	12.22 (0.19)	1.61	0.112
Performance mean (SD)	13.50 (1.65)	13.02 (0.50)	0.87	0.209

Table 2: Comparison of Cardiopulmonary Resuscitation (CPR) knowledge, attitude, and performance of participants in two simulation and virtual groups

Group	Before[a]*	After[b]**	One month[c]***	Repeated-measures analysis of variance	Pairwise comparisons
Knowledge, mean (SD)					
Virtual	11.97 (1.15)	16.78 (1.54)	15.92 (1.87)	<0.001	a<b, c c<b
Simulation	11.71 (1.27)	16.60 (1.42)	16.57 (1.21)	<0.001	a<b, c
Independent-sample test	*t*=0.914 df=71, *p*=0.364	*t*=0.592 df=71, *p*=0.556	*t*=1.737 df=71, *p*=0.087	-	
Attitude, mean (SD)					
Virtual	12.63 (0.94)	14.81 (0.92)	14.86 (0.81)	<0.001	a<b, c
Simulation	12.22 (1.19)	15.28 (0.66)	15.57 (0.65)	<0.001	a<b, c
Independent-sample test	*t*=1.61 df=71, *p*=0.112	*t*=2.469 df=71, *p*=0.016	*t*=4.053 df=71, *p*<0.001	-	
Performance, mean (SD)					
Virtual	13.50 (1.65)	16.23 (1.47)	15.28 (1.37)	<0.001	a<b, c c<b
Simulation	13.02 (1.50)	18.94 (0.87)	18.54 (0.78)	<0.001	a<b, c
Independent-sample test	*t*=1.269 df=71, *p*=0.209	*t*=9.420 df=71, *p*<0.001	*t*=12.300 df=71, *p*<0.001	-	

*a=before, **b=after, ***c=1 month

$p < 0.001$), where the mean score obtained after the intervention ($p < 0.001$) and 1 month after the intervention ($p < 0.001$) was higher than before [Table 2].

Cardiopulmonary Resuscitation (CPR) attitude

The results of the independent *t*-test showed that the two groups did not have statistically significant differences before the intervention. However, this difference was statistically significant after the intervention ($t_{71} = 2.469$; $p = 0.016$) and 1 month after the intervention ($t_{71} = 4.053$; $p < 0.001$) in both groups, with the mean score obtained in the simulation group being higher. The repeated-measures ANOVA indicated that the mean perspective score in the virtual group had a statistically significant difference at least at one of the time points ($F_{2,74} = 99.271$; $p < 0.001$), with the mean score obtained after the intervention ($p < 0.001$) and 1 month after the intervention ($p < 0.001$) being higher than before the intervention. In the simulation group, there was a statistically significant difference at least at point ($F_{2,68} = 152.36$; $p < 0.001$), with the score obtained after the intervention ($p < 0.001$) and 1 month after the intervention ($p < 0.001$) being higher than before [Table 2].

Cardiopulmonary Resuscitation (CPR) performance

The results of the independent *t*-test indicated that the two groups did not have a statistically significant difference before the intervention. However, this difference was statistically significant after ($p < 0.001$) and 1 month after the intervention ($p < 0.001$) in both groups, where the mean score obtained in the simulation group was higher. The results of the repeated-measures ANOVA showed that the mean performance score in the virtual group had a statistically significant difference at least at one of the time points ($F_{2,74} = 50.674$; $p < 0.001$), where the mean score obtained after the intervention was higher than before ($t_{71} = 9.42$; $p < 0.001$), as well as 1 month after the intervention ($t_{71} = 12.3$; $p < 0.001$). One month after the intervention, the mean score obtained was also higher than before ($p < 0.001$). In the simulation group, there was a statistically significant difference at least at one of the time points ($F_{2,68} = 319.821$; $p < 0.001$), where the mean score obtained after the intervention ($p < 0.001$) and 1 month after the intervention ($p < 0.001$) was higher than before [Table 2].

