Original Article

The Effect of High and Medium Fidelity Simulator in Cardiopulmonary Resuscitation Training on Nursing Students' Knowledge and Performances

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Abstract

The study was planned as a quasi-experimental study to compare the effect of training with high-fidelity and medium-fidelity simulator cardiopulmonary resuscitation manikins on nursing students' knowledge and performances. The participating students included two groups that trained with a medium-fidelity cardiopulmonary resuscitation manikin. Experimental group 1 (n=44) performed scenario-based cardiopulmonary resuscitation with a high-fidelity simulator. Experimental group 2 (n=46) performed the practice with a medium-fidelity cardiopulmonary resuscitation manikin. After one and 6 months, the performance of all the students was assessed. It was determined that the changes in the knowledge and performance scores in both groups were similar, though an intra-groups comparison demonstrated significant increases in scores. After one and 6 months, the performance assessment scores in both groups were similar and were significantly higher than other performance scores ($p<0.001$). The outcomes from this exploration highlight the efficiency of simulation-based education as well as the permanence of cardiopulmonary resuscitation performances.

Keywords: Simulation, high fidelity simulator, medium fidelity simulator, cardiopulmonary resuscitation, nursing education

Introduction

Simulation plays a significant role in nursing education, especially in knowledge and performance acquisition and the process of fostering competent nurses (Ahmad&Safadi 2009; Luctkar-Flude, Wilson-Keates&Larocque 2012; Tivener&Gloe 2015). High Fidelity Simulators (HFS) and Medium Fidelity Simulators (MFS) help nursing undergraduates practice, cultivate, and utilize the knowledge acquired in simulations within a safe and representative clinical setting as they contribute in interactive educational scenarios devoid of risk to patients (Cheng et al. 2015; Tuzer, Dinc &Elcin 2016; McCoy et al. 2019).HFS and MFS are applied as an efficient learning method for the acquisition of cardiopulmonary resuscitation (CPR). (Wehbe-Janek et al. 2012).

Cardiac arrest is an important phenomenon that increases mortality and morbidity rates. (Rubeen et al. 2013; GabrielIO&Aluko2019). In the 2013 data reported by the American Heart Association (AHA), the incidence of in-hospital sudden cardiac arrest is estimated to be 209,000 cases (Meaney et al. 2013). Survival rates during discharge following in-hospital cardiac arrest are only 22.3–28.1%(Girotra et al. 2012) A well-trained and highly efficient medical team ensures that the results of cardiac arrest are optimal by working in harmony. As nurses frequently respond to cardiac arrest situations, CPR remains a vital performance and, as such, is a mandatory requirement for nursing students. (Kardong-Edgren 2010)However, studies have shown that CPR training is generally inadequate (Paul 2010; Dine et al. 2008). In a study CPR performance quality was found to be incomplete and inconsistent (Paul 2010). Similar studies demonstrated that CPR performances are lacking in a number of nursing students(Makinen et al. 2010; Oermann, Kardong-Edgren & Odom-Maryon 2011). The lack of CPR knowledge and performances is a critical issue because students have inadequate practice to attain the required abilities when pursuing their undergraduate education (McCoy et al. 2019). These demands can be met through simulations that create learning opportunities otherwise inaccessible in clinical practice, such as CPR (Mundell et al. 2013) An effective training and regular performance reassessment should be made mandatory for nurses (Dine et al. 2008).

A study conducted by Madden et al. (Madden 2006) revealed that performances attained for CPR among nursing students decline some weeks following the initial lecture irrespective of the type of CPR training received. However, it is known that simulation training provides the opportunity to make the learned theoretical knowledge more permanent (Tivener & Gloe 2015). Aqel et al. (Aqel & Ahmad 2014) further argues that inadequate research has been done with HFS in CPR upon long-term knowledge and performance achievements. Thus, additional investigations should be undertaken to explore the outcome of HFS as an alternative or supplementary teaching technique to improve the maintenance of CPR performances and knowledge. This is the first study to show the short- and long-term influence of HFS and MFS on knowledge and performances of nursing students in Turkey. The main objective of this research was to examine the short- and long-term consequences of HFS and MFS on performances and knowledge of nursing students.

Materials and Methods

Study Design : This quasi-experimental study investigated the effects of HFS and MFS CPR manikins on the performance and knowledge of nursing undergraduates.

Study sample: Participants were third-year nursing students from a public university who completed the “First Aid and Emergency Care” course in the 2017–2018 academic year. Ninety of 121 total students who consented to participating in the research were recruited for the sample. The participating students were classified into two groups using a computer-generated list with random sampling. To prevent observer bias, performance assessments were performed by three other expert researchers. As a result of assessments made by these three researchers regarding CPR practice, a perfect consistency in scores was found (ICC=0.923, %95 GA:0.893-0.946, $p<0.001$).

Data collection instruments: The “Test for Pre- and Post-Measurement of CPR Knowledge Level”, “CPR Performance Assessment Form”, and “Medium Fidelity CPR Manikin Performance Log Reports” were used for data collection.

Test for Pre- and Post-Measurement of CPR Knowledge Level: A test was designed in line with the literature for measuring the CPR knowledge level of students that included 20 multiple-choice questions (Madden 2006; Dine et al. 2008; Rodgers, SecurroJr&Pauley 2009; Aqel&Ahmad 2014).

CPR Performance Assessment Form: The CPR Performance Assessment Form was designed in line with the literature to observe, record, and score the students’ steps in performing CPR properly and in precise order. (Madden 2006; Kardong-Edgren&Adamson 2009; Aqel&Ahmad 2014). This form consisted of 13 items and includes options of “Not observed”, “Mistaken/Incomplete” and “Correct/Complete”, with each option scored as 0, 1, and 2, respectively.

Medium Fidelity CPR Manikin Performance Log Reports: Students' performance log reports on Medium Fidelity CPR manikins were gathered immediately after practicing on the manikin. Compression rate and depth, hand position, and level of release were evaluated.

Implementation of the Research : This study was performed in seven stages.

Pre-test Assessment: A pretest was performed to measure students' level of knowledge on CPR prior to the training.

Theoretical Education: The students were trained on CPR using a PowerPoint presentation and demonstration techniques for four hours on a MFS.

First Performance Assessment: Students were asked to perform CPR on a Medium Fidelity CPR manikin and these performances were assessed by three expert researchers using the CPR Performance Assessment Form to generate CPR Performance 1 (CPR P1) scores. With the log reports of Medium Fidelity CPR manikins (compression rate and depth, hand position, and level of release), Medium Fidelity CPR Performance 1 (MFCPR P1) output was obtained.

Second Performance Assessment: One week later, experimental group 1 (n = 44) performed HFS CPR under the supervision of the researcher using scenario-based training. These were shown as CPR Performance 2 (CPR P2) scores. Following the performances, debriefing sessions were held for the students in groups of five students. Experimental group 2 (n = 46) continued to repeat the practice with the Medium Fidelity CPR manikin. During practices, the researcher assessed students' performances with the "CPR Performance Assessment Form". These were shown as CPR Performance 2 (CPR P2) scores.

Third Performance Assessment: All students practiced on Medium Fidelity CPR manikins and Medium Fidelity CPR Performance 3 (MFCPR P3) output was obtained. The researcher assessed students' performances with the CPR Performance Assessment Form and CPR Performance 3 (CPR P3) scores were obtained.

Post-test Assessment: A post-test was performed to measure students' CPR knowledge levels at the end of the training.

Fourth Performance Assessment: After six months, all students once again performed on Medium Fidelity CPR manikins and Medium Fidelity CPR Performance 4 (MFCPR P4) output was obtained. The researcher assessed students' performance with the CPR Performance Assessment Form and these were shown as CPR Performance 4 (CPR P4) scores.

Data Analysis: Distributions of the knowledge scores and CPR/MFCPR performance scores were examined by the Shapiro–Wilk test. Knowledge scores and CPR performance scores were summarized as mean ± SD, while the median (min–max) was given for MFCPR scores. The agreement between CPR performance scores rated by three observers was investigated using single measurement ICC with two-way mixed ANOVA design. Repeatedly measured knowledge scores and CPR performance scores of two groups were compared by two-way mixed ANOVA to determine the group × time interaction effect. Repeatedly measured MFCPR performance score of two groups was compared by F1-LD-F1 design, nonparametric analogues of two-way mixed ANOVA, since the assumptions were not met; *p* value of ANOVA-type test statistics for interaction effects were given. As interaction effect was not significant, intergroup and intragroup comparisons were made by Mann–Whitney U test and Friedman test, respectively; $p < 0.05$ was considered statistically significant. F1-LD-F1 design was performed by "nparLD" package in R. All other statistical analyses were performed via IBM SPSS Statistics 21.0.

Ethical considerations: This study protocol was approved from the Ankara Yildirim Beyazit University Ethics Committee of the university (Decision No: 264). Written permission was also obtained from nursing school. All students written informed consent before participating in the study.

