PLOS ONE

Effects of different cardiopulmonary resuscitation education interventions among university students: A randomized controlled trial

Yu-Tung Chang[1,2]*, Kun-Chia Wu[3], Hsiang-Wen Yang[4], Chung-Yi Lin[5‡], Tzu-Fu Huang[1‡], Yi-Chi Yu[1‡], Yih-Jin Hu[1‡]

1 Department of Health Promotion and Health Education, National Taiwan Normal University, Taipei, Taiwan, 2 Department of Health Care Management, College of Health Technology, National Taipei University of Nursing and Health Sciences, Taipei, Taiwan, 3 Department of Medical VR, HTC Corporation, Taipei, Taiwan, 4 Taiwan SAVEANNE Education Association, Taipei, Taiwan, 5 Department of Shipping and Transportation Management, National Taiwan Ocean University, Keelong, Taiwan

☯ These authors contributed equally to this work.
‡ These authors also contributed equally to this work.
* emtpjack@gmail.com

Abstract

Cardiopulmonary resuscitation (CPR) education for the public may improve bystander intention to perform CPR on cardiac arrest patients. Studies have shown that different CPR education intervention methods can improve learning performance, with key indicators including attitude toward to CPR, intention to perform CPR, and degree of CPR knowledge and skills. The present study compared the traditional face-to-face method to hybrid and virtual reality (VR) methods to observe difference in learning performance and length of performance retention. This study adopted randomized controlled trial to compare CPR learning performance between traditional face-to-face, hybrid, and VR methods. Participants from each intervention group completed a pretest and 2 posttests. The measurement tools included an attitude and intention questionnaire, knowledge examination, and skill examination with a RESUSCI ANNE QCPR ® manikin. The performance among all participants in pretest showed no significant difference between the intervention groups, indicating no difference in their background attitude, knowledge, and skill level. Significant differences were observed in the average degree of intention to perform CPR between the hybrid and traditional groups in 1st and 2nd posttest. Compared to the pretest results, the posttests revealed significantly higher attitude toward CPR, intention to perform CPR, knowledge examination results, accuracy of overall chest compression, accuracy of CPR procedure, accuracy of AED usage, accuracy of chest compression rate, and accuracy of chest compression depth. The average time to reattending CPR learning and practice session was 11–12 weeks reported by participants. The hybrid and VR methods to CPR education resulted in the same level of improvement in learning performance as traditional face-to-face teaching. The suggested frequency for renewing CPR knowledge and skills is 12

weeks which may be considered in new strategies aimed at promoting CPR education and exposure to the public.

Introduction

Early activation of "chain of survival" has been proven a key behavior in saving patients from a cardiac arrest [1]. In the steps of the survival chain, activation of emergency response, high-quality cardiopulmonary resuscitation (CPR), and defibrillation are the three most important and fundamental skills that can be performed by bystanders or first responders to a cardiac arrest [1]. Global resuscitation data indicated that survival rates range from 4.6% to 32%, and bystander CPR rates range from 20% to 51% [2–9]. Compared to this global data, Taiwan's bystander CPR rate is relatively low and should be addressed by first aid educators [5].

CPR education is effective for improving bystander CPR knowledge, attitude, and skill performance [10–18]. In 2015, the American Heart Association suggested that CPR instructors use multimedia, the internet, simulation, and CPR feedback devices to create a hybrid learning environment to improve learning outcomes effectiveness [19]. Studies have indicated that hybrid CPR education approaches effectively improve participant knowledge, attitude, skill, and intention to CPR [13,18]. The retention length of CPR knowledge and skill after CPR education courses has also been considered a measurement of CPR education effectiveness, with previous studies having reported an average retention length of CPR knowledge and skill of 3 months after an education intervention [20–26]. However, there is lack of evidence measuring the results of attitude, and intention to do CPR, and then combining it with length of retention after CPR education.

Approaches to teach CPR include traditional face-to-face, hybrid, and virtual reality (VR) methods [18]. Studies on face-to-face and hybrid courses are well established in the literature, but VR courses are a relatively new style of learning CPR that has only emerged in the past 5 years [18]. Semeraro et al. researched the features of VR in CPR education [27,28]. Since 2019, different types of CPR VR software and applications have been developed by resuscitation councils, universities, and medical education companies [29–37]. However, evidence comparing the overall performance of CPR education approaches with VR is limited.

To compare the effectiveness of different education approaches, the present study investigated two desired outcomes after different methods of CPR education. The first outcome included improvement in knowledge, attitude, skill, and intention to perform CPR after a CPR education course, the second outcome was the length of time until the first outcome was retained.

Materials and methods

Study design

This randomized controlled trial (RCT) aimed to exam the CPR performance, attitude toward to CPR, and intention to perform CPR in three teaching methods, including traditional face-to-face, hybrid, and VR methods. Participants underwent a pre-test before CPR education course and two post-tests after CPR education course. There was 1 month interval between 2 post-tests that were held, comprising an attitude questionnaire, knowledge examination, skill examination, and self-reflective feedback about the length of interval between each renewal session. The attitude questionnaire comprised 12 questions measuring the participants' attitude toward CPR and intention to perform CPR. The knowledge examination included 15 multiple choice questions on topics ranging from basic cardiac physiology, and acute coronary

syndrome to CPR and automated external defibrillator (AED) procedures. The CPR skill examination measured the accuracy of CPR and AED steps and CPR performance, including depth, speed, chest recoil, and discontinue time of chest compressions. To be more accurate and consist measure CPR performance, the present study used a RESUSCI ANNE QCPR ® manikin with motor sensor and combined with its software to collect CPR performance data of each session of chest compression.

