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Original article

Efficacy of online cardiopulmonary resuscitation and automated external defibrillator training for lay people

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Abstract

Background: Cardiac arrest is a leading cause of death outside of hospitals with myocardial infarction accounting for most cases. In out of hospital cardiac arrest (OHCA), bystanders are often the closest to the patient. Cardiopulmonary resuscitation (CPR) can increase survival rates if provided promptly. The American heart association 2020 guideline recommends basic life support (BLS) training and automated external defibrillators (AED) training for lay rescuers. An effective learning method for teaching CPR to the public is through electronic learning (e-learning).

Objective: This study aimed to evaluate the efficacy of online BLS training for laypeople by recruiting employees of a Thai bank.

Methods: The research involved a one group pretest-posttest design, with subjects taking a pre-test, a post-test, and practicing on a simulated CPR mannequin. Pre and post-test scores were compared and the test scores were compared with CPR simulation scores to assess efficacy of e-learning for BLS training.

Results*:* The post-test showed an average score of 14.0, which was significantly higher than the average score of 10.8 on the pretest ($P = 0.0001$). The use of an AED was significantly associated with higher post-test scores ($P < 0.05$).

Conclusion: Online CPR and AED training for laypeople is effective and has a moderately positive relationship with simulated practice scores.

Keywords: Automated external defibrillator, basic life support, out of hospital cardiac arrest, online training, laypeople.

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Cardiac arrests can unfortunately happen anywhere and anytime, in which cardiovascular disease is the most common cause of out of hospital cardiac arrest (OHCA).[1] Prompt and effective cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) application increases survival rates. [2] In OHCA, first rescuers are usually nearby lay people, so people with accurate BLS knowledge will increase survival rates of OHCA. To provide adequate resuscitation, it is important that the public is given appropriate CPR and basic life support (BLS) training. However, challenges lie in low socioeconomic communities where public knowledge of BLS is limited. [2-6] There is limited assessment on public knowledge of BLS in the Thai population. Although there is increasing acknowledgement on the importance of BLS knowledge in Thailand, BLS training for the public is believed to be inadequate when compared to the American heart association (AHA) 2020's guideline which contains theoretical knowledge along with simulated practice modules.[7]

To overcome the challenge, laypeople should be given standardized BLS training. Given the COVID-19 situation, an appropriate method for BLS training in a large group of people is via e-learning to limit physical contact and disease transmission. Advantages to e-learning is that it can provide knowledge and skills to a large group of people while minimizing expenses, reducing number of instructors needed to teach, making post-training assessments easier and reduce face-to-face contact during COVID-19 outbreak.[8-11] As this study was conducted amid the COVID-19 outbreak, this study aimed to use e-learning as a means of BLS training for the general population and assess the effectiveness of online BLS training for non-medical lay people in Thailand. The objective of this study is to create and evaluate an online BLS course which can be used during the COVID-19 outbreak while also effectively teach BLS to non-medical people.

Materials and methods

The research utilizes the quasi-experimental study design with one group pre-test and post-test assessments for quantifying the efficacy of e-learning for BLS and CPR training with simulated practice modules. The target population was bank employees and there was no control population. The sample size for this study was calculated to be 30 people which was considered a sufficient size according to the central limit theorem (CLT).[12] The research proposal was presented to the research ethics review committee from the Faculty of Medicine, Chulalongkorn University for approval and funding (IRB no. 753/63).

The bank employees were invited to attend an online course about BLS and CPR. The inclusion criteria included bank employees over the ages of 18 years old and the exclusion criteria were those who did not complete the online BLS course or the CPR practice simulation. Informed consent was obtained from volunteers with an initial contact between the subjects and researchers. Information about the research and its process, benefits and possible risks were explained to the bank employees and questions and concerns were answered on the 14th and 21st November 2020 at the headquarters of a Thai bank. Applicants were given time to decide before signing the informed consent form. Individuals who were interested in joining the study were given a subject information sheet and the consent form before making their final decision. The informed consent process follows the three main principles: the information given is complete and transparent, subjects fully understand the study and its process, and volunteers willingly agree to join the study without any coercion, incentive, or pressure. Subjects who did not sign the informed consent could participate in the BLS training.

