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The use of high-fidelity mannequin training to improve the quality of healthcare providers' performance of CP

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Abstract

Objective: To investigate the effect of high-fidelity mannequins in cardiopulmonary resuscitation (CPR) training to improve clinical practice for healthcare providers.

Methods: A quasi-experimental (practical pre-test and practical post-test) design was used to evaluate healthcare providers' quality of knowledge and level of skill before and after using high-fidelity mannequins for cardiopulmonary resuscitation training. The 166 participants in the study were primarily healthcare providers enrolled on a basic life support (BLS) course at the Clinical Skills and Simulation Center at Hera General Hospital in Saudi Arabia, between October 2016 and February 2017. The study focused on adult CPR. A practice test was undertaken in eight batches of BLS courses, with practical pre- and post-tests.

Results: In all, 156 BLS course participants took part in the training. Almost 63% were female and the majority were nurses and physicians. The results of the pre-training practice showed a low quality of CPR (mean score = 16.21%, SD = 21.51; pass score 50%). The interventions (debriefing, video, and workshops) led to differences in the effectiveness and quality of CPR. Of the 156 participants, 123 passed the first time of testing, 27 had to take the test a second time, and only six had to make a third attempt.

Conclusion: High-fidelity mannequin training achieves the target of improving healthcare providers' skills in high-quality CPR. The percentage of compressions at the correct depth and in the right-hand position improved significantly.

Introduction

Since 2010, guidelines have emphasized the importance of high-quality cardiopulmonary resuscitation (CPR) to improve cardiac arrest survival and outcome. However, it is critical to train as many people as possible in this technique and utilizing high-fidelity mannequins in training sessions could be of benefit.

Some health institutions have undertaken investigations of learning outcomes using high-fidelity simulation. We decided to conduct this study on a practical basis due to the possibility of a written examination being provided through online access.

Cardiac arrest patients have a narrow window for survival with quality of life post-CPR [1,2]. Therefore, high-quality CPR, including early recognition, compression, defibrillation, and advanced care, followed by post-resuscitation care, is required to increase the chances of survival [3-5]. Training is needed to achieve high-quality CPR and improve the quality of life afterwards. There is variability in the teaching methods used by healthcare providers attempting to improve the retention of knowledge and skills related to CPR [6,7]. High-fidelity simulations are one of the methods used and have demonstrated improvements in learning outcomes [5,7]. According to Boet et al. (2011), high-fidelity simulation practice sessions followed by debriefing develop the participants' clinical skills [8]. It is important to emphasize the positive experience of using innovative teaching methodologies among healthcare providers and the effectiveness of CPR through the use of high-fidelity mannequins rather than standard ones [9]. However, this may also cause stress, which could in turn affect performance [10].

Learning-based simulation is considered a safe environment for training, as the patients and trainees are not exposed to risk [11,12]. Also, it can be planned, designed, and redesigned with clinically required skills in mind, and can be used to enhance trainees' attainment of clinical skills and competence by allowing the opportunity for repeated practice within a team. High-fidelity-based simulation can allow healthcare providers to experience uncommon and critical case scenarios in a safe setting. Furthermore, the standard of the program can be developed and allow time for debriefing [9].

In contrast, the main disadvantages of learning through high-fidelity simulation are the significant costs involved and a lack of infrastructure, such as instructors and curricula [13,14]. Also, the attitude of learners in approaching a simulator will be different to real-life situations [12,14]. Nonetheless, Everett-Thomas (2016) argued that the use of high-fidelity mannequins is promising, as it enables healthcare providers to retain the knowledge and skills necessary to perform CPR successfully. However, it is still important for instructors to develop their skills and methods of teaching [15].

The aim of this study is to investigate the effect of CPR training on high-fidelity mannequins to improve clinical practice for health care providers.

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Methods

Research methods

A quasi-experimental (practical pre-test and practical post-test) design was used to evaluate healthcare providers' quality of knowledge and level of skill before and after a CPR training session that involved the use of high-fidelity mannequins.

Participants

A total of 166 participants took part in the study, the majority of whom were healthcare providers enrolled on a basic life support (BLS) course at the Clinical Skills and Simulation Center at Hera General Hospital, between October 2016 and February 2017. The participants were randomly distributed between those seeking new certification and those renewing certification and were also distributed according to language preference (Arabic or English).

Instruments

The study focused on adult CPR, and a practice test was undertaken in eight batches of BLS courses, with practical pre- and post-tests. Pre-tests were carried out for every candidate without guidance or a presentation on CPR. However, the applicants were informed that the practical pre-test score would not count towards their final performance results.

The mannequin was set up according to the standard CPR requirements of the Saudi Heart Association [16], via an iPad device, and with a compression depth target of 5 cm (2 inches) and ventilation of 400ml-700 ml. Candidates were asked to respond to a case scenario and applied their skills on a mannequin lying on the bed and attached to a control device. The case scenario was an adult who had lost consciousness, and when the pulse was checked, there was no sign of a heartbeat.

A post-test was carried out for 156 candidates who were deemed fit for practice after giving them feedback on their performance and allowing them to reflect. Following the two attempts, we recorded each participant's performance on a skill evaluator mannequin with an iPad device, with the practice focusing on one-minute compression and ventilation only. The passing score was 50%. Candidates with chronic diseases (e.g., asthma and joint arthritis) and those who were pregnant were excluded from the post-practice test and the study.

Procedure

The BLS course started at 8:00 am, at which time the participants checked in for the course. The director welcomed the candidates and explained the nature of the course, starting with the practical pre-test procedure and emphasizing that the instructor who provided the case scenario would not be allowed to guide them during the pre-test, as candidates had to use their initiative to save the patient.

A debriefing was provided after the practical pre-test, which entailed formal and systematic questioning after simulation to obtain beneficial information and sustain and improve future performance, thus providing an efficient way of educating the adult professional [17]. Simulation-based educators consider debriefing an essential activity following the simulation event for reflection and feedback [18,19].

Then, the participants watched a video lasting one hour that demonstrated the CPR standards and skills for adults, children, and infants, and also learnt about the use of an automated external defibrillator (AED) and received training on choking. The candidates were divided into four groups for the workshops.

Finally, a post-test was run for every candidate unless they were deemed not fit for practice. Candidates who scored less than 50% were debriefed again and then retook the post-test.

Data analysis

IBM SPSS was used to calculate descriptive statistics (means and standard deviations), p-values, and 95% confidence intervals (CIs). The hypotheses were tested using means, standard deviations, paired sample t-tests, and one-way ANOVA, and the results were considered statistically significant at the 0.05 level.

Ethical approval

The research committee approved this study at the Postgraduate, Education, and Training Centre of Hera General Hospital. The purpose and methods of the study were explained to all participants, informed consent was obtained, and confidentiality was assured.

Results

Table 1 presents the sample characteristics. A total of 156 BLS course participants from a range of different hospital departments took part in the training. Almost 63% were female, and the majority were nurses and physicians. Approximately 73% of candidates had taken the course before and were renewing their training (Table 1).

Pre-training performance

The results of the pre-training practice showed low-quality CPR ability (mean score = 16.21%, SD = 21.51; pass score 50%). Among the healthcare providers, paramedics exhibited considerably the best mean performance (42%), followed by pharmacologists (18.38%), physicians (16.62%), and nurses (14.75%).

As shown in (Table 2), renewing (re-certifying) participants exhibited better skills in terms of CPR performance than new candidates (those attending for the first time), although the mean scores for both groups were lower than the 50% pass score.

Table 1. Trainees' characteristics (N=156)

	Frequency	Percentage
Gender		
Male	58	37.2
Female	98	62.8
Role		
Physician	50	32.1
Nurse	59	37.8
Paramedic	3	1.9
Pharmacologist	8	5.1
Lay person	5	3.2
Other	31	19.9
Training		
First time	42	26.9
Renew	114	73.1
Workplace		
Emergency	12	7.7
ICU	11	7.1
Medical	17	10.9
Surgical	9	5.8
Clinic	26	16.7
OR	5	3.2
Office	8	5.1
Non-healthcare provider	6	3.8
Other	62	39.7

Table 2. Descriptive statistics and *t*-test results for CPR performance (new/renewing) (p =.002)

	Pre-test			95% CI for mean difference		
	M	SD	N		t	df
CPR performance (new)	7.45	11.87	42	11.08-17.86	8.44	155
CPR performance (renewing)	19.43	23.33	114			

Post-training performance

The interventions (debriefing, video, and workshops) led to differences in the effectiveness and quality of CPR. Of the 156 participants, 123 passed the test on their first attempt, 27 had to take the test a second time, and only six had to make a third attempt.

(Table 3) shows the descriptive statistics for the pre- and post-test results according to specialization for healthcare providers and department (workplace). No significant differences were found regarding specialism or department in a one-way analysis of variance (ANOVA). Rather, as (Table 4) shows, improvements were found overall.

A further interesting finding concerns the number of times participants took the post-test (one, two, or three). In (Table 5) reports the descriptive statistics for the pre-test and post-tests for the various groups and Table 6 presents the results of the associated *t*-test.

As can be seen, the difference between the scores of the different groups is significant at p = .000. Moreover, a one-way ANOVA was conducted to examine the effect of the number of trials on CPR performance. The analysis shows that the effect is significant: F (2,153) = 5.078, p = .007.

Discussion

This study shows a significant improvement in the performance of CPR based on the use of high-fidelity mannequins and debriefing compared with the results of the pre-training group (p = 0.000), thus supporting the arguments in the literature [9,19,20] concerning the benefits of such interventions.

The pre-training practice showed a low-quality CPR ability (mean score = 16.21%, SD = 21.51; pass score 50%). Among the healthcare providers, paramedics exhibited considerably the best mean performance (42%) and nurses showed the lowest performance (14.75%). Aufderheide et al. (2006) found a similar result in a visual observation study, concluding that paramedics performed incomplete chest decompression cycles during resuscitation efforts (46%) on out-of-hospital adults suffering from cardiac arrest [21]. It should be noted that although the differences here are not statistically significant, all these means fall below the passing score of 50%, clearly indicating the need for training. This finding reveals that healthcare providers turn to the BLS course without preparation despite being aware that the course is assessed.

Moreover, the findings demonstrate that these results hold for all groups of healthcare providers, regardless of specialism or department, rather than benefiting any one group in particular. Social workers, physiotherapists, laboratory technicians (including clinical laboratory technicians), dentists, dieticians, and administrative staff showed the greatest improvements in CPR skills, with a mean of 75.74, despite rarely performing CPR or routinely coming across patients suffering from cardiac arrest. However, it seems that for those who undertook the practical test a third time, there was minimal improvement in their skills. Therefore, we would recommend allowing two trials only as a basis for deciding the certification of healthcare providers.

Approximately 73% of the participants were renewal candidates, having last attended a CPR course two years prior to our study. However, the pre-training test results showed a low quality (retention) of skills regarding performance and knowledge. Also, it was noticeable that the majority of the candidates had not read or prepared for the BLS course despite the fact that it was a compulsory planned course for all healthcare providers. The pre-training results are consistent with findings in the literature. For example, Finn et al. (2015) suggest providing refresher courses after the initial training every three to twelve months to maintain CPR skills [22]. One randomized controlled study found that candidates who took a refresher course within seven months were more likely to retain their skills than those who had a refresher course after twelve months [23]. Moreover, according to Niles et al. (2009), the more frequently refresher sessions are conducted with healthcare providers, the better their psychomotor skills and self-reported gains in confidence [24]. Therefore, we would encourage the provision of refresher courses after three months and

Table 3. Descriptive statistics according to specialism/healthcare provider and department/workplace (pre- and post-test)

Specialism	Pre-test			Post-test		
	M	SD	N	M	SD	N
Physician	16.62	19.77	50	72.36	14.06	50
Nurse	14.75	22.18	59	72.85	15.31	59
Paramedic	42.00	21.38	3	71.67	4.73	3
Pharmacologist	18.38	20.76	8	73.88	16.57	8
Department						
Emergency	27.33	35.55	12	72.00	18.28	12
ICU	27.64	23.27	11	78.18	10.70	11
Medical	12.82	20.33	17	73.18	14.77	17
Surgical	16.44	16.26	9	72.44	12.89	9
Clinic	12.23	17.68	26	67.19	15.27	26
OR	10.60	13.20	5	79.60	18.69	5
Office	10.13	14.08	8	68.25	16.94	8
Certification						
New	7.45	11.866	42	69.74	15.44	42

Table 4. Descriptive statistics and *t*-test results for CPR performance. (p = .000).

	Pre-test			Post-test			95% CI for mean difference		
	M	SD	N	M	SD	N		t	df
CPR performance	16.21	21.51	156	72.87	14.49	156	-60.29, -53.03	-30.86	155

Table 5. Descriptive statistics for scores according to the number of times the post-test (pre- and post-test) was taken.

Number of post-tests	Pre-test			Post-test		
	M	SD	N	M	SD	N
One	17.13	22.25	123	74.40	14.23	123
Two	14.19	19.83	27	69.26	14.21	27
Three	6.33	7.87	6	57.67	10.63	6
Total	16.21	21.51	156	72.87	14.49	156

Table 6. Paired sample *t*-test for the number of times the post-test was taken. (p = .000).

	Post-test			95% CI for mean difference	t	df
	M	SD	N			
CPR performance	72.87	14.49	156	69.30, 73.93	61.16	155

regularly thereafter, as well as regular mock drills – both for healthcare professionals and those rarely involved in CPR – to help maintain knowledge and skills.

The debriefing session was an essential element in this study, as it allowed candidates to reflect on their performance in terms of their psychomotor skills immediately after the pre-training tests and highlight where they performed well and where they needed to improve before starting any training. Such immediate post-event debriefing has been shown to yield significant results in terms of improving performance when combined with hands-on training [23, 25, 26].

The high-fidelity mannequin proved to be an excellent tool in this study, as it displays physiological changes via a computerized system (based on the intervention, i.e., training) and records performance [23]. High-fidelity-based simulation allows healthcare providers to experience uncommon and critical case scenarios and potentially reduces anxiety in real situations [27].

High-quality CPR requires both psychomotor skills and knowledge (practice and theory). This study focuses primarily on practice in terms of measuring skills in performance. Providing hands-on training combined with debriefing within the team helps healthcare providers make gains in performance within a short period. Hands-on training is standard in CPR training, at both basic and advanced levels. In contrast, theoretical training alone has been shown to yield poor quality gains [17,28].

Conclusion

High-fidelity mannequin training achieves the target of improving healthcare providers' skills in providing high-quality CPR. It was observed that the percentage of compressions at the correct depth performed in the right-hand position improved significantly. The interventions included debriefing, which may well be an invaluable contribution in terms of improving CPR performance. Healthcare professionals in all areas of specialization and in all departments, can benefit from such training. However, those needing to repeat the practical trial may not make such gains.

Recommendations

- Encourage healthcare providers to read about CPR (providing recommended reading) before undertaking the BLS course.
- Reassess healthcare providers within six months of the course.
- Put in place refresher courses, particularly for those who rarely attend CPR courses and for healthcare providers who have minimal skills.
- Allow two trials only when assessing (certifying) healthcare providers.
- Redesign the current BLS course and replicate the practical pre-test in all Saudi Heart Association BLS courses.

Limitations

This study was limited to one Clinical Skills and Simulation Center, located at Hera General Hospital.

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