High-Fidelity Simulation Effects on CPR Knowledge, Skills, Acquisition, and Retention in Nursing Students

Ahmad A. Aqel, RN, PhD • Muayyad M. Ahmad, RN, PhD

ABSTRACT

Background: There is a gap in the literature regarding learning outcomes linked to the use of high-fidelity simulators compared to that of traditional teaching methods.

Aim: To examine the effect of using high-fidelity simulators on knowledge and skills acquisition and retention with university students.

Methods: A randomized two-arm trial using two different educational approaches on 90 nursing students assigned randomly to two groups was used at two points of time.

Findings: The results showed significant differences in favor of the participants in the high-fidelity simulator group on both the acquisition and retention of knowledge and skills over time. However, a significant loss of cardiopulmonary resuscitation knowledge and skills occurred at 3 months after training in both groups.

Conclusions: The findings of this study may assist educators in integrating high-fidelity simulators in education and training. In addition, the findings may help nursing educators to arrange additional cardiopulmonary resuscitation training sessions in order to improve cardiac arrested patients’ outcomes.

Linking Evidence to Action: High-fidelity simulation (HFS) provides students with interactive learning experiences in a safe controlled environment. HFS enables teachers to implement critical clinical scenarios, such as cardiac arrest, without risk to patients. Integrating the simulation training into nursing curricula will help to overcome the challenges that face many courses, specifically the shortage of clinical areas for training and the increase in numbers of nursing students.

BACKGROUND

High-fidelity simulation (HFS) provides students with interactive learning experiences in a safe, controlled environment where they can practice with no harm to patients (Decker, Sportsman, Puetz, & Billings, 2008). HFS is a new trend in education that has been introduced by the nursing community (Nehring & Lashley, 2010; Sarac & Ok, 2010). Although many health educators continue to rely on the traditional classroom lecture as the primary method for presenting clinical knowledge, experimental learning through simulation can enhance students’ knowledge and skills (Brannan, White, & Bezanson, 2008). Traditional teaching using a lecture format means that students rely on memory rather than a deep understanding of the content (Jefferies, 2007). Although there are some advantages of traditional lecturing to novice students, such as clarifying unfamiliar concepts, using a lecture format in conjunction with experimental active learning helps students with the acquisition and retention of knowledge (Kaddoura, 2011).

HFS consists of an interactive manikin driven by computers, and has many features that replicate physiological parameters, such as the ability to produce pulse, breathing, and blinking (Lasater, 2007). In addition, HFS enables educators to implement clinical scenarios that give students the opportunity to practice critical situations, such as cardiac arrest without risk to patients (Alinier, Hunt, Gordon, & Harwood, 2006). Furthermore, HFS enhances experimental learning, giving students the opportunity to practice skills in a safe environment, demonstrate clinical decision-making, observe other students, and learn from feedback during debriefing sessions (Brannan et al., 2008). However, there is a gap in literature related to the effectiveness of using HFS as a supportive approach to a traditional lecture-teaching method (Nehring & Lashley, 2010).

Simulation has become an important element in nursing education, specifically in teaching the necessary skills and knowledge to prepare competent nurses (Ahmad & Safadi, 2009; LucTkar-Flude, Wilson-Keates, & Larocque, 2012). Instructors can control the manikin’s responses and the HFS can respond to interventions provided by the student (Lasater, 2007). Furthermore, HFS allows nursing students to practice,
develop, and apply knowledge and skills in a realistic clinical situation and safe environment as they participate in interactive learning experiences without risk to patients (Alasad & Ahmad, 2005; Gates, Parr, & Hunghen, 2012). Simulation is used to support teaching, promote critical thinking among students, and enhance the quality of patients’ care (McFetrich & Price, 2006). The high-fidelity simulator METI-emergency care manikin was used in this study (METI, 2011). It is a full-size manikin; has the ability to check airway, breathing, circulation, chest compression, and defibrillation; respond to pharmacological intervention; and is designed with multiple scenarios for clinical situations with the ability to build more scenarios within it.

Many nursing colleges have used different teaching methods to improve the retention of students’ cardiopulmonary resuscitation (CPR) knowledge and skills (Yuan, Wiverly, Fang, & Ye, 2012). Nursing students have positively valued simulation-based learning as effective as learning in real settings in terms of increasing confidence in the ability to perform CPR (Leighton & Scholl, 2009; Tawalbeh & Ahmad, 2013b). Furthermore, adding simulation as a clinical teaching method proved to be a valuable experience for learning psychomotor skills and developing critical thinking over time (Brannan et al., 2008).

Other researchers investigated the retention of CPR knowledge and skills after virtual simulation training over 18 months and 6 months apart (Luctkar-Flude et al., 2012). The intervention group attended 2-hr virtual simulation training sessions 6 months apart, while the control group only had a traditional CPR training. The researchers found no significant difference in knowledge between the groups, and a drop in knowledge and skills over time for both groups. However, the small sample size in this study increases the risk of type II error. Thus, more research is needed to investigate the outcome of HFS as an alternative method of teaching that enhances retention of CPR knowledge and skills. The purpose of this study was to examine the acquisition and retention of CPR knowledge and skills by using two methods of teaching: (a) traditional didactic CPR lecture accompanied with low-fidelity simulation (LFS), and (b) didactic CPR lecture accompanied by HFS training.

**RESEARCH HYPOTHESES**

This study has three research hypotheses:

1. There is no difference in CPR knowledge between the control and the intervention groups before initiation of CPR training.

2. The intervention group that received HFS CPR training will demonstrate a higher level of CPR knowledge and skills acquisition than the control group that received LFS CPR training.

3. The intervention group will have a higher level of knowledge and skills retention at 3 months after training in comparison to the control group.

**METHODS**

**Study Design**

An experimental, pretest-posttest design was conducted to examine the effectiveness of HFS training versus LFS CPR training on the acquisition and retention of CPR knowledge and skills among second-year nursing students. Participants were randomly assigned into two equivalent groups. The control group participated in a 4-hr session of traditional training, which consisted of a PowerPoint presentation of AHA adult basic life support (BLS), including automated external defibrillator (AED), and demonstrations on a LFS CPR manikin. The intervention group received the same PowerPoint lecture in addition to training on a HFS.

**Sample and Setting**

The inclusion criteria were that participants: (a) were nursing students enrolled in the first adult health nursing course, (b) agreed to participate in the study, and (c) had no previous experience with CPR. Students who had previous experience with CPR, who held a BLS certificate, or who were bridging from an associate’s degree to a baccalaureate degree were excluded from participating in this study. This study was conducted in the nursing laboratory at the University of Jordan. The nursing laboratory is well-equipped with simulators.

Sample size was calculated using $G^* \text{power 3.0 software}$ (Faul, Erdfelder, Lang, & Buchner, 2007). In this study, comparisons between groups with $t$ tests (one tail) for independent samples, medium effect size ($d = .50$), a sample of 51 participants in each group was needed to provide 80% power to detect difference at 0.05 significance level (Polit, 2010). The final number of participants who completed the phases of the study was 90.

**Ethical Considerations**

The study method and protocol were reviewed by the ethical committee in the Faculty of Nursing at the University of Jordan. Target students willing to participate in this study received both oral and written information about the purpose, content, and duration of the study. A code number was provided to each participant, which protected the confidentiality of the participants. The participants were assured that withdrawal from the study at any time carried no penalty. Students were asked to sign the informed consent if they agreed to participate in the study. Permission to use the skill and knowledge checklists was obtained from the AHA.
Instrumentation
The instrument used in this study had two sections. The first section was the demographic data sheet used to identify any potential group variances. The demographic data sheet consisted of a checklist and gap-fill questions on variables, such as age, gender, grade point average (GPA), CPR experience, and whether bridging to baccalaureate. The second section was 14 multiple choice questions on CPR knowledge (American Heart Association [AHA], 2012). This test was used to evaluate the participants’ CPR knowledge at the baseline and acquisition phase. Questions related to infants and children as well as those related to stroke and foreign body airway obstructions were removed as this study was focused on adult CPR only. The most important aspects of CPR knowledge questions related to knowledge of the correct sequence of CPR, rate and depth of compression, rescue breathing, ratio of compression to ventilation, performance of compression and breath, and use of AED.

To measure CPR skills, mock codes were conducted; the students were asked to respond to a full-body CPR manikin lying on the floor. Their responses were recorded on the AHA final evaluation skill sheet for adult CPR, which the AHA has made publicly available (AHA, 2012). The adult CPR skills checklist was designed by AHA to evaluate CPR skills on adult victims. Permission to use the tools was obtained from AHA. The CPR skills checklist is composed of 14 items covering the assessment of the victim, correct delivery of compression and ventilation, in addition to operating the AED.

Data Collection
At the baseline phase, all the participants in the two groups filled the demographic data and a pretest for CPR knowledge. The participants in the control group then attended a lecture on CPR. The acquisition phase consisted of a demonstration on a LFS with static manikin (traditional teaching method), and training on a HFS manikin for the intervention group. A posttest was immediately conducted to evaluate CPR knowledge and CPR skills within a cardiac arrest scenario. Both groups were evaluated on a static manikin.

Procedure
All participants completed a pretest for CPR knowledge examination, then all participants received the CPR lecture. Next, the CPR knowledge test was completed for all participants. Participants were then randomly assigned to either the control group or intervention group. Participants in each group were divided randomly into 15 small groups, each composed of three students. Each student represented the main three CPR roles: chest compression, rescue breathing by using the Ambu-bag, and defibrillation by using AED. Each small group participated in a cardiac arrest scenario, which began with a full report on a simulated patient condition. After 60 s, simulated patients went into cardiac arrest. The researcher observed the actions of students as a team, and how they performed and followed the sequence of CPR skills. After 15 min, the researcher ended the scenario and started an oral debriefing session, which took about 10 min. The debriefing session provided the students the opportunity to review their response to the cardiac arrest scenario and to learn from mistakes. After training on CPR with HFS for intervention group and LFS for the control group, the posttest to assess knowledge and skills was performed.

The researcher who holds an AHA instructor certificate was the only trainer in this study. Furthermore, a panel of experts, who hold AHA instructor certificates, validated the CPR scenario. For confidentiality purposes, the CPR knowledge test was under control of the AHA instructors at the AHA training center at King Hussein Cancer Center in Amman.

Knowledge and skills retention tests were conducted 3 months after training for the control and intervention groups. The participants received one mark for each correct response on the CPR skills and knowledge checklists. Contamination of the study results may have occurred if the participants in both groups were exposed to a CPR experience from any source during the 3 months from pre- to postassessment.

Data Analysis
Data coding and analyses were carried out using the Statistical Package for Social Sciences for Windows (IBM Corporation, 2012). The researchers used descriptive statistics (mean, median, standard deviation, percentage, and frequency) to analyze the demographic data of the study sample. Independent sample t-tests were used to compare the mean differences in acquisition and retention of CPR knowledge and skills between the intervention and control groups at two time points. Paired t-test was conducted to find significant differences the study groups.

RESULTS
Sample Characteristics
The 124 nursing students enrolled in the first adult health nursing course completed the demographic data sheet. Only 90 students completed all phases of the study. Based on the inclusion and exclusion criteria, 30 students were excluded. In addition, four students did not sign the informed consent to participate.

The majority of the participants were female (N = 71, 78.9%). The participants’ ages ranged between 18 and 28 years (M = 19.87, SD = 1.78). Approximately 60% of the participants reported their GPA as being better than “good.” All participants indicated that they had neither previous CPR experience nor HFS training. The mean GP for the participants in the control group was higher than the intervention group (M = 3.09, 2.82, respectively); both groups were almost equal in terms of gender and age (see Table 1).
Analyses of the Research Hypotheses

Research hypothesis 1. An independent sample t test was used to examine if there was a difference in CPR knowledge between the two groups before commencing CPR training. The result revealed that there was no significant difference ($p = .53$) in the baseline CPR knowledge between the intervention group ($M = 5.78, SD = 1.18$) and the control group ($M = 5.93, SD = 1.15$).

Research hypothesis 2. First, the researchers examined if each group had a significant CPR knowledge and or skills acquisition after training. A paired t test revealed that both groups gained CPR knowledge from their respective teaching and training methods. The posttest scores of CPR knowledge for the participants in the control group ranged between 9 and 13 out of the 14 possible points; while in the intervention group, the scores ranged between 10 and 14. The posttest scores of CPR skills for the participants in the control group ranged between 8 and 14 out of 14, while scores of those in the intervention group ranged between 10 and 14 (see Table 2).

To examine if the gained knowledge and skills differed significantly between groups, an independent sample t test was used. The results revealed the existence of a significant difference in the posttest CPR knowledge as well as the CPR skills in favor of participants in the intervention group (see Table 3).

Research hypothesis 3. The knowledge retention scores for the participants in the control group ranged from 7 to 14. A dependent sample $t$ test revealed a significant difference ($t = 8.05; p \leq .001$) between the intervention group ($M = 12.27; SD = 1.13$) and the control group ($M = 10.07; SD = 1.43$) in the retention of CPR knowledge after 3 months of training.

A paired $t$ test was conducted to examine the difference in CPR knowledge and CPR skills within each group in the retention level. The results revealed that both groups suffered a loss of CPR knowledge at 3 months after training ($p < .001$; see Table 4).

The analysis of the differences in the retention of CPR skills showed that the scores for the participants in the control group ranged from 7 to 13 out of 14, while the participants’ scores in the intervention group ranged from 8 to 14. An independent sample $t$ test revealed a significant difference in CPR retention skills between the groups ($p \leq .001$; see Table 5).

DISCUSSION

Although many researchers support the theory that HFS enhances critical thinking of the participants (Wotton, Davis, Button, & Kelton, 2010), knowledge acquisition through HFS has not been well integrated in teaching programs (Jefferies, 2007; Levett-Jones, Lapkin, Hoffman, Arthur, & Roche, 2011). The findings of this study support the effectiveness of using HFS over the traditional static manikin as LFS CPR knowledge acquisition. In this study, knowledge and skills acquisition were evaluated immediately after training. It could be argued that further research is required to ascertain the appropriate time for posttraining evaluation.

The baseline phase of this study aimed to evaluate the participants’ CPR knowledge before initiation of CPR training for control and intervention groups. The results showed no significant differences between the two groups. This finding supports the homogeneity in the knowledge variance at the baseline level. Furthermore, this study showed that the participants in both groups had a low level of CPR knowledge at baseline.

The results of this study showed a significant difference in CPR knowledge and skills at the acquisition phase between the

Table 2. Paired t Test on the Level of CPR Knowledge Acquisition within Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pretest CPR</th>
<th>Posttest CPR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
</tr>
<tr>
<td>Control group</td>
<td>5.93 (1.15)</td>
<td>11.22 (0.90)</td>
</tr>
<tr>
<td>Intervention group</td>
<td>5.78 (1.18)</td>
<td>12.67 (1.06)</td>
</tr>
</tbody>
</table>

*p ≤ .001
Table 3. Independent Sample t Test on Level of CPR Knowledge and Skills Acquisition between Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control group</th>
<th>Intervention group</th>
<th>t statistics</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge acquisition</td>
<td>11.22 (0.90)</td>
<td>12.67 (1.07)</td>
<td>−6.94∗</td>
<td>−1.47</td>
</tr>
<tr>
<td>Skill acquisition</td>
<td>11.58 (1.63)</td>
<td>13.13 (1.01)</td>
<td>−5.44∗</td>
<td>−1.14</td>
</tr>
</tbody>
</table>

*p ≤ .001

Table 4. Paired t Tests for CPR Knowledge and Skills Retention within Groups over Time

<table>
<thead>
<tr>
<th>Variable</th>
<th>Time</th>
<th>Control group</th>
<th>t statistics</th>
<th>Intervention group</th>
<th>t statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M (SD)</td>
<td></td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>Direct after training</td>
<td>11.22 (0.90)</td>
<td>8.14∗</td>
<td>12.67 (1.06)</td>
<td>4.97∗</td>
</tr>
<tr>
<td></td>
<td>Three months later</td>
<td>10.07 (1.44)</td>
<td></td>
<td>12.27 (1.14)</td>
<td></td>
</tr>
<tr>
<td>Skills</td>
<td>Direct after training</td>
<td>11.58 (1.63)</td>
<td>10.50∗</td>
<td>13.13 (1.01)</td>
<td>3.71∗</td>
</tr>
<tr>
<td></td>
<td>Three months later</td>
<td>10.31 (1.88)</td>
<td></td>
<td>12.80 (1.44)</td>
<td></td>
</tr>
</tbody>
</table>

*p ≤ .001

Table 5. Independent Sample t Test on the Level of CPR Skills Retention between Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Intervention</th>
<th>t statistics</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retention of CPR skills</td>
<td>10.31 (1.88)</td>
<td>12.80 (1.44)</td>
<td>−7.05∗</td>
<td>−1.49</td>
</tr>
</tbody>
</table>

*p ≤ .001

two groups as an effect of the different teaching methods. After teaching and training, CPR knowledge and skills were significantly increased in both groups; however, the participants in the HFS group gained greater knowledge and skills than those of the LFS group. These results are consistent with the findings of previous studies (Nehring & Lashley, 2010; Gates et al., 2012; González et al., 2013).

Findings from this study emphasize the effectiveness of HFS on students’ acquisition of knowledge and skills. These benefits enhance learning outcomes for nursing students. Furthermore, educators should determine the best practice of integrating HFS into nursing curriculum. They should use simulation scenarios that are suitable for students’ levels. To gain the maximum possible benefit from HFS, different scenarios should be used according to the level of the students using the simulation.

Significant differences were found between the intervention and control groups in CPR knowledge and skills retention. It is noteworthy that CPR knowledge and skills were significantly decreased in both groups after 3 months of training. However, the participants in the intervention group showed more retention of knowledge and skills than participants in the LFS group. This result is consistent with the findings of previous studies that examined CPR knowledge and skills retention (Ackermann, 2009; Tawalbeh & Ahmad, 2013a). Smith and colleagues found that nurses who received CPR training on a static manikin had a nearly 37% deterioration of their skills and knowledge within 3 months of training and 42% at 12 months. Furthermore, a high percentage (85%) of the intervention group in this study retained these skills 3 months after training. This finding emphasizes the value of HFS training over LFS training.

**LINKING EVIDENCE TO ACTION**

- Simulation in nursing education has become an important educational strategy, specifically teaching students the necessary skills and knowledge to develop as competent nurses.
The findings of this study underscore the effectiveness of HFS on students’ acquisition and retention of knowledge and skills. As a result, it is suggested that nursing educators integrate simulation training in their curricula. This will help to overcome challenges that face many courses, specifically the shortage of clinical areas for training and the increase in the number of nursing students.

RECOMMENDATIONS

The replication of our study in more than one university, with a larger sample size, is recommended. Additional research that examines the use of HFS with other nursing courses to measure learning outcomes is needed. Nurse educators in both academic institutions and healthcare facilities need to implement special CPR review courses for nurses and nursing students to maintain and update their knowledge and skills. This will improve the safety of nursing interventions, specifically in critical situations. Follow-up assessment at 6 and 12 months after training is recommended.

Author information

Ahmad A. Aqel, Assistant Professor, Clinical Nursing Department, University of Jordan, Amman, Jordan; Muayyad M. Ahmad, Professor, Clinical Nursing Department, Faculty of Nursing, University of Jordan, Amman, Jordan

The authors acknowledge the partial funding from the University of Jordan.

Address correspondence to Muayyad Ahmad, Clinical Nursing Department, Faculty of Nursing, University of Jordan, Amman, Jordan

Accepted 30 May 2014

Copyright © 2014, Sigma Theta Tau International

References


doi 10.1111/wvn.12063
WVN 2014:00:1–7