Sample size

The sample size was estimated through a statistical power analysis with GPower 3.1.9.7 software, with effect size 0.25, alpha type I error of 0.05, power of 0.8, and 3 groups with 3 times of measurements. The estimated total sample size of all interventional groups was 57. The target population comprised undergraduate and postgraduate students studying in northern Taiwan. The inclusion criteria were over 20 years old, no existing disease, easily stimulated by light and audio, and not holding valid CPR or first aid certification within 2 years. The exclusion criteria were having impaired vision and hearing, undergoing CPR or first aid training, obtaining valid CPR or first aid certification.

Randomization

Those 3 teaching methods were equally adapted in 9 CPR education courses that were available for participants to registration (Fig 1). Participants did not know which teaching methods in each course when they registered. This single-blind approach made participants randomly assigned to each teaching method group.

Intervention

Teaching methods, including traditional face-to-face, hybrid, and VR methods, were the main interventions in this study. In order to minimize the effects of different teaching methods, the
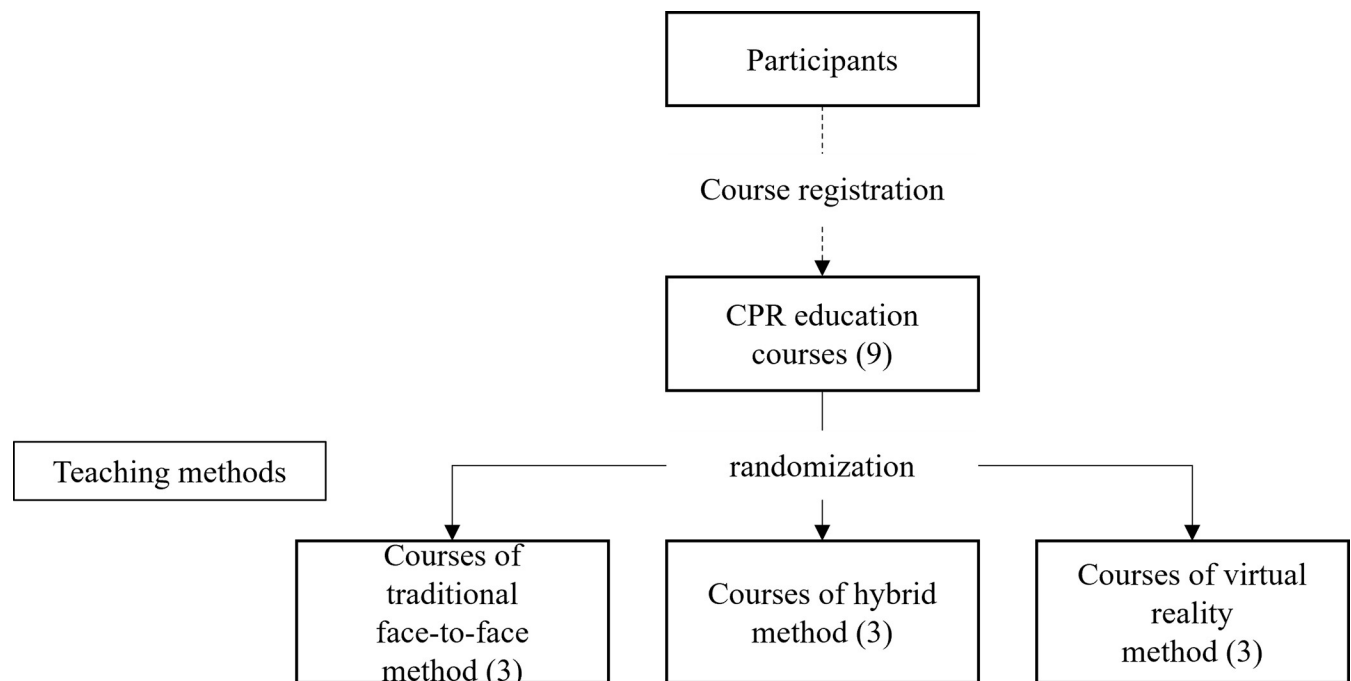
Fig 1. Study randomization.

agenda of each intervention were set up in the same manner, which included 40 minutes lecture and 70 minutes practice. The difference between each intervention was the approach to deliver lecture and practice session. The traditional face-to-face method delivered face-to-face approach in both lecture and practice. The hybrid method delivered a web-based video playlist as lecture and face-to-face approach in practice session. The web-based video playlist was provided and authorized by one of Taiwanese online first aid training organization called ANNE School. The VR methods delivered both lecture and practice in HTC Basic Life Support VR platform and using HTC Corporation VR goggles. For each CPR course, the standardized instructor to participant ratio was 1:6 in this study. The CPR courses taught both chest compression only CPR and compression with ventilation. The pre- and post-test examined only chest compression only CPR.

Ethical approval

The present study was reviewed and approved by the Ethical Committee at En Chu Kong Hospital, Taiwan (ECKIRB1101001). Before each CPR course, instructors introduced the purpose and process of this study to all participants, and guided them through all the contents of informed consent form. Participants signed off informed consent form by themselves and submitted to instructors before study commencement. All signed informed consent forms were kept by person-in-charge (PI) of this trail. The confidential data od participants were kept in encrypted hard-drive by PI as well.