Prior to and after the BLS course, the subjects took an online pre and post-test questionnaire in Thai language. Both the pre and post-tests contain the exact same contents. Assessment form of BLS consists of two parts: basic subject information and evaluation of BLS skills as depicted in **Table 1** which is an English translation of the questionnaire. This questionnaire was derived from key points in BLS training according to the 2020 AHA guideline. The first part asks about the subject's personal information and contains six questions which are identification number, gender, age, past BLS and CPR experiences, confidence in BLS and CPR skills, and readiness to perform those skills. The second part evaluates the subject's knowledge on CPR and BLS with 20 questions that can be separated into three categories: assessment of patient's condition with six questions, understanding of chest compression with seven questions, and concept of AED use with seven questions.

Table 1. English translation of the survey subjects were asked to complete before and after taking the online BLS course.

Personal information

1. Subject number
2. Age
   - o 20 - 30 years
   - o 31 - 40 years
   - o 41 - 50 years
   - o More than 60 years
3. Gender
   - o Male
   - o Female
4. Have you had any past BLS training?
   - o Yes
   - o No
5. How confident are you in performing BLS?
   - o No confidence (you cannot perform BLS)
   - o Low confidence (you can evaluate who needs BLS but cannot perform)
   - o Moderate confidence (you can perform BLS to a certain extent, but cannot use the AED)
   - o High confidence (you can perform BLS and use the AED)
6. How confident are you in initiating CPR on an unresponsive person?
   - o No confidence (you will not initiate CPR in this situation)
   - o Low confidence (you are unlikely to initiate CPR)
   - o Moderate confidence (you are likely to initiate CPR)
   - o High confidence (you will certainly initiate CPR)

Basic knowledge on BLS

1. Which statement is correct regarding BLS?
   - o Chest compressions should be deep and very fast to increase the blood flow rate.
   - o Squeeze the Ambu bag as hard as possible to increase oxygen level.
   - o Correct ventilation is seeing the chest rise according to the rate that you squeeze the Ambu bag.
   - o You should not make sure the airway is clear because it may cause overventilation.
2. Which one of the following is the correct steps for BLS when you find an unresponsive patient who isn't breathing?
   - o Assess responsiveness, call for help, chest compressions, defibrillation with AED
   - o Call for help, assess responsiveness, chest compressions, defibrillation with AED
   - o Call for help, assess responsiveness, palpate for pulse, chest compressions, defibrillation with AED
   - o assess responsiveness, palpate for pulse, chest compressions, defibrillation with AED
3. What is the first thing you should do in BLS?
   - o Request an ambulance
   - o Immediate chest compressions
   - o Check for scene safety
   - o Call for help and AED
4. If you are the first person to find an unresponsive patient who isn't breathing and has gone into cardiac arrest, what is the first step in resuscitation?
   - o Ask someone to call 1660 and request an ambulance and medical help
   - o Start mouth-to-mouth rescue breathing
   - o Immediate chest compressions
   - o Take the patient to a nearby hospital
5. Which of the following is the phone number for medical emergency assistance in Thailand?
   - o 191
   - o 199
   - o 1669
   - o 112
6. In CPR, what is the correct compression to ventilation ratio?
   - o 10 chest compressions followed by 1 ventilation breath
   - o 15 chest compressions followed by 1 ventilation breath
   - o 30 chest compressions followed by 2 ventilation breaths
   - o 2 minutes of chest compressions followed by 2 ventilation breaths

Table 1. (Cont.) English translation of the survey subjects were asked to complete before and after taking the online BLS course.

7. Which person in the following scenarios require immediate chest compressions?
   - o An elderly with chest tightness, sweating, cold extremities and increased respiratory rate.
   - o A young female with loss of consciousness, gasping for air, and no pulse
   - o A toddler with high fever with clonic seizure
   - o A child with difficulty breathing, increased respiratory and pulse rates
8. The AED has arrived while you are giving CPR, when should you use the AED?
   - o After 2 minutes of chest compressions
   - o After giving 200 chest compressions
   - o Immediately use once AED arrives
   - o When medical personnel arrives at scene
9. What is the correct chest compression rate?
   - o 80 times per minute
   - o 80 - 100 times per minute
   - o 100 - 120 times per minute
   - o As fast as possible
10. What is the correct depth of chest compression?
   - o 4 - 5 centimeters
   - o 5 - 6 centimeters
   - o 6 - 7 centimeters
   - o 7 - 8 centimeters
11. For the most efficient CPR, how long should chest compressions be performed continuously?
   - o No longer than 10 seconds
   - o No longer than 30 seconds
   - o No longer than 1 minute
   - o No longer than 2 minutes
12. Which of the following is incorrect regarding efficient chest compression techniques?
   - o Compression depth of 5 centimeters
   - o Full recoil
   - o Changing person giving CPR every 2 minutes
   - o Compression position at left chest wall
13. Which is the correct hand position for chest compressions?
   - o Place the heel of your hand on the center of the chest at the sternum and then place the heel of your other hand above, slightly bend elbows and apply pressure on your hands.
   - o Place the heel of your hand on the center of the chest at the sternum and then place the heel of your other hand above, slightly bend elbows and apply pressure on your arms
   - o Place the heel of your hand on the center of the chest at the sternum and then place the heel of your other hand above, keep elbows straight and push down vertically onto the chest
   - o Place the heel of your hand on the center of the chest at the sternum and then place the heel of your other hand above, keep elbows straight and apply pressure towards arms
14. What is AED?
   - o Autonomous energy defibrillator
   - o Automated external device
   - o Automatic energy delivery
   - o Automated external defibrillator
15. Who can use the AED?
   - o Health personnel only
   - o Laypeople who are trained in BLS
   - o Community health volunteers
   - o Laypeople who have not been trained in BLS
16. Which is the correct placement of the AED pads in adult patients?
   - o Below right shoulder and below left nipple line
   - o On left and right chest walls
   - o Center of anterior and posterior chest wall
   - o Center of anterior chest wall

Table 1. (Cont.) English translation of the survey subjects were asked to complete before and after taking the online BLS course.

17. What is the correct next step after pressing the shock button as suggested by the AED?
    - o Re-evaluate patient's breathing
    - o Immediate chest compressions
    - o Place patient on left lateral decubitus position
    - o Open airway and start ventilation
18. What are the correct steps in using the AED?
    - o Place AED pads on patient, turn on device, device analyzes, chest compressions
    - o Turn on device, place AED pads on patient, device analyzes, press the shock button as suggested by the device.
    - o Turn on device, place AED pads on patient, chest compressions while the device analyzes, and press the shock button as suggested by the device.
    - o Place AED pads on patient, turn on device, device analyzes, press the shock button as suggested by the device.
19. Which of the following is statement when the AED suggests pressing the shock button?
    - o Immediately press the shock button
    - o Call for emergency medical team
    - o Make sure no one is directly contacting the patient and press the shock button
    - o Continue chest compressions
20. When should you stop performing BLS and CPR?
    - o Ambulance arrives and the medical team takes over
    - o Patient regains consciousness
    - o Scene is not safe for rescuers
    - o All of the following are correct

The online BLS course was developed and instructed by Rojanasarntikul D., an attending emergency medicine physician and also an ACLS instructor at King Chulalongkorn Memorial Hospital, Thai Red Cross Society. The BLS course lasts approximately 10 minutes and includes basic resuscitation skills including patient's consciousness assessment, high-quality CPR for adults, and early use of AED. After completion of the online course, subjects will partake in 60 minutes of hands-on BLS simulation with a life-like manikin. During the session, subjects are assessed based on seven components: evaluate patient's responsiveness, call for urgent medical emergency assistance, request for AED, high quality chest compressions at correct location, effect chest compressions at rate of 100 - 120 times per minute, consistent compressions at appropriate depth with full recoil and minimized interruptions, and early use of AED.

The subjects were evaluated by trained emergency medicine physicians who were not involve in the study into three categories: complete, incomplete, and not done. The duration of participation is approximately three hours. Subjects' scores on the pre- and post-test were collected from the google platform, along with their graded performances on the simulated CPR session. Data analysis including creation of tables and figures were done on Microsoft Excel and Word Document. After completion of the study, the researchers informed the subjects of their performance and scores individually.

Statistical analysis

This study was performed using SPSS (IBM Corp, Armonk, New York, USA) version 25.0 and data were expressed as mean ± standard deviation (SD). Subject's information was categorical and continuous data. Pre and post-test scores were analyzed using paired *t* - test for normal distribution data and Wilcoxon signed-ranks test for non-normal distribution data. Pre and post-test scores were analyzed with simulated CPR performance using Pearson correlation (*r*). $P < 0.05$ was considered statistically significant.

Results

According to **Table 2**, most subjects were female amounting to a total of 123 volunteers or more than 50.0% of all subjects. The most common age group is between 31 to 40 years old with 84 subjects (36.4%). Less than half of the volunteers have previous BLS training prior to this study. Most subjects had moderate confidence in performing BLS and high confidence in performing BLS prior to taking the online BLS course with 44.2% and 67.5%, respectively. After the online BLS course, the number of subjects with moderate and high confidence in performing BLS increased to 49.8% and 39.4%, respectively. There was a slight decrease in the number of subjects who were highly confident in initiating CPR after taking the online course from 156 to 155 people.

According to **Figure 1**, the average post-test score was significantly higher than the pre-test score of 14.0 and 10.8, respectively ($P < 0.0001$). The average pre-test scores based on different age groups were 10.8 for ages 20 - 30 years, 10.8 for ages 31 - 40 years, 10.8 for ages 41 - 50 years, 11.0 for ages 51 - 60 years, and 10.00 for ages more than 60 years. The average post-test score for subjects between ages 20 - 30, ages 31 - 40, ages 41 - 50, ages 51 - 60 and over ages 60 are 14.1, 14.1, 14.1, 14.2, and 13.0, respectively. There is no SD value for pre and post-test scores in age group of more than 60 years old as there was only one person in that category.

Table 2. Demographics of subjects in the study.

Demographics	Number of subjects n = 231 (%)
Gender	
Male	108 (46.8)
Female	123 (53.2)
Age	
20 - 30 years	35 (15.1)
31 - 40 years	84 (36.4)
41- 50 years	79 (34.2)
51 - 60 years	32 (13.9)
More than 60 years	1 (0.4)
Previous BLS training	
No	152 (65.8)
Yes	79 (34.2)
Before BLS course	
Confidence level in performing BLS	
No confidence	8 (3.5)
Low confidence	44 (19.0)
Moderate confidence	102 (44.2)
High confidence	77 (33.3)
Confidence in initiating CPR	
No confidence	6 (2.6)
Low confidence	11 (4.8)
Moderate confidence	58 (25.1)
High confidence	156 (67.5)
After BLS course	
Confidence level in performing BLS	
No confidence	3 (1.3)
Low confidence	22 (9.5)
Moderate confidence	115 (49.8)
High confidence	91 (39.4)
Confidence in initiating CPR	
No confidence	2 (0.9)
Low confidence	9 (3.9)
Moderate confidence	65 (28.1)
High confidence	155 (67.1)

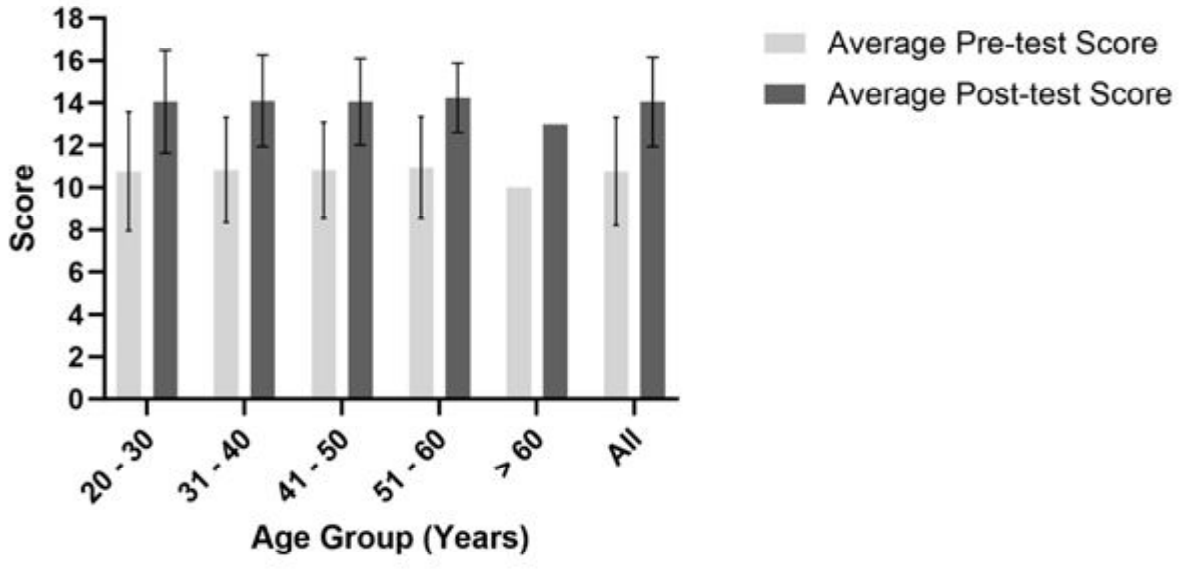

Figure 1. Comparison of average pre and post-test scores on BLS training for different age groups.

Table 3. Comparing performances of subjects with and without prior BLS training during the BLS simulation using seven criteria.

Criteria	Prior BLS training (%)	No BLS training (%)
Evaluation of patient's consciousness	99.3	97.5
Calling for emergency medical help	98.7	92.4
Requesting for AED	98.7	100.0
Correct CPR position	94.1	83.5
Consistent chest compression rate 100 - 120 beats per minute	96.7	86.1
Adequate chest compression depth of 5 centimeters with full recoil and limiting interruptions less than 10 seconds	100.0	97.5
Using AED as soon as possible	100.0	96.2

As shown in **Table 3**, the percentage of subjects who evaluated patient's consciousness, called for urgent medical emergency assistance, requested for AED, performed correct chest compression, gave consistent chest compressions at a rate of 100-120 times per minute, practiced high-quality chest compressions at a depth of 5 centimeters with full recoil and minimize interruptions to less than 10 seconds, and immediately used the AED once available was 99.3%, 98.7%, 98.7%, 94.1%, 96.7%, 100.0%, and 100.0%, respectively, in the group of subjects with previous BLS training, and 97.5%, 92.4%, 100.0%, 83.5%, 86.1%, 97.5%, and 96.2%, respectively, in the group without past BLS training. As for performance on BLS and CPR simulation sessions, subjects with and without past BLS training had similar performance scores in most areas. However, those with previous BLS training had significantly higher percentages of immediately using AED and performing chest compressions that are 5 centimeters deep ($P < 0.05$). Furthermore, there was a significant correlation between higher post-test scores and the request for AED ($P < 0.05$).

Discussion

The average post-test score was significantly higher than that of the pre-test which may indicate that the online BLS training given was an effective method in teaching non-medical laypeople about basic resuscitation skills. However, there was a slight decrease in the number of subjects who were highly confident in initiating CPR after taking the online course. A possible explanation is that after the course, the subjects were overwhelmed with the information making them doubt their ability to effectively perform BLS.

Compared to subjects without previous BLS training, those with past BLS training performed better in handling the AED. However, in other areas including evaluation of patient's consciousness, asking for medical help, requesting for AED, and correct chest compression position and rate, there was no significant difference between people with and without training. As the BLS is a hands-on motor skill, people with BLS and CPR experience are more familiar with performing CPR and handling the AED with more confidence. Therefore, they were able to execute correct chest compressions with adequate depth and use the AED as soon as possible.

To the best of our knowledge, BLS training had never been executed online prior to this study. Hence, it can be assumed that subjects with prior training were taught in classrooms not online. There was a significant difference between average pre and post-test scores which indicate that even those with previous BLS training gained new knowledge and improved their skills from the online course. Similar to our results, Tobase L, *et al*.[8] concluded that the online BLS course was effective in teaching BLS skills to nursing students who were able to correctly perform BLS steps during the simulation session. In accordance with our study, Tobase L, *et al.* also revealed a significantly higher post-test score after taking the online BLS course.[8]

Limitations in this study include the reliance on technological devices such as smartphones for administering tests and the online course to subjects. Hence, some subjects may not be familiar with using these technological devices affecting their ability to learn and take the online tests. Furthermore, the study population is bank employees which may not be representative of a wider variety of the Thai population. A confounding factor is the level of education of subjects included in this study which may affect the efficacy of BLS training and the results of the study.

Possible future works include the use of e-learning for BLS training for Thai population to increase bystander CPR and clinical outcomes for OHCA. The online learning method may increase accessibility to people in rural areas and low socio-economic groups which have limited knowledge on BLS due to challenges in receiving BLS training.

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Conflicts of interest statement

All authors have completed and submitted the International Committee of Medical Journal Editors Uniform Disclosure Form for Potential Conflicts of Interest. None of the authors disclose any conflict of interest.

Data sharing statement

The present review is based on the references cited. All data generated or analyzed during the present study are included in this published article and the citations herein. Further details, opinions, and interpretation are available from the corresponding author on reasonable request.

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