Discussion

This study aimed to compare the effectiveness of mannequin-based simulation training with virtual training on the learning of CPR among nursing students. The results of the study indicated an improvement in knowledge, attitude, and performance in both the simulation and virtual training groups, with statistically significant differences observed before and after the training in both groups. However, there were no significant differences between the two groups in terms of knowledge, attitude, and performance dimensions immediately after the study, except for the performance of the students 1 month after the intervention. Consistent with the findings of this study, multiple studies have shown the effectiveness of simulation-based training using mannequin in enhancing knowledge and performance among learners. The results of Akhu-Zaheya *et al*.'s[34] study showed that simulation-based training increases knowledge and performance in nursing students, which is consistent with this study. A study conducted by Bazrafkan *et al*.[35] showed that simulation increases knowledge and performance in resuscitation teams. The results of Hamilton's[36] study (2005) demonstrated that while different teaching methods can be effective in enhancing the knowledge and performance of nurses, the best approach is to utilize computer-based instructional programs and audiovisual mannequin for simulation. In a study conducted by Akbari Farmad *et al*.[37] (2021), simulation-based training for CPR resulted in a positive impact on the clinical knowledge and performance of nurses and was recommended as an effective method. Also, Takhdat *et al*.[38] (2022), in a longitudinal experimental study conducted in Morocco, aimed to evaluate the effect of high-fidelity simulation on self-efficacy and knowledge retention in CPR among undergraduate nursing students compared to case-based learning. The study showed that knowledge retention and self-efficacy in CPR of students in the simulation group, 1 month after training, statistically significantly differed from the control group. Furthermore, the study by Heydarizadeh *et al*. (2014)[39] and Demirtas *et al*. (2021)[1] has shown that simulation-based training has been effective and recommended for CPR training. Their study, along with the review by Onan *et al*. (2017)[40] and the study by Dyrstad *et al*. (2021),[41] positively evaluated simulation-based training. Based on these findings, it can be generally concluded that mannequin-based simulation training is more effective in developing CPR skills.

However, virtual training has gained attention over the past decade. In the study by Farzaneh *et al*. (2023),[42] which aimed to compare the effect of CPR training using a combination of traditional and virtual methods on the knowledge and performance of medical students during the coronavirus disease 2019 (COVID-19) crisis, no significant difference was observed between the two groups. In another study by Nas *et al*. (2020),[43] researchers concluded that although virtual training reaches a wider target group, the quality of CPR is lower compared to face-to-face training. Additionally, Kuyt *et al*. (2021)[44] reported the great potential of virtual training for CPR. They also claimed that the use of technology and collaboration with the research community is beneficial for the growth and accessibility of easy and widespread training in society. Additionally, Alcázar Artero *et al*.'s study (2023)[45] evaluated positively the virtual training. Alongside, the findings of Buttussi *et al*.'s study (2020)[46] suggested that virtual training has a positive impact on knowledge, manual skills, and self-efficacy in CPR. However, for proper understanding of chest compression pressure, it should be practiced on a mannequin. Furthermore, Farmad and Yosefian's study (2022)[47] showed the implementation of a virtual CPR training course was effective and positive on reaction and learning levels. Also, Jalili *et al*. (2022),[48] in a study comparing two methods of in-person and virtual training in advanced CPR concepts among emergency interns, stated that both in-person and virtual training methods are positive, and the effectiveness of virtual training in theoretical knowledge is greater than practical skills.

In our study, limitations included the potential for information dissemination between two distinct participant groups. To address this, we implemented the intervention at varying time intervals. Additionally, educational interventions were conducted amidst the COVID-19 pandemic, which was greatly reduced due to the reduction of face-to-face communication between students.

Conclusion

This study confirms the positive effectiveness of the virtual approach in CPR training among students. Additionally, the better performance of students in the simulation group 1 month after training indicates a more effective learning outcome for this instructional method. It is recommended to use both instructional methods separately or as a complement alongside other educational methods to enhance learning. Some limitations of this study include issues with the virtual system, such as disconnections during class sessions, weaker virtual infrastructure, and less control over students compared to in-person training.

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Conflicts of interest

Nothing to declare.