Statistical analysis

Continuous variables are described using the mean and standard deviation (SD). Categorical variables are presented as frequencies and percentages. The mean comparison of continuous variables between groups was computed using analysis of variance (ANOVA). For comparison of repeated measurements within group, the Wilcoxon Sign Rank Test was adopted due to the sample size. A generalized estimating equation (GEE) was employed to examine the effect on learning performance between the different groups and times of measurement. For all results, $p < 0.05$ was considered statistically significant. Analyses were performed using SPSS 23.

Results and discussion

Results

Eighty-four participants were eligibly enrolled into this study. Twenty-three of them were allocated in traditional face-to-face intervention group, 30 were in hybrid intervention group, and 23 were in VR intervention group. (Fig 2)

A total of 76 participants enrolled into this study. The average age was 28.3 years (SD 10.6), with slightly more men (n = 41, 53.9%) than women (n = 35, 46.1%). Among all the participants, 66 (86.8%) reported having no heart disease, 5 (6.6%) had previously received a heart disease diagnosis, and the other 5 (6.6%) were recorded as unknown. For family history, 39 (51.3%) reported having no family history of heart disease, 30 (39.5%) stated that they had a family history of heart disease, and the remaining 7 (9.2%) were recorded as unknown (Table 1).

Table 2 summarizes the CPR learning performances results and shows a comparison between and within the groups. The drop-out rate of participants varied from 6% to 45%, which was attributed to a sudden spike in COIVD-19 cases during the study period. The performance among all participants in the pretest showed no significant difference between groups, including that had similar background attitudes (F = 0.38), knowledge (F = 1.49), and
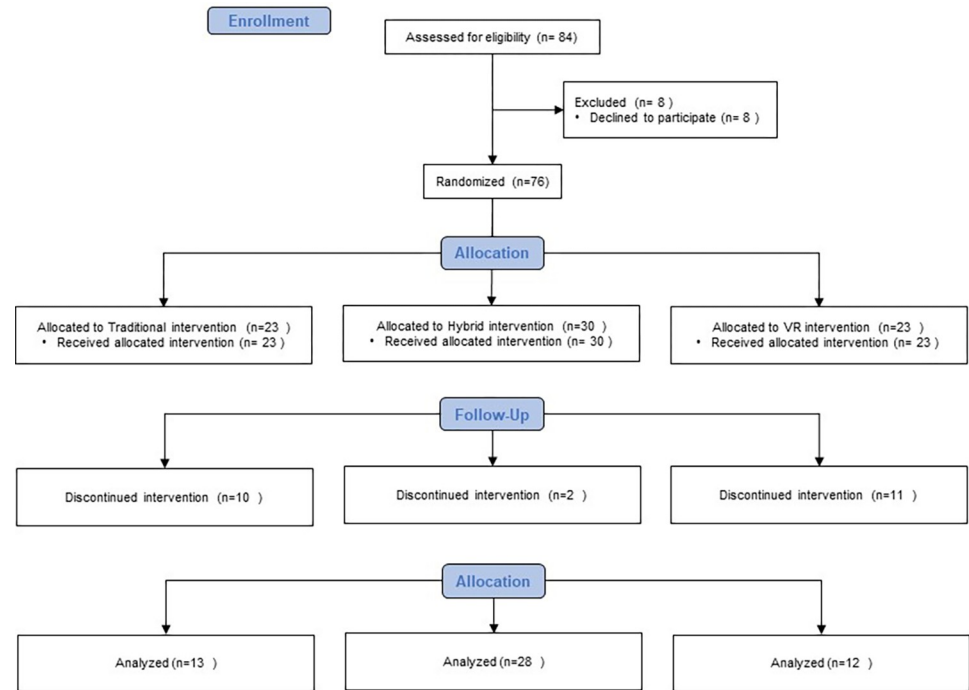
Fig 2. CONSORT diagram for recruitment.

https://doi.org/10.1371/journal.pone.0283099.g002

skills (F = 1.28). The average degree of intention to perform CPR between the groups differed significantly between the hybrid and traditional groups in both posttests (F = 4.90 and 4.41). Both the traditional and hybrid groups significantly outperformed the better VR group in the 1st posttest results for the knowledge examination, accuracy of overall chest compression, accuracy of CPR procedure, and accuracy of chest compression rate. The traditional group exhibited more accurate chest compression depth than did the VR group in the 1st posttest. Except for intention to perform CPR, all other outcomes differed significantly between the groups at the 2nd posttest. Analysis of the difference between the pretest and posttest

Table 1. Descriptive analysis of participants background between groups.