Results

In groups where HFS and MFS were used, changes in performance scores were similar ($F = 0.448$, $p = 0.719$) (e.g. Table 1). Average scores of CPR P3 and CPR P4 in both groups were similar and were significantly higher than others ($p < 0.001$, e.g. Table 1). Additionally, CPR performance scores increased significantly with time. The changes in performance scores were similar between groups (F = 0.448, *p* = 0.719) (e.g. Table 2). In groups where HFS and MFS were used, changes in knowledge scores were similar (F = 1.650, *p* = 0.202; e.g. Table 2, Figure 1). When intragroup knowledge score differences were examined, it was noted that both groups demonstrated significant increases in scores (*p*< 0.001). In the Medium Fidelity CPR manikin group, median correct compression rate score was 1% for MFCPR P1 (min–max: 0–27%), 18% for MFCPR P3 (min–max: 0–88%), and 12.5% for MFCPR P4 (min–max: 0–77%). According to log reports of the Medium Fidelity CPR manikin, correct compression rate and wrong hand position rate were found to change significantly over time in both groups (*p*< 0.05; e.g. Table 3). In the Medium Fidelity CPR model and in the HFS group, the correct compression rate of MFCPR P1 was found to be significantly lower than the other two performance times (*p*< 0.05). In the Medium Fidelity CPR model, the wrong hand position rate of MFCPR P1 was determined to be higher than the other two performance times. In the HFS group, the wrong hand position rate of MFCPR P1 was higher than the MFCPR P3 time (*p*< 0.05; e.g. Table 3)

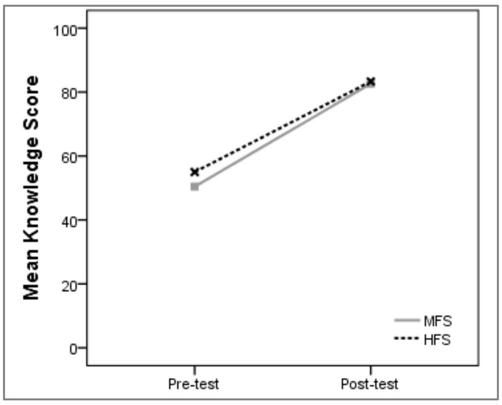

Figure 1. Group based change in knowledge score

Table 1. Distribution of CPR performance scores

Performance Score	**MFS(n=46)** Mean±SD	**HFS (n=44)** Mean±SD	p-value
CPR P1	52.59±12.54[a]	53.06±11.30[d]	0.853
CPR P2	73.91±12.56[b]	74.13±12.26[e]	0.935
CPR P3	85.28±9.47[c]	84.88±11.68[f]	0.856
CPR P4	83.44±10.16[c]	86.45±8.36[f]	0.130
p-value	**<0.001**	**<0.001**	

[a,b,c,d,e,f]Same letters reflect similar means for intragroup comparisons.
Two-way mixed ANOVA

Table 2. Two-way Mixed ANOVA results for CPR performance and knowledge scores

Measurement	**Source of effect**	**F-statistics**	**p-value**
CPR performance score	Group	0.387	0.536
	Time	182.847	**<0.001**
	Group*Time	0.448	0.719
Knowledge core	Group	2.267	0.136
	Time	355.142	**<0.001**
	Group*Time	1.650	0.202

Table 3. Medium Fidelity CPR Manikin Performance Log Reports

Medium Fidelity CPR manikin performance log reports	**MFS (n=46)** Median(min-max)	**HFS (n=44)** Median(min-max)	**p-value**
Number Correct (Compression rate)			0.430[1]
MFCPR P1	1 (0-27)[a]	0 (0-24)[c]	0.674[3]
MFCPR P3	18 (0-88)[b]	14.5 (0-96)[d]	0.958
MFCPR P4	12.5 (0-77)[b]	21.5 (0-82)[d]	0.221
p-value[2]	**<0.001**	**<0.001**	
Too Shallow			0.456
MFCPR P1	54.5 (3-100)	63 (0-100)	0.599
MFCPR P3	37 (0-100)	49 (0-100)	0.490
MFCPR P4	55.5 (1-100)	50 (1-100)	0.339
p-value	0.161	0.235	
Wrong Hand Position			0.578
MFCPR P1	60.5 (0-100)[a]	58 (0-100)[c]	0.396
MFCPR P3	44.5 (5-100)[b]	43 (0-100)[d]	0.372
MFCPR P4	44 (5-98)[b]	48.5 (0-98)	0.503
p-value	**<0.001**	**0.015**	
Hand position Too Low			0.883
MFCPR P1	31.5 (0-100)	26 (0-100)	0.730
MFCPR P3	24.5 (0-100)	20 (0-100)	0.298
MFCPR P4	31.5 (0-98)	24.5 (0-98)	0.284
p-value	**0.039***	0.468	
Incomplete release			0.459
MFCPR P1	0.5 (0-90)	1 (0-61)	0.952
MFCPR P3	1 (0-31)	1 (0-74)	0.593
MFCPR P4	1 (0-51)	1 (0-43)	0.248
p-value	0.880	0.279	