References

1. Demirtas A, Guvenc G, Aslan Ö, Unver V, Basak T, Kaya C. Effectiveness of simulation-based cardiopulmonary resuscitation training programs on fourth-year nursing students. Australasn Emerg Care 2021;24:4-10.
2. Merchant RM, Topjian AA, Panchal AR, Cheng A, Aziz K, Berg KM, *et al*. Part 1: Executive summary: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2020;142(suppl_2):S337-57.
3. Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, Hirsch KG, *et al*. Part 3: Adult basic and advanced life support: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2020;142(suppl_2):S366-468.
4. Sullivan NJ, Duval-Arnould J, Twilley M, Smith SP, Aksamit D, Boone-Guercio P, *et al*. Simulation exercise to improve retention of cardiopulmonary resuscitation priorities for in-hospital cardiac arrests: A randomized controlled trial. Resuscitation 2015;86:6-13.
5. Oermann MH, Kardong-Edgren SE, Odom-Maryon T. Effects of monthly practice on nursing students' CPR psychomotor skill performance. Resuscitation 2011;82:447-53.
6. Abella BS. The importance of cardiopulmonary resuscitation quality. Curr Opin Crit Care 2013;19:175-80.
7. Chamberlain DA, Hazinski MF. Education in resuscitation. Resuscitation 2003;59:11-43.
8. Pivač S, Gradišek P, Skela-Savič B. The impact of cardiopulmonary resuscitation (CPR) training on schoolchildren and their CPR knowledge, attitudes toward CPR, and willingness to help others and to perform CPR: Mixed methods research design. BMC Public Health 2020;20:915.
9. Olasveengen TM, Mancini ME, Perkins GD, Avis S, Brooks S, Castrén M, *et al*. Adult basic life support: 2020 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Circulation 2020;142(suppl_1):S41-91.
10. Madden C. Undergraduate nursing students' acquisition and retention of CPR knowledge and skills. Nurs Educ Today 2006;26:218-27.
11. Mohsen pour m, Imani z, Abdolkarimi M. The effect of education of cardiopulmonary resuscitation (C.P.R) on knowledge of nursing staff and C.P.R team members in a hospital in Kerman province. J Qual Res Health Sci 2010;09:1-7. (In Persian).
12. Roel S, Bjørk IT. Comparing nursing student competence in CPR before and after a pedagogical intervention. Nurs Res Pract 2020;2020:7459084.
13. Babanazari Z, Mansouri P, Amini M, Zare N, Raiesi H. Comparison of the effects of cardiopulmonary resuscitation training through modified team based learning and traditional method on knowledge and skills of nursing students in the College of Nursing and Midwifery, Shiraz, 2012. J Nurs Edu 2017;6:8-16. (In Persian).
14. Kim SS, Roh YS. Status of cardiopulmonary resuscitation curricula for nursing students: A questionnaire study. Nurs Health Sci 2016;18:496-502.
15. Baldi E, Contri E, Bailoni A, Rendic K, Turcan V, Donchev N, *et al*. Final-year medical students' knowledge of cardiac arrest and CPR: We must do more! Int J Cardiol 2019;296:76-80.
16. Chandrasekaran S, Kumar S, Bhat SA, Saravanakumar, Shabbir PM, Chandrasekaran V. Awareness of basic life support among medical, dental, nursing students and doctors. Indian J Anaesth 2010;54:121-6.
17. Cason CL, Baxley SM. Learning CPR with the BLS anytimeTM for healthcare provider's kit. Clin Simul Nurs 2011;7:e237-43.
18. Husebø SE, Friberg F, Søreide E, Rystedt H. Instructional problems in briefings: How to prepare nursing students for simulation-based cardiopulmonary resuscitation training. Clin Simul Nurs 2012;8:e307-18.
19. Zhonggen Y. A meta-analysis of use of serious games in education over a decade. Int J Comput Games Technol 2019;2019:4797032.
20. Sanford PG. Simulation in nursing education: A review of the research. Qual Rep 2010;15:1006.
21. Beck CT. How students perceive faculty caring: A phenomenological study. Nurse Educ 1991;16:18-22.
22. Farsi Z, Yazdani M, Butler S, Nezamzadeh M, Mirlashari J. Comparative effectiveness of simulation versus serious game for training nursing students in cardiopulmonary resuscitation: A randomized control trial. Int J Comput Games Technol 2021;2021:6695077.
23. Shearer R, Davidhizar R. Using role play to develop cultural competence. J Nurs Educ 2003;42:273-6.
24. Aqel AA, Ahmad MM. High-fidelity simulation effects on CPR knowledge, skills, acquisition, and retention in nursing students. Worldviews Evid Based Nurs 2014;11:394-400.
25. McCoy CE, Rahman A, Rendon JC, Anderson CL, Langdorf MI, Lotfipour S, *et al*. Randomized controlled trial of simulation vs. standard training for teaching medical students high-quality cardiopulmonary resuscitation. West J Emerg Med 2019;20:15-22.
26. Semeraro F, Ristagno G, Giulini G, Gnudi T, Kayal JS, Monesi A, *et al*. Virtual reality cardiopulmonary resuscitation (CPR): Comparison with a standard CPR training mannequin. Resuscitation 2019;135:234-5.
27. Semeraro F, Scapigliati A, Ristagno G, Luciani A, Gandolfi S, Lockey A, *et al*. Virtual reality for CPR training: How cool is that? Dedicated to the "next generation". Resuscitation 2017;121:e1-2.
28. Means B, Toyama Y, Murphy R, Bakia M, Jones K. Evaluation of Evidence-based Practices in Online Learning: A Meta-analysis and Review of Online Learning Studies. US Department of Education; 2009. Available from: https://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf.
29. Nas J, Thannhauser J, Konijnenberg LSF, van Geuns R-JM, van Royen N, Bonnes JL, *et al*. Long-term effect of face-to-face vs virtual reality cardiopulmonary resuscitation (CPR) training on willingness to perform CPR, retention of knowledge, and dissemination of CPR awareness: A secondary analysis of a randomized clinical trial. JAMA Network Open 2022;5:e2212964-e.
30. Nicolaidou I, Antoniades A, Constantinou R, Marangos C, Kyriacou E, Bamidis P, *et al*. A virtual emergency telemedicine serious game in medical training: A quantitative, professional feedback-informed evaluation study. J Med Internet Res 2015;17:e150.
31. Cheng A, Duff JP, Kessler D, Tofil NM, Davidson J, Lin Y, *et al*. Optimizing CPR performance with CPR coaching for pediatric cardiac arrest: A randomized simulation-based clinical trial. Resuscitation 2018;132:33-40.
32. Faul F, Erdfelder E, Buchner A, Lang A-G. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. Behav Res Methods 2009;41:1149-60.
33. Dick W, Carey L. Instructor's Manual for the Systematic Design of Instruction: Scott, Foresman and Company; 1978.
34. Akhu-Zaheya LM, Gharaibeh MK, Alostaz ZM. Effectiveness