Groups	Overall (N = 76)		Traditional group n = 23 (30.3%)		Hybrid group n = 30 (39.5%)		VR group n = 23 (30.3%)	
	n (%)	M (SD)	n (%)	M (SD)	n (%)	M (SD)	n (%)	M (SD)
Age		28.3(10.6)		34.4(8.9)		25.0(8.0)		26.4(12.6)
Gender								
Male	35(46.1)		13(56.5)		6(20.0)		16(69.6)	
Female	41(53.9)		10(43.5)		24(80.0)		7(30.4)	
Personal history of heart disease								
No	66(86.8)		22(95.7)		27(90.0)		17(73.9)	
Diagnosed	5(6.6)		1(4.3)		2(6.7)		2(8.7)	
Unknown	5(6.6)		0(0)		1(3.3)		4(17.4)	
Family history of heart disease								
No	39(51.3)		12(52.2)		15(50.0)		12(52.2)	
Diagnosed	30(39.5)		11(47.8)		11(36.7)		8(34.8)	
Unknown	7(9.2)		0(0)		4(13.3)		3(13.0)	

https://doi.org/10.1371/journal.pone.0283099.t001

Table 2. Comparison of attitude, intention, knowledge, and performance (between and within groups).

Outcomes	Observations	(A)Traditional group				(B)Hybrid group				(C)VR group			Compare between groups	
		n	M(SD)	Compare within group		n	M(SD)	Compare within group		n	M(SD)	Compare within group	F	Post hoc
Attitude toward CPR	Pretest	23	9.1(0.8)	baseline		30	8.8(0.8)	baseline		22	8.9(1.2)	baseline	0.38	n/a
	1st Posttest	23	9.4(0.6)	-3.08*		30	9.7(0.4)	-4.31*		22	9.5(0.6)	-3.17*	1.23	n/a
	2nd Posttest	13	9.3(0.5)	-1.26		28	9.5(0.4)	-4.12*		12	9.2(0.9)	-2.22*	1.61	n/a
Intention to perform CPR	Pretest	23	6.9(2.1)	baseline		30	7.5(1.5)	baseline		22	7.0(2.4)	baseline	0.71	n/a
	1st Posttest	23	8.5(1.1)	-3.37*		30	9.4(0.8)	-4.70*		22	9.0(0.9)	-3.52*	4.90*	(B)>(A)
	2nd Posttest	13	8.1(1.5)	-2.27*		28	9.1(0.9)	-4.35*		12	8.3(0.8)	-3.06*	4.41*	(B)>(A)
knowledge examination	Pretest	23	61.4 (16.3)	baseline		30	67.7 (13.1)	baseline		22	62.7 (13.2)	baseline	1.49	n/a
	1st Posttest	23	89.2 (7.1)	-4.02*		30	88.2 (7.9)	-4.54*		22	81.2 (12.2)	-3.81*	5.18*	(A)>(C) (B)>(C)
	2nd Posttest	13	79.4 (10.3)	-2.75*		28	79.0 (10.2)	-3.83*		12	80.5 (14.6)	-2.98*	0.07	n/a
Accuracy of overall chest compression	Pretest	23	54.4 (32.4)	baseline		30	65.6 (32.3)	baseline		22	53.0 (29.9)	baseline	1.28	n/a
	1st Posttest	23	97.6 (5.6)	-3.95*		30	96.6 (5.1)	-4.00*		22	75.9 (27.5)	-2.20*	14.5*	(A)>(C) (B)>(C)
	2nd Posttest	13	85.3 (20.7)	-2.76*		28	91.2 (17.1)	-3.67*		12	87.3 (18.9)	-2.51*	0.49	n/a
Accuracy of CPR procedure	Pretest	23	60.0 (25.9)	baseline		30	62.3 (22.8)	baseline		22	59.5 (23.5)	baseline	0.10	n/a
	1st Posttest	23	94.7 (10.8)	-3.85*		30	93.6 (10.6)	-4.61*		22	83.6 (20.1)	-3.02*	4.34*	(A)>(C) (B)>(C)
	2nd Posttest	13	82.3 (17.3)	-2.31*		28	85.0 (12.9)	-3.73*		12	75.0 (22.7)	-2.65*	1.52	n/a
Accuracy of AED usage	Pretest	23	75.5 (23.9)	baseline		30	82.0 (21.6)	baseline		22	84.0 (11.6)	baseline	1.13	n/a
	1st Posttest	23	97.2 (7.4)	-3.41*		30	97.0 (7.8)	-3.26*		22	93.7 (10.7)	-3.23*	1.20	n/a
	2nd Posttest	13	91.3 (11.8)	-1.41		28	93.3 (7.2)	-1.66		12	97.9 (4.8)	-2.33*	2.15	n/a
Accuracy of chest compression rate	Pretest	23	26.2 (38.1)	baseline		30	33.2 (36.3)	baseline		22	18.4 (30.2)	baseline	1.07	n/a
	1st Posttest	23	93.0 (11.4)	-3.35*		30	94.5 (23.5)	-4.02*		22	49.6 (34.0)	-3.50*	22.0*	(A)>(C) (B)>(C)
	2nd Posttest	13	57.7 (39.4)	-2.20*		28	74.1 (31.2)	-3.55*		12	51.8 (36.5)	-1.68	2.12	n/a

(*Continued*)

Table 2. (Continued)

Outcomes	Observations	(A)Traditional group				(B)Hybrid group				(C)VR group			Compare between groups	
		n	M(SD)	Compare within group		n	M(SD)	Compare within group		n	M(SD)	Compare within group	F	Post hoc
Accuracy of chest compression depth	Pretest	23	64.6 (41.5)	baseline		30	81.7 (35.6)	baseline		22	73.8 (38.0)	baseline	1.29	n/a
	1st Posttest	23	99.8 (0.4)	-3.51*		30	98.3 (6.4)	-2.77*		22	89.5 (23.2)	-1.60	4.06*	(A)> (C)
	2nd Posttest	13	90.1 (20.0)	-2.70*		28	90.7 (22.4)	-2.19*		12	89.0 (24.5)	-2.70*	0.02	n/a
Accuracy of chest recoil rate	Pretest	23	78.9 (33.5)	baseline		30	72.9 (33.4)	baseline		22	75.1 (35.4)	baseline	0.19	n/a
	1st Posttest	23	91.8 (21.7)	-1.21		30	82.8 (30.1)	-1.31		22	83.8 (28.6)	-0.50	0.78	n/a
	2nd Posttest	13	86.6 (26.9)	-1.32		28	83.8 (28.4)	-1.85		12	81.5 (29.8)	-1.06	0.10	n/a

*$p < 0.05$.

n/a Post hoc was unnecessary due to no significant difference between groups.

outcomes, within groups showed that the performance in the posttests was significantly higher than that in the pretest for attitude toward CPR, intention to perform CPR, knowledge examination results, accuracy of overall chest compression, accuracy of CPR procedure, accuracy of AED usage, accuracy of chest compression rate, and accuracy of chest compression depth. Only the accuracy of chest recoil rate did not differ between the pretest and posttests within all groups.

This study collected repeated measurements from each participant. Table 3 summarizes the results from the GEE analysis comparing the effects of CPR learning performance from each group and its interaction with the time variable. The attitude toward CPR, intention to perform CPR, knowledge examination results, and accuracy of CPR procedure showed no significant in the interaction between groups and time that those performance may not change over time. However, the accuracy of overall chest compression and accuracy of AED usage showed that may change in different time points. The figures of comparing each performance between pretest and posttests were provided as supporting information below.

After the intervention, the participants were asked to provide feedback on how frequently they would be willing to attend CPR learning and practice sessions after attending an initial CPR course so they could maintain their knowledge and skill. Overall, the average weeks for re-attending the CPR learning and practice session was 11–12 weeks. This average did not differ significantly between the groups.

Discussion

Studies have suggested that CPR education intervention may positively affect a bystander's attitude toward CPR, intention to perform CPR, knowledge, and skill performance [10–18]. Comparing to traditional face-to-face teaching, newly developed methods, such as hybrid and VR methods, show partial improvements in attitude, knowledge, and skill performance [13,18]. The results of the present study also show that CPR education improves CPR attitude, intention to perform CPR, knowledge, and skill which supports the literature. However, the current study is the first to investigate the effectiveness of both the hybrid method and HTC

Table 3. Analysis of the interaction between CPR education intervention groups and time to CPR learning performance.

Parameters	Attitude toward CPR Wald χ² Test B	SE	Wald χ² Test	Intention to perform CPR Wald χ² Test B	SE	Wald χ² Test	Knowledge examination results Wald χ² Test B	SE	Wald χ² Test	Accuracy of overall chest compression Wald χ² Test B	SE	Wald χ² Test	Accuracy of CPR procedure Wald χ² Test B	SE	Wald χ² Test	Accuracy of AED usage Wald χ² Test B	SE	Wald χ² Test
[Group]	**0.29**			**6.60***			**1.96**			**9.16***			**3.50**			**2.63**		
[Time]	**57.11***			**72.08***			**193.68***			**58.99***			**104.68***			**47.11***		
[Group]*[Time]	**11.85**			**1.70**			**8.19**			**11.08***			**2.40**			**11.13***		
[Groups = VR]	-0.16	0.30	0.28	0.48	0.74	0.43	1.28	4.32	0.08	-1.38	9.09	0.02	-0.45	7.22	0.04	1.28	4.32	0.08
[Group = Hybrid]	-0.22	0.22	1.00	0.78	0.59	1.76	6.32	4.07	2.40	11.23	8.80	1.62	2.33	6.69	0.12	6.32	4.07	2.40
[Group = Traditional]	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.
[Time = 2nd Posttest]	0.51	0.23	4.89	1.48	0.50	8.77*	17.67	3.55	24.71*	30.96	7.96	15.11	21.41	5.73	13.94*	17.67	3.55	24.71*
[Time = 1st Posttest]	0.45	0.17	6.94*	1.91	0.42	20.33*	27.82	3.36	68.20*	43.26	6.98	38.30	34.78	5.59	38.61*	27.82	3.36	68.20*
[Time = Pretest]	0ª			0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.
[Groups = VR] * [Time = 2nd Posttest]	0.24	0.13	3.40	-0.04	0.72	0.03	-1.26	5.21	0.05	3.51	11.98	0.08	-6.69	9.12	0.53	-1.26	5.21	0.05
[Groups = VR] * [Time = 1st Posttest]	0.34	0.09	12.95*	0.22	0.65	0.11	-9.35	4.34	4.63	-20.39	11.30	3.25	-10.69	8.19	1.70	-9.35	4.34	4.63
[Groups = VR] * [Time = Pretest]	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.
[Group = Hybrid] * [Time = 2nd Posttest]	0.01	0.34	0.01	0.31	0.59	0.27	-6.53	4.09	2.54	-5.42	10.02	0.29	1.19	7.04	0.02	-6.53	4.09	2.54
[Group = Hybrid] * [Time = 1st Posttest]	0.25	0.21	1.36	0.16	0.52	0.10	-7.38	3.93	3.51	-12.26	9.32	1.73	-3.44	6.61	0.27	-7.38	3.93	3.51
[Group = Hybrid] * [Time = Pretest]	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.
[Group = Traditional] * [Time = 2nd Posttest]	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.
[Group = Traditional] * [Time = 1st Posttest]	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.
[Group = Traditional] * [Time = Pretest]	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.	0ª	.	.

*p<0.05.

ª. Set to zero to because this parameter is redundant.

VR method in Taiwan. Although the level of improvement in performance by the experimental groups did not differ significantly from that in the controls, the results still showed a significant improvement after the intervention. New education methods might not necessarily replace existing methods, but they may be ideal options for CPR instructors to implement in circumstances such as the COVID-19 pandemic or where close-contact restrictions apply.

Previous studies have reported that the average retention length of CPR knowledge and skill was 3 months after an education intervention [20–26]. Due to a spike of COVID-19 cases in Taiwan, the present study could only observe the length of retention till 1 month after the intervention. Nonetheless, the results show significant improvement both immediately after the intervention and 1 month after the intervention. It would be ideal to continue any observations after an intervention to more accurately measure the real length of the CPR education effect. Despite this shortcoming in the present study, the participants still provided valuable information about self-evaluation and that the ideal frequency for re-attending CPR learning and practice sessions after CPR course was approximately 12 weeks. Current regulations in

Taiwan state that the renewal period for maintaining CPR certification is 2 years [5]. Attending and conducting regular CPR courses every 12 weeks would be time consuming and a cost burden for both the public and CPR instructors. As an alternative approach to increase the frequency of public exposure to CPR knowledge, CPR education institutes and instructors may consider using multimedia channels, social networks, and technologies such as VR to provide key information on CPR. Regarding the frequency of CPR practice sessions for the public, more accessible approaches that meet the 12-week frequency exposure might include short and deliberate practice sessions or CPR practice kiosks in public areas. In the adaptation of new and emerging technologies, VR may also be an option for practicing CPR without having to physically travel to an education site.

Future studies may wish to investigate the length of CPR performance between non-intervention and frequent intervention groups. Examining the effects of newly developed CPR education approaches and VR techniques may reveal ways to improve public accessibility to CPR education during period of global uncertainty, such as with the COVID-19 pandemic. Also, considering the benefit of operating new teaching method and technology may reduce the numbers of educators in each teaching session or can become remotely accessing each session and allow more students to participate.

Two limitations were noted while conducting in this study. First, public fear due to a spike in COVID-19 cases caused a high drop-out rate in the follow-up observation that led to underpower sample size. Second, the target population was composed entirely of university students who may have already been exposed to CPR or first-aid information before. Although the recruitment process followed randomized approach, the discrepancy in gender and age in each group should be improved in further study. Future studies should consider recruiting participants from a more diverse range of backgrounds or age groups.

Conclusions

In conclusion, different CPR teaching methods were equally effectiveness to improving attitude toward CPR, intention to perform CPR, knowledge, and skill performance after a CPR training intervention. The participants indicated that approximately 12 weeks was the ideal frequency for CPR education exposure. CPR instructors may wish to consider how this affects the delivery of and accessibility to CPR courses for the public.

Supporting information

S1 Fig. Figures for GEE results.
(PDF)

Acknowledgments

Author Contributions

Conceptualization: Yu-Tung Chang.

Data curation: Yu-Tung Chang, Chung-Yi Lin, Yi-Chi Yu, Yih-Jin Hu.

Investigation: Tzu-Fu Huang.

Methodology: Yu-Tung Chang.

Project administration: Yu-Tung Chang, Kun-Chia Wu, Hsiang-Wen Yang, Tzu-Fu Huang.

Resources: Kun-Chia Wu, Hsiang-Wen Yang, Chung-Yi Lin, Tzu-Fu Huang, Yi-Chi Yu.

Software: Kun-Chia Wu, Hsiang-Wen Yang.

Supervision: Chung-Yi Lin, Yi-Chi Yu, Yih-Jin Hu.

Writing – original draft: Yu-Tung Chang.

Writing – review & editing: Yih-Jin Hu.

References

1. American Heart Association. AMERICAN HEART ASSOCIATION 2020 CPR and ERC Guideline. 2020.

2. Ambulance Victoria. Ambulance Victoria Annual-Report-2018. 2018.

3. Ong MEH, Shin S Do, De Souza NNA, Tanaka H, Nishiuchi T, Song KJ, et al. Outcomes for out-of-hospital cardiac arrests across 7 countries in Asia: The Pan Asian Resuscitation Outcomes Study (PAROS). Resuscitation. 2015; 96:100–8. https://doi.org/10.1016/j.resuscitation.2015.07.026 PMID: 26234891

4. Bray JE, Smith K, Case R, Cartledge S, Straney L, Finn J. Public cardiopulmonary resuscitation training rates and awareness of hands-only cardiopulmonary resuscitation: a cross-sectional survey of Victorians. EMA—Emergency Medicine Australasia. 2017; 29(2):158–64. https://doi.org/10.1111/1742-6723.12720 PMID: 28087894

5. Chiang WC, Ko PCI, Chang AM, Chen WT, Liu SSH, Huang YS, et al. Bystander-initiated CPR in an Asian metropolitan: Does the socioeconomic status matter? Resuscitation. 2014; 85(1):53–8. https://doi.org/10.1016/j.resuscitation.2013.07.033 PMID: 24056397

6. Plunien R, Eberhard C, Dinse-Lambracht A, Struck MF, Muth CM, Winkler BE. Effects of a media campaign on resuscitation performance of bystanders: A manikin study. European Journal of Emergency Medicine. 2017; 24(2):101–7. https://doi.org/10.1097/MEJ.0000000000000305 PMID: 26267074

7. Puhan MA, Chandra D, Mosenifar Z, Ries A, Make B, Hansel NN, et al. An "Intention-Focused" paradigm for improving bystander CPR performance. Resuscitation. 2015; 88:48–51. https://doi.org/10.1016/j.resuscitation.2014.12.006 PMID: 25534077

8. Yamaguchi Y, Woodin JA, Gibo K, Zive DM, Daya MR. Improvements in Out-of-Hospital Cardiac Arrest Survival from 1998 to 2013. Prehospital Emergency Care. 2017; 21(5). https://doi.org/10.1080/10903127.2017.1308604 PMID: 28426258

9. Yasuda Y, Takayama Y, Suzukawa M, Yamashita K, Yonekawa C, Toyokuni Y, et al. Effect and quality of bystander CPR in Japan–Is bystander CPR performed definitely? Resuscitation. 2012; 83:50.

10. Huang Q, Hu C, Mao J. Are Chinese Students Willing to Learn and Perform Bystander Cardiopulmonary Resuscitation? Journal of Emergency Medicine. 2016; 51(6):712–20. https://doi.org/10.1016/j.jemermed.2016.02.033 PMID: 27727043

11. Lee MJ, Hwang SO, Cha KC, Cho GC, Yang HJ, Rho TH. Influence of nationwide policy on citizens' awareness and willingness to perform bystander cardiopulmonary resuscitation. Resuscitation. 2013; 84(7):889–94. https://doi.org/10.1016/j.resuscitation.2013.01.009 PMID: 23328406

12. Birkun A, Kosova Y. Social attitude and willingness to attend cardiopulmonary resuscitation training and perform resuscitation in the Crimea. World J Emerg Med. 2018; 9(4):237–48. https://doi.org/10.5847/wjem.j.1920-8642.2018.04.001 PMID: 30181790

13. Lactona ID, Suryanto S. Efficacy and knowledge of conducting CPR through online learning during the COVID-19 pandemic: A literature review. J Public Health Res. 2021 Apr; 10(2). https://doi.org/10.4081/jphr.2021.2208 PMID: 33855429

14. Huang PC, Chiang WC, Hsieh MJ, Wang HC, Yang CW, Lu TC, et al. Public knowledge, attitudes and willingness regarding bystander cardiopulmonary resuscitation: A nationwide survey in Taiwan. Journal of the Formosan Medical Association. 2019; 118(2):572–81. https://doi.org/10.1016/j.jfma.2018.07.018 PMID: 30190091

15. Vaillancourt C, Kasaboski A, Charette M, Islam R, Osmond M, Wells GA, et al. Barriers and facilitators to CPR training and performing CPR in an older population most likely to witness cardiac arrest: A national survey. Resuscitation. 2013; 84(12):1747–52. https://doi.org/10.1016/j.resuscitation.2013.08.001 PMID: 23989115

16. Fratta KA, Bouland AJ, Lawner BJ, Comer AC, Halliday MH, Levy MJ, et al. Barriers to bystander CPR: Evaluating socio-economic and cultural factors influencing students attending community CPR training.

American Journal of Emergency Medicine. 2019; 37(1):159–61. https://doi.org/10.1016/j.ajem.2018.05.022 PMID: 29857943

17. Karuthan SR, Firdaus PJFB, Angampun ADAG, Chai XJ, Sagan CD, Ramachandran M, et al. Knowledge of and willingness to perform Hands-Only cardiopulmonary resuscitation among college students in Malaysia. Medicine. 2019 Dec; 98(51):e18466. https://doi.org/10.1097/MD.0000000000018466 PMID: 31861024

18. Ali DM, Hisam B, Shaukat N, Baig N, Ong MEH, Epstein JL, et al. Cardiopulmonary resuscitation (CPR) training strategies in the times of COVID-19: a systematic literature review comparing different training methodologies. Scand J Trauma Resusc Emerg Med. 2021 Mar; 29(1):53. https://doi.org/10.1186/s13049-021-00869-3 PMID: 33781299

19. Bhanji F, Donoghue AJ, Wolff MS, Flores GE, Halamek LP, Berman JM, et al. Part 14: Education: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2015 Nov 3; 132(18 Suppl 2):S561–73. https://doi.org/10.1161/CIR.0000000000000268 PMID: 26473002

20. Anderson KL, Niknam K, Laufman L, Sebock-Syer SS, Andrabi S. Multi-Community Cardiopulmonary Resuscitation Education by Medical Students. Cureus. 2020; 12(6). https://doi.org/10.7759/cureus.8647 PMID: 32685315

21. Chamdawala H, Meltzer JA, Shankar V, Elachi D, Jarzynka SM, Nixon AF. Cardiopulmonary resuscitation skill training and retention in teens (CPR START): A randomized control trial in high school students. Resuscitation Plus. 2021; 5(November 2020):100079. https://doi.org/10.1016/j.resplu.2021.100079 PMID: 34223345

22. Jang TC, Ryoo HW, Moon S, Ahn JY, Lee DE, Lee WK, et al. Long-term benefits of chest compression-only cardiopulmonary resuscitation training using real-time visual feedback manikins: a randomized simulation study. Clin Exp Emerg Med. 2020 Sep; 7(3):206–12. https://doi.org/10.15441/ceem.20.022 PMID: 33028064

23. Kim YJ, Cho Y, Cho GC, Ji HK, Han SY, Lee JH. Retention of cardiopulmonary resuscitation skills after hands-only training versus conventional training in novices: a randomized controlled trial. Clin Exp Emerg Med. 2017 Jun; 4(2):88–93. https://doi.org/10.15441/ceem.16.175 PMID: 28717778

24. Nord A, Svensson L, Claesson A, Herlitz J, Hult H, Kreitz-Sandberg S, et al. The effect of a national web course "Help-Brain-Heart" as a supplemental learning tool before CPR training: a cluster randomised trial. Scand J Trauma Resusc Emerg Med. 2017 Sep; 25(1):93. https://doi.org/10.1186/s13049-017-0439-0 PMID: 28899418

25. Papalexopoulou K, Chalkias A, Dontas I, Pliatsika P, Giannakakos C, Papapanagiotou P, et al. Education and age affect skill acquisition and retention in lay rescuers after a European Resuscitation Council CPR/AED course. Heart Lung. 2014 Jan; 43(1):66–71. https://doi.org/10.1016/j.hrtlng.2013.09.008 PMID: 24246726

26. Zhou XL, Wang J, Jin XQ, Zhao Y, Liu RL, Jiang C. Quality retention of chest compression after repetitive practices with or without feedback devices: A randomized manikin study. American Journal of Emergency Medicine. 2020; 38(1):73–8. https://doi.org/10.1016/j.ajem.2019.04.025 PMID: 31005392

27. Semeraro F, Luciani A, Müller MP, Gandolfi S, Lockey A, Ristagno G, et al. Virtual Reality for CPR training: How cool is that? Dedicated to the "next generation." Resuscitation. 2017; 121:e1–2.

28. Semeraro F, Tucci R, Scapigliati A, Gnudi T, Giulini G, Kayal JS, et al. Virtual reality cardiopulmonary resuscitation (CPR): Comparison with a standard CPR training mannequin. Resuscitation. 2018; 135:234–5. https://doi.org/10.1016/j.resuscitation.2018.12.016 PMID: 30597133

29. Buckler DG, Almodovar A Jr, Snobelen P, Abella BS1, Blewer A, Leary M. Observing the stages of bystander intervention in virtual reality simulation. World journal of emergency medicine. 2019; 10(3):1–2. https://doi.org/10.5847/wjem.j.1920-8642.2019.03.003 PMID: 31171944

30. Bench S, Winter C, Francis G. Use of a Virtual Reality Device for Basic Life Support Training: Prototype Testing and an Exploration of Users' Views and Experience. Simulation in Healthcare. 2019; 14 (5):287–92. https://doi.org/10.1097/SIH.0000000000000387 PMID: 31490865

31. Barsom EZ, Duijm RD, Dusseljee-Peute LWP, Landman-van der Boom EB, van Lieshout EJ, Jaspers MW, et al. Cardiopulmonary Resuscitation Training for High School Students Using an Immersive 360-Degree Virtual Reality Environment. Vol. 51, British Journal of Educational Technology. p. 2050–62.

32. Nas J, Thannhauser J, Van Geuns RJM, Van Royen N, Bonnes JL, Brouwer MA. Optimal combination of chest compression depth and rate in virtual reality resuscitation training: A post hoc analysis of the randomized lowlands saves lives trial. Journal of the American Heart Association. 2021; 10(2):1–6. https://doi.org/10.1161/JAHA.120.017367 PMID: 33442988

33. Leary M, McGovern SK, Chaudhary Z, Patel J, Abella BS, Blewer AL. Comparing bystander response to a sudden cardiac arrest using a virtual reality CPR training mobile app versus a standard CPR

training mobile app. Resuscitation. 2019; 139(February):167–73. https://doi.org/10.1016/j.resuscitation.2019.04.017 PMID: 31005588

34. Jaskiewicz F, Kowalewski D, Starosta K, Cierniak M, Timler D. Chest compressions quality during sudden cardiac arrest scenario performed in virtual reality: A crossover study in a training environment. Medicine. 2020; 99(48):e23374. https://doi.org/10.1097/MD.0000000000023374 PMID: 33235109

35. Aksoy E. Comparing the effects on learning outcomes of tablet-based and virtual reality-based serious gaming modules for basic life support training: Randomized trial. JMIR Serious Games. 2019; 7(2). https://doi.org/10.2196/13442 PMID: 31042153

36. 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 cardiology. 2020 Mar; 5(3):328–35. https://doi.org/10.1001/jamacardio.2019.4992 PMID: 31734702

37. Issleib M, Kromer A, Pinnschmidt HO, Süss-Havemann C, Kubitz JC. Virtual reality as a teaching method for resuscitation training in undergraduate first year medical students: a randomized controlled trial. Scandinavian journal of trauma, resuscitation and emergency medicine. 2021 Feb; 29(1):27. https://doi.org/10.1186/s13049-021-00836-y PMID: 33526042