[a,b,c,d] Same letters reflect similar means for intragroup comparisons.
*Pairwise comparisons reveal no significance difference between performance score
[1]p value of group*time interaction obtained from F1-LD-F1 design.
[2]Friedman test result. [3]Mann-Whitney U test result

Discussion

Professional development in nursing education programs remains critical for the acquisition of knowledge and proper performances of CPR. (Paul 2010). The competency level of nurses is a serious factor influencing positive patient results in CPR. Through HFS and MFS training, students can accurately practice and acquire CPR psychomotor performances.

The results of our study revealed that both HFS and MFS groups increased their level CPR knowledge after training. Although CPR knowledge was significantly increased in both groups, there was no significant variance between the groups. These findings are comparable to other research results from available studies (Kardong-Edgren & Adamson 2009; Rodgers, SecurroJr&Pauley 2009; Tuzer, Dinc &Elcin 2016). In the study by Rodgers et al. CPR knowledge level in the group in which HFS was used increased significantly relative to the group in which a Low Fidelity Simulator (LFS) was used (Rodgers, SecurroJr&Pauley 2009). In a study by King et al. it was stated that there was no significant change between the groups in which HFS and LFS were used in terms of CPR knowledge level but, after simulation training, knowledge level in these groups increased considerably (King and Reising 2011).

The study undertaken by Kardong-Edgren et al. reported no variation in HFS and LFS in terms of short- and long-term knowledge acquisition; both HFS and LFS resulted in knowledge level increases (Kardong-Edgren & Adamson 2009). The outcomes of this study highlight the effectiveness of both HFS and MFS on learners' attainment of knowledge. However, there is no difference between these two different methods; neither of the two methods for teaching CPR training display superiority over one another. The simulator can be differentiated according to the complexity or content of the subject. According to our research results, MFS may be sufficient for this skill.

Rodgers et al. reported similar results in terms of CPR psychomotor performances of groups that used HFS and LFS. The findings from this research corroborated with those of Rodgers et al. who highlight the efficacy of both HFS and LFS on attainmentof performances and knowledge by students. In this study, it was noted that students' CPR performances increased immediately following the training and were maintained six months later (Rodgers, SecurroJr&Pauley 2009). Similarly, Wik et al. indicated that CPR performances did not change between the end of the training and asix-month follow-up assessment (Wik et al. 2005). A study by Aqel and Ahmad found that most students in the intervention group (85%) maintained CPR performances three months following the training (Aqel & Ahmad 2014).

In a study by Roh et al. it was found that within CPR psychomotor performances, compression depth and hand placement increased considerably after simulation-based training but compression rate did not change. In this study, it was found that compression rate increased after the training in the MFS CPR manikin group and HFS group but shallow rate, wrong hand position, and incomplete release did not change significantly (Roh, Lim &Issenbergb 2016).Oerman et al. reported that participants were trained on compression depth on a simulation manikin for six minutes yet compression depth did not change (Oermann, Kardong-Edgren&Odom-Maryon 2011)

Conclusion

The outcomes of this study highlighted the effectiveness of both HFS and MFS on the attainment of performances and the level of knowledge among nursing undergraduates. Simulation-based education also resulted in the retention of students' CPRperformances. Both methods are valuable for students' CPR training but, according to the results of the study, it is sufficient to use MFS alone; however, depending on the complexity of the scenarios, HFS may be preferred. Further studies should be designed in other universities utilizing larger sample sizes and a control group. Additional studies that scrutinize the effectiveness of MFS and HFS with other nursing programs to measure knowledge results may also be useful. Furthermore, it is recommended that continuous monitoring at 6- and 12-month intervals after training should be undertaken.

Study Limitations

There were certain limitations in the study; the study was conducted in a single center, lacked a control group, and evaluated a limited number of students. Another limitation was that, in the second performance evaluation, there lacked similar log reports from HFS and MFS between experimental groups 1 and 2.

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