of Simulation on knowledge acquisition, knowledge retention, and self-efficacy of nursing students in Jordan. Clin Simul Nurs 2013;9:e335-42.

35. Bazrafkan L, Kojuri J, yarmahmodi f, zahadatpour z, Razavinejad SM, Bahrami R, *et al*. Evaluation of the effectiveness of training by simulation and reporting in small groups on the performance of the neonatal resuscitation team. Educ Dev Judishapur 2022;13:160-8.
36. Hamilton R. Nurses' knowledge and skill retention following cardiopulmonary resuscitation training: A review of the literature. J Adv Nurs 2005;51:288-97.
37. Akbari Farmad S, Khoshnoodi far M, Rezaee M, Farajpour A. The effect of simulation-based cardiopulmonary resuscitation training on knowledge and clinical skills of nurses in Baharloo Hospital. Educ Dev Judishapur 2021;12:511-20. (Persian).
38. Takhdat K, Eddabbah M, El Hamzaoui H, Lamtali S, El Adib AR. High-fidelity simulation effects on cardiopulmonary resuscitation self-efficacy and knowledge retention in undergraduate nursing students: A two-group, experimental, longitudinal pilot study. Nurs Educ Perspect 2022;43:E118-20.
39. Heidarzadeh A, Kazemi M, Forouzi M, jahani Y. Comparing the effect of two methods of cardiopulmonary resuscitation education including computer-based stimulation and mannequin stimulation on nursing students knowledge and satisfaction. Journal of Medical Education Development 2015;8:12-20. (Persian).
40. Onan A, Simsek N, Elcin M, Turan S, Erbil B, Deniz KZ. A review of simulation-enhanced, team-based cardiopulmonary resuscitation training for undergraduate students. Nurse Educ Pract 2017;27:134-43.
41. Dyrstad DN, Bodsberg KG, Søiland M, Bergesen ÅU, Urstad KH. Value of simulating holistic nursing care: A quantitative study. Clin Simul Nurs 2021;54:113-20.
42. Farzaneh R, Baharfar A, Rahimaghaee F, Ahmadnezhad S. Virtual cardiopulmonary resuscitation training during the COVID-19 Crisis?! Updates Emerg Med 2022;2.
43. Nas J, Thannhauser J, Vart P, van Geuns RJ, Muijsers HEC, Mol JQ, *et al*. Effect of face-to-face vs virtual reality training on cardiopulmonary resuscitation quality: A randomized clinical trial. JAMA Cardiol 2020;5:328-35.
44. Kuyt K, Park S-H, Chang TP, Jung T, MacKinnon R. The use of virtual reality and augmented reality to enhance cardio-pulmonary resuscitation: A scoping review. Adv Simul (Lond) 2021;6:11.
45. Alcázar Artero PM, Pardo Rios M, Greif R, Ocampo Cervantes AB, Gijón-Nogueron G, Barcala-Furelos R, *et al*. Efficiency of virtual reality for cardiopulmonary resuscitation training of adult laypersons: A systematic review. Medicine (Baltimore) 2023;102:e32736.
46. Buttussi F, Chittaro L, Valent F. A virtual reality methodology for cardiopulmonary resuscitation training with and without a physical mannequin. J Biomed Inform 2020;111:103590.
47. Farmad S, Yosefian F. Evaluation of the effectiveness of virtual CPR training in midwives of Shahid Hasheminezhad Hospital in Mashhad. mededj 2022;10:7-16. (Persian).
48. Jalili E, Niazi S, khanlarzade E, Salimi R. Comparison of two methods of face-to-face training and virtual training in learning advanced cardiopulmonary resuscitation concepts among emergency department interns. Res Med Educ 2022;14:58-65. (Persian).