Available online at www.sciencedirect.com

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

EUROPEAN RESUSCITATION COUNCIL

Simulation and education

Self-learning training versus instructor-led training for basic life support: A cluster randomised trial[☆]

Helene Bylow[a,*], *Thomas Karlsson*[b], *Andreas Claesson*[c], *Margret Lepp*[d,e,f], *Jonny Lindqvist*[g], *Johan Herlitz*[a,g,h]

[a] Department of Molecular and Clinical Medicine, Institute of Medicine, Sahlgrenska Academy at University of Gothenburg, Gothenburg, Sweden
[b] Health Metrics Unit, Institute of Medicine, Sahlgrenska Academy at University of Gothenburg, Gothenburg, Sweden
[c] Department of Medicine, Centre for Resuscitation Science, Karolinska Institute, Stockholm, Sweden
[d] Institute of Health and Care Sciences, Sahlgrenska Academy, University of Gothenburg, Sweden
[e] Østfold University College, Halden, Norway
[f] School of Nursing and Midwifery, Griffith University, Australia
[g] Centre of Registers Västra Götaland, Gothenburg, Sweden
[h] Prehospen-Centre of Prehospital Research, Faculty of Caring Science, Work Life and Social Welfare, University of Borås, Sweden

Abstract

Aim: To compare the effectiveness of two basic life support (BLS) training interventions.

Methods: This experimental trial enrolled 1301 lay people in BLS training. The participants were cluster randomised to either self-learning training or to traditional instructor-led training. Both groups used the Mini-Anne Kit (Laerdal Medical, Stavanger, Norway) and standardised film instructions. After training, the participants practical skills were measured on a Resusci Anne manikin and an AED trainer with the PC SkillReporting system (Laerdal Medical, Stavanger, Norway). The primary outcome was the total score from the modified Cardiff Test of basic life support with automated external defibrillation (19–70 points), six months after training. The secondary outcomes were total score directly after training and quality of individual variables, self-assessed knowledge, confidence and willingness to act, directly and six months after training.

Results: For primary outcome six months after training there was no statistically significant difference ($p = 0.44$) between the total score for the self-learning group ($n = 670$; median 59, IQR 55–62) compared with the instructor-led group ($n = 561$; median 59, IQR 55–63). The instructor-led training resulted in a statistically significant higher total score (median 61 versus 59, $p < 0.0001$), self-assessed knowledge and willingness to act, directly after training (secondary outcomes) compared with the self-learning training.

Conclusions: There was no statistically significant difference in practical skills or willingness to act when comparing self-learning training with instructor-led training six months after training in BLS. However, directly after the intervention, practical skills were better when the training was led by an instructor.

Keywords: Out-of-hospital cardiac arrest, Cardio-pulmonary resuscitation, Automated external defibrillator, Basic life support, Learning, Self-learning, Education

☆ The study was registered at ClinicalTrials.gov (ID: NCT03618888)

* Corresponding author.
E-mail address: helene.bylow@gu.se (H. Bylow).

https://doi.org/10.1016/j.resuscitation.2019.03.026
Received 31 October 2018; Received in revised form 22 February 2019; Accepted 16 March 2019

Introduction

The early start of cardiopulmonary resuscitation with automated external defibrillation (CPR-AED) may double survival from out-of-hospital cardiac arrest (OHCA).[1–6] The Swedish Registry for Cardiopulmonary Resuscitation (SRCR) reports 11% for 30-day survival after OHCA, even though CPR is initiated in 75% of cases before the arrival of the ambulance.[2]

One important factor for survival from OHCA is the delay from cardiac arrest to the start of CPR-AED.[1–6] It is therefore important that as many people as possible have the knowledge necessary quickly to identify OHCA, call for help and start high-quality CPR-AED. The implementation of frequent training[7] opportunities is crucial.

Little is known about the effectiveness of self-directed training as compared to instructor-led education for basic life support (BLS) in Sweden. Around three million people in Sweden[2] from a population of 10 million inhabitants have participated in a BLS course, despite a wide spread education programme based on the European Resuscitation Council (ERC) guidelines. Previous studies reveal no differences in terms of effectiveness, when comparing self- versus instructor-led teaching,[8–15] apart from one study in 2018 which reported higher retention for self-learning three months after training.[16] Despite several studies, we believe that there is a gap of large randomised controlled trials in workplaces with lay people included.

The aim of this trial was to compare the effectiveness of two BLS training interventions i.e. self-learning training and instructor-led training. Our primary hypothesis was that instructor-led training has a positive impact and that the participants achieve a higher total score for practical skills on a retention-test six months after intervention as compared to self-learning training. Our secondary hypothesis was that instructor-led training contributes to higher scores and quality on individual variables for practical skills, self-assessed knowledge, confidence and willingness to act in a real-life OHCA situation at post-test directly after training and at a retention-test compared with self-learning training.

Methods

Study design and ethics

The present study was a cluster randomised controlled trial comparing two different types of training, including participants from a BLS project for non-healthcare workplaces in Sweden, 2014–2016 (BLS project, Fig. 1). A pilot study tested the design and the instruments.[17] In the present trial, self-learning training (experimental group) was compared with instructor-led training (control group) and the Consort 2010 Statement for flow-charts was used (www.consort-statement.org). Ethical approval from the Regional Ethical Review Board in Gothenburg was granted (23 March 2014/134-14) and the study was registered at ClinicalTrials.gov (ID: NCT03618888).

Study population

Adults over eighteen years of age were included. They had either no training in BLS or no training in BLS within the past five years. Strategic sampling was used with volunteer participants who had read the information and personally signed a consent form (submitted to Data in Brief). In all, 2623 individuals from 84 workplaces in three counties with 4.5 million inhabitants signed up to attend and were included. The present trial, enrolled 1301 participants of which 1258 were available for analysis.

Randomisation

Clusters of participants were randomised to self-learning training or instructor-led training using a computer list of numbers (randomizer.org), in blocks of 25 participants in 112 clusters. The study was performed according to the PROBE (Prospective Randomised Open Blinded End-Point Evaluation) Design.[18] The participants and the instructor were therefore aware of the treatment strategy, but the investigator was not.

Intervention

The training was based on the 2010 ERC guidelines.[19,20] All practical training was performed using a personal Mini-Anne-Plus manikin and a personal paperboard AED in a kit (Laerdal Medical, Stavanger, Norway). The learning model was to practise while watching a standardised instruction film,[21] called the Mini-Anne film (Swedish Resuscitation Council). The film lasted for 60 min and contained an OHCA situation, knowledge and facts about BLS, CPR and AED, together with practical instructions.

The self-learning group received individual instructions for the practical training and from the standardised film. The time for the self-learning training was estimated to be as long as the film, 60 min. The participants were able to attend the self-learning training as many times as they wanted for about two weeks for practical training and to incorporate theoretical knowledge with no limits.

The instructor-led group received instructions from the standardised film and from the instructor who facilitated the training, both theoretically by answering questions and practically by helping the participants with the technique to achieve the learning objectives. The time for the training was 90 min in an organised group of 12–25 participants per one or two instructors. In total for the project, sixteen independents nationally certified BLS instructors, up-dated on the 2010 ERC guidelines,[20] facilitated the instructor-led training.

Assessment and data collection

Data were collected from practical skills on a Resusci Anne manikin, the PC SkillReporting system™ 2.4.1, a HeartStart 1 Trainer (Laerdal Medical, Stavanger, Norway), a Sony HD video camera and a modified version of the Cardiff Test of basic life support and automated external defibrillation (Cardiff Test). Theoretical knowledge was collected by questionnaires provided after the training and was submitted before the follow-up meeting, directly after training and six months later.

All the participants were informed about a fifteen-minute personal follow-up directly after the training (or within one day) and six months after the training. The assessor (HB), was a nationally certified head-instructor and educated ALS instructor. The calculated time for the test was three minutes to identify OHCA and perform CPR and about two minutes to use the AED. Before assessment, the participants were asked to participate in a simulated scenario while measuring data and filming. The manikin was wearing a soft jacket and pants and lay on the floor in a real-life environment. After the participant had signed the consent form, a simulated OHCA story was told by the assessor. "You are at work. A colleague looks pale, puts her/his hand in the middle of her/his chest

The BLS research project for lay people in Sweden 2014-2016			
1. SELF-LEARNING App-instruction	5. SELF-LEARNING Film-instruction	9. INSTRUCTOR-LED Film-instruction	13. INSTRUCTOR-LED Film-instruction Comp-feedback
2. SELF-LEARNING App-instruction Pre-web education	6. SELF-LEARNING Film-instruction Pre-web education	10. INSTRUCTOR-LED Film-instruction Pre-web education	14. INSTRUCTOR-LED Film-instruction Comp-feedback Pre-web education
3. SELF-LEARNING App-instruction Reflective-questions	7. SELF-LEARNING Film-instruction Reflective-questions	11. INSTRUCTOR-LED Film-instruction Reflective-questions	15. INSTRUCTOR-LED Film-instruction Comp-feedