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The TrueCPR device in the process of teaching cardiopulmonary resuscitation

A randomized simulation trial

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Abstract

Background: International resuscitation guidelines emphasize the importance of high quality chest compressions, including correct chest compression depth and rate and complete chest recoil. The aim of the study was to assess the role of the TrueCPR device in the process of teaching cardiopulmonary resuscitation in nursing students.

Methods: A prospective randomized experimental study was performed among 94 first year students of nursing. On the next day, the participants were divided into 2 groups—the control group practiced chest compressions without the use of any device for half an hour, and the experimental group practiced with the use of TrueCPR. Further measurement of chest compressions was performed after a month.

Results: The chest compression rate achieved the value of 113 versus 126 ($P < .001$), adequate chest compression rate (%) was 86 versus 68 ($P < .001$), full chest release (%) 92 versus 69 ($P = .001$), and correct hand placement (%) 99 versus 99 (*P*, not significant) in TrueCPR and standard BLS groups, respectively. As for the assessment of the confidence of chest compression quality, 1 month after the training, the evaluation in the experimental group was statistically significantly higher (91 vs 71; $P < .001$) than in the control group.

Conclusions: Cardiopulmonary resuscitation training with the use of the TrueCPR device is associated with better resuscitation skills 1 month after the training. The participants using TrueCPR during the training achieved a better chest compression rate and depth with in international recommendations and better full chest release percentage and self-assessed confidence of chest compression quality comparing with standard cardiopulmonary resuscitation training.

Abbreviations: AED = automated external defibrylator, AHA = American Heart Association, BLS = basic life support, CPM = compressions per minute, CPR = cardiopulmonary resuscitation, ERC = European Resuscitation Council, IQR = interquartile range.

Keywords: cardiopulmonary resuscitation, feedback device, training, TrueCPR

1. Introduction

International cardiopulmonary resuscitation (CPR) guidelines emphasize the importance of high quality chest compressions, including correct chest compression depth and rate and complete chest recoil.[1,2] These guidelines suggest the "high quality" resuscitation parameters to be 5 to 6 cm of chest compression depth, 100 to 120/min rate and full chest recoil with minimal interruptions in chest compressions.[1] The high-quality chest compression is an important factor enabling to maintain vital organ perfusion and influencing cardiac arrest patients'

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Informed consent was obtained from all individual participants included in the study.

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outcome.[3,4] Maintaining the high quality throughout a prolonged CPR is difficult, even for medical personnel. For this reason, the current guidelines recommend to change the rescuer every 2 to 3 minutes, especially during prolonged resuscitation.[5] One of the major CPR problem is not letting the chest recoil, which can lower the effectiveness of resuscitation, by reducing the venous return and decreasing the overall cardiac output.[6,7] Any interruptions in chest compressions, including hands-off time, decrease the quality of chest compressions.[5,8]

The technical progress enables the development of various equipment for monitoring the CPR quality. Several types of medical devices have been developed to increase the quality of chest compressions. These are, among others, metronomes, mechanical chest compressions, and feedback devices. The CPR feedback devices allow to monitor the quality of resuscitation and inform the rescuer about the basic parameters of the manual chest compressions being performed, including chest compression rate and depth, and full chest recoil. They are still being improved, and new methods for assessing chest compression depth include an algorithm for spectral analysis of chest acceleration.[9]

There are several CPR feedback devices on the market, for example, TrueCPR (Physio-Control, Redmond, WA), CPRmeter (Laerdal, Stavanger, Norway; Fig. 1), and even mobile phone applications such as PocketCPR (ZOLL Medical Corporation, Chelmsford, MA). Some publications suggest that a smart watch with a built-in accelerometer can be used as an effective feedback device during chest compression in adults, enabling to achieve an ideal chest compression depth in out-of-hospital settings.[10,11]

TrueCPR coaching device allows to measure the depth of chest compressions on the basis of 3-dimensional induction of magnetic field, so it can be used on different surfaces that the patient is placed on. It uses several sensors on the anterior chest surface and below the back of the patient. The analyzed data include the chest compression depth and rate and are displayed on the panel located on the anterior chest sensor. The device is also equipped with a metronome.

The aim of the study was to assess the role of the TrueCPR device in the process of teaching CPR in nursing students.

Figure 1. TrueCPR cardiopulmonary resuscitation feedback device.

2. Material and methods

2.1. Study design and participants

The study was designed as a prospective randomized experimental study, involving first year of nursing students at the Poznan University of Medical Sciences and the Wroclaw Medical University during the 2017 to 2018 academic year. The study protocol was approved by the institutional review board of the Polish Society of Disaster Medicine (approval no. 31.07.2017. IRB). Overall, 94 nursing students participated in the study. The inclusion criteria were the following: having the status of a first year student of nursing and no previous participation in a CPR training. Back or wrist pain, as well as failure to meet the inclusion criteria constituted the exclusion criteria. Voluntary written informed consent was obtained from each participant. The study abided the principles of Helsinki Declaration.

2.2. Study protocol

Prior to the survey, all participants attended a standard training course in basic life support (BLS) based on the American Heart Association (AHA) 2015 guidelines, conducted by accredited AHA instructors.

After a successful completion of the theoretical training, the participants underwent a 10-minute practical training during which they performed unassisted chest compressions. After the practical training, they rested for an hour and then performed a 2-minute CPR cycle with continuous chest compressions (baseline). On the next day, the participants were divided into 2 groups with the use of the Research Randomizer (randomizer.org) software. The control group practiced chest compressions without the use of any device for half an hour, and the experimental group practiced with the use of TrueCPR.

Further measurement of chest compressions was performed after a month, when the participants were asked to perform a 2-minute unassisted (instrument-free) resuscitation cycle. The randomization procedure is presented in detail in Fig. 2.

2.3. Measurements

During the study, only parameters related to the quality of chest compressions were analyzed. These were measured with the use of the simulator control panel and then exported to a database. The evaluation covered the frequency and depth of chest compressions, and the degree of full chest relaxation. The correct chest compression rate was based on the current AHA guidelines and equaled 100 to 120 compressions/min, while the appropriate chest compression depth was set at 5 to 6 cm.[13] In addition, self-assessed confidence of chest compression quality of the subjects was measured with a 100-point scale (1: no confidence; 100: full confidence).

2.4. Statistical analysis

On the basis of previous studies, we calculated the necessary sample size as at least 62 participants using the G* Power 3.1 software (Heinrich-Heine-Universität, Düsseldorf, Germany) (two-tailed *t* test; Cohen *d*, 0.8; alpha error, 0.05; power, 0.95). In order to increase the power of the study, we decided to qualify 94 participants.

The statistical analysis was performed with the Statistica13.3EN statistical package (StatSoft, Tulsa, OK). Qualitative variables

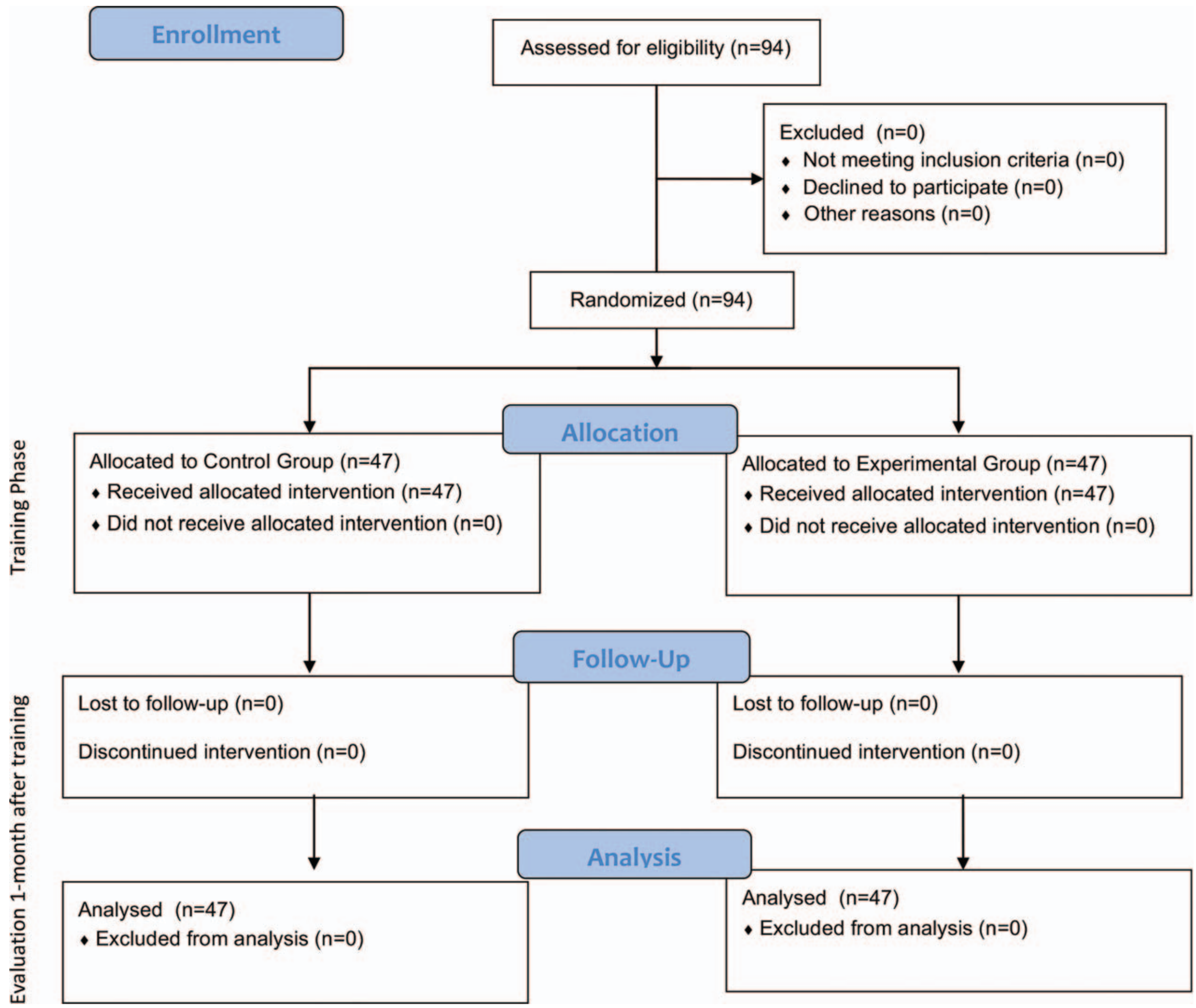

Figure 2. Randomization flow chart.

were expressed as absolute frequencies (n) and percentages (%). Quantitative variables were expressed as medians and interquartile ranges (IQRs). The statistical comparison between the groups was performed with Student *t* test or Mann–Whitney *U* test for quantitative variables and the chi-square or Fisher tests for qualitative variables. Within-group comparison of qualitative variables employed McNemar test, whereas Wilcoxon or Student *t* test with a Bonferroni correction for paired data were used for

Table 1

The chest compression quality parameters and attitude of rescuers in the experimental and control groups.

Parameter	Control group	Experimental group	*P*-value
Baseline			
Chest compression rate, /min	128 (122–136)	127 (122–135)	NS
Adequate chest compression rate (%)	72 (56–74)	71 (53–75)	NS
Chest compression depth, mm	45 (42–48)	45 (42–48)	NS
Full chest release (%)	92 (83–95)	93 (82–93)	NS
Correct hand placement (%)	98 (94–100)	98 (95–100)	NS
Attitude	93 (90–99)	92 (85–96)	NS
1 month after training			
Chest compression rate, /min	126 (120–133)	113 (107–118)	<.001
Adequate chest compression rate (%)	68 (51–71)	86 (75–97)	<.001
Chest compression depth, mm	43 (40–46)	53 (52–55)	<.001
Full chest release (%)	69 (64–92)	92 (84–93)	.001
Correct hand placement (%)	99 (98–99)	99 (96–100)	.871
Attitude	71 (64–79)	91 (83–96)	<.001

NS = not significant.

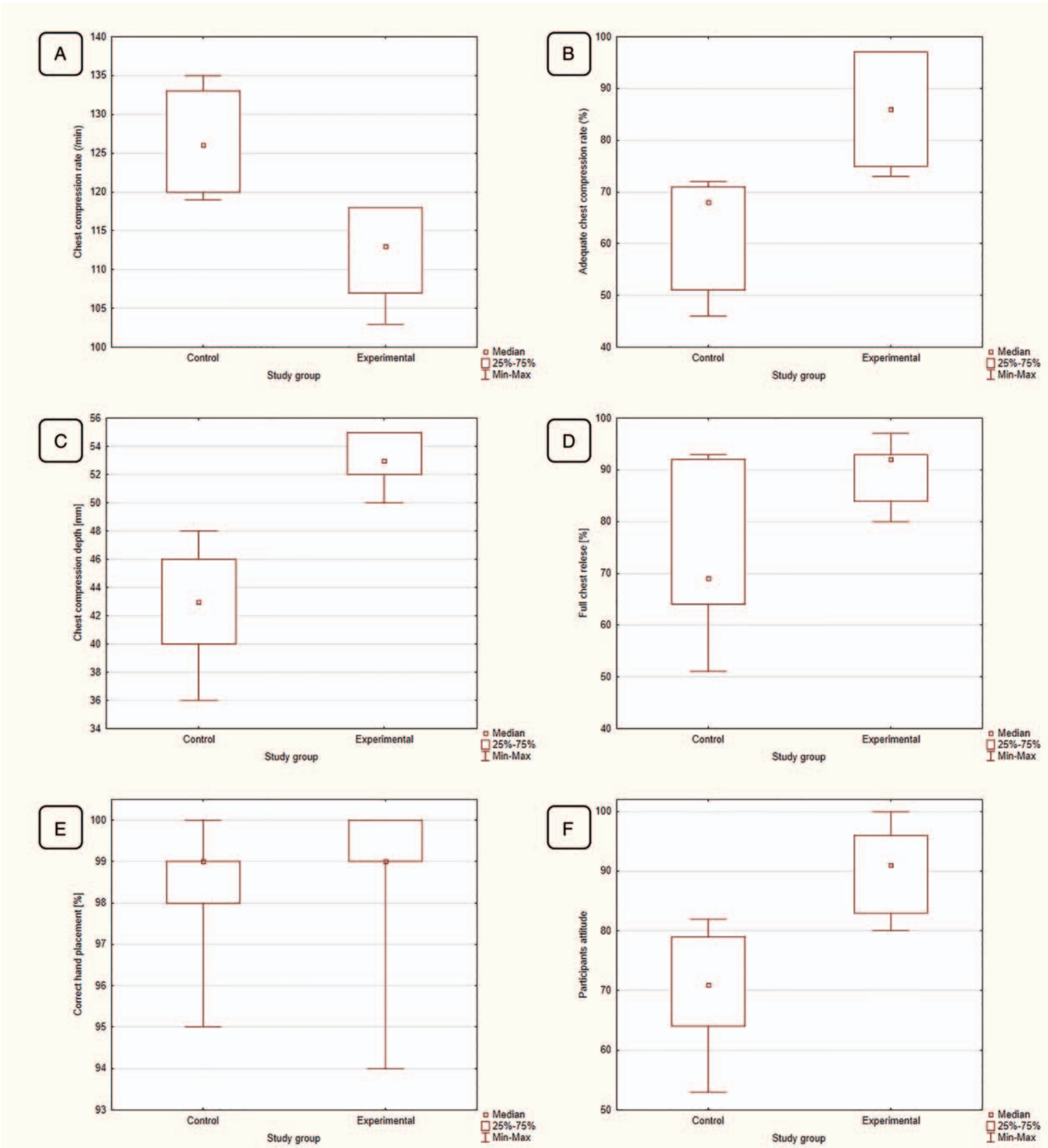

Figure 3. Chest compression parameters one month after training: (A) chest compression rate; (B) adequate chest compression rate; (C) chest compression depth; (D) percentage of full chest release; (E) correct hand placement; (F) participant's attitude.

quantitative variables. *P* values $\leq$.05 were considered statistically significant.

3. Results

The results obtained in the study are presented in Table 1 and on Fig. 3. In the first part of the study, there were no significant differences in chest compression quality parameters between the experimental and control group. Baseline values were as follows: chest compression rate was 128 (IQR 122–136) min^{-1} in control and 127 (IQR 122–135) min^{-1} in experimental group (P=ns). The percentage of compressions with adequate chest compression rate was 72 (IQR 56–74)% in control and 71 (IQR 53–75)% in experimental group (P=ns). The chest compression depth achieved 45 (IQR 42–48) mm in control and 45 (IQR 42–48) mm in experimental group (P=ns). The percentage of chest compressions with full chest release was 92 (IQR 83–95)% in control and 93 (IQR 82–93)% in experimental group (P=ns). The percentage of chest compression with correct hand placement achieved 98 (IQR 94–100)% in control and 98 (IQR 95–100)% in experimental group (P=ns). Self-assessed confidence of chest compression quality was 93 (IQR 90–99) in control and 92 (IQR 85–96) in experimental group (P=ns). However, 1 month after the training, the adequate chest compression rate, chest compression depth, and full chest release were statistically significantly better in the experimental group. One month after the training chest compression rate was 126 (IQR 120–133) min^{-1} in control and 113 (IQR 107–118) min^{-1} in experimental group ($P<.001$). The percentage of compressions with adequate chest compression rate was 68 (IQR 51–71)% in control and 86 (IQR 75–97)% in experimental group ($P<.001$). The chest compression depth achieved 43 (IQR 40–46) mm in control and 53 (IQR 52–55) mm in experimental group ($P<.001$). The percentage of chest compressions with full chest release was 69 (IQR 64–92)% in control and 92 (IQR 84–93)% in experimental group ($P=.001$). The percentage of chest compression with correct hand placement achieved 99 (IQR 98–99)% in control and 99 (IQR 96–100)% in experimental group (P=ns). Self-assessed confidence of chest compression quality was 71 (IQR 64–79) in control and 91 (8 IQR 3–96) in experimental group ($P<.001$).

The study participants, using a 100-point scale, assessed their confidence of chest compression quality and it was revealed that 1 month after the training, the evaluation in the experimental group was statistically significantly higher than in the control group.

4. Discussion

The study showed that; the participants using TrueCPR during the training achieved a better chest compression rate and depth with in international recommendations and better full chest release percentage comparing with standard cardiopulmonary resuscitation training. CPR training with the use of TrueCPR can improve the ability to obtain high-quality chest compressions 1 month after the training and self-assessed confidence of chest compression quality.

The ability to perform high quality chest compressions is important for nurses, who frequently are first responders in in-hospital settings.[12,13] The use of high-technology, simulation based training for nursing students was associated with decreased response time in a resuscitation simulation.[14] Some publications suggest that the quality of visual assessment of hand placement, compression depth, chest decompression, and rate during CPR is suboptimal.[15] This observation implies that feedback devices should be incorporated in BLS training.

Feedback devices can be used during standard training with the instructor supervision and also for self-training without any instructor supervision.[16–26] Their role in layperson CPR training was highlighted in several publications.[23–26] These devices have also been tested in several conditions, including long-distance trains with distributed traction, where they proved to be accurate despite accelerations and the electromagnetic interferences induced by the train.[15]

Feedback devices' role in CPR training has been analyzed in several publications. In a simulation study performed by Majer et al,[18] the use of the TrueCPR device by physicians resulted in a significant improvement in the quality of chest compressions in relation to the frequency and depth of chest compressions and correctness of chest relaxation. Also, a study by Truszewski et al[19] suggested that in a simulated resuscitation scenario, only TrueCPR significantly affected the increased effectiveness of chest compression compared with standard BLS, CPREzy, and iCPR. In a study by Brown et al[20] the quality of CPR improved with the use of a CPR feedback device. Similar results were obtained by different authors; Kurowski et al,[21] Iskrzycki et al,[22] Zapletal et al.[23] There are some other studies exist with conflicting results in the literature. In a study by Sutton et al[24] these devices when used during CPR can influence the rate of chest compressions, by decreasing it. No clinically significant improvement was observed in infant chest compressions with the addition of a metronome or a visual feedback device in Austin et al[25] study.

Some studies suggested that the use of specific types of feedback, such as a smart phone application, was associated with a higher degree of incomplete chest decompressions.[23] Niles et al[26] observed in their pediatric manikin study that the use of accelerometer devices can decrease the incomplete chest compression release. The use of visual real-time feedback devices significantly improved CPR quality in unexperienced CPR providers, including life guards.[22] In a study by Wang et al,[27] an audio visual feedback device also improved CPR quality in the case of rescuers with body weight <71 kg. In a study by Aguilar et al,[28] significantly better CPR was obtained in participants assigned to perform chest compressions with the use of audiovisual feedback in terms of the average rate of chest compressions and correct chest compression percentage.

Full chest relaxation after each compression also plays a significant role in the quality of CPR. In our study, the full chest recoil rate was higher in the TrueCPR group. This parameter is emphasized as especially important in AHA and European Resuscitation Council (ERC) guidelines.[28–30]

The information received by the rescuer enables better compliance with international guidelines.[1,31] Many studies have highlighted that the basic CPR parameters are suboptimal in both laypersons and medical personnel; these include the rate and depth of chest compressions, full chest relaxation, and hand position during chest compressions.[7]

A rapid deterioration of resuscitation abilities after the training in adults and children is a well-known phenomenon.[18,32] Feedback devices can be used for low dose training and they were revealed to produce an improvement in chest compression performance during CPR.[22,33] The use of feedback devices can increase the chance for better retention of abilities to perform high quality chest compressions. As in other studies, the chest compression rate without the use of a feedback device was too high and exceeded recommended 100 to 120 per minute.[34,35] But more surprisingly, 1 month after the training, the study participants not previously trained with TruCPR also exceeded the recommended chest compression rate, and the rate in those trained with TrueCPR was within the recommendations.

There are also some other studies performed in prehospital setting using these feedback devices in the literature. Baldi et al[36] analyzed the impact of feedback devices during laypersons' CPR training on chest compression quality in 450 participants of BLS courses. They observed that real-time visual feedback improved CPR quality, with a suggestion that the devices should be used in each BLS or automated external defibrillator (AED) course for laypersons. Weston et al[37] suggested that CPR feedback devices were associated with marginally improved quality of CPR in the prehospital setting. Gyllenborg et al[38] suggest that in an out-of-hospital setting, the use of AED with audio feedback does not deteriorate in time and stays within recommendations. Also, Weston et al[37] suggested that CPR feedback devices were associated with marginally improved quality of CPR in the prehospital setting. However, in a observational study by Cheskes et al,[3] the compliance with AHA guidelines for CPR quality was not associated with improved out comes in out-of-hospital cardiac arrest but it was emphasized that strategies used to improve overall compliance with resuscitation guidelines had a significant impact on outcomes in out-of-hospital cardiac arrest.

The use of TrueCPR is associated with considerable ease and comfort, and a high level of trust as assessed by responders.[23] There were several studies comparing the impact of different retraining intervals for CPR on the quality of resuscitation. Some of them suggest that a 6-month interval may be considered for training compression-only CPR and AED when balancing outcomes and resources.[39] In our study, resuscitation quality 1 month after the training was tested.

There are several limitations in our study. Among the main ones is the use of a manikin model. However, it is a standard for CPR studies, and the manikins applied in our study are widely used in CPR simulation and research, allowing repetition of resuscitation activities with equal conditions for all cases.[40,41] These seccond limitation is the study group. The results in fact refer to nursing students and not to other medical professions. The third limitation is the tested period of 1 month. A longer period after the training could impede the results.

5. Conclusions

CPR training with the use of a TrueCPR device is associated with a better maintenance of CPR skills after the training. The study participants who used TrueCPR during the training achieved better chest compression rate and depth within international recommendations, better full chest release percentage, and higher self-assessed confidence of chest compression quality as compared with standard CPR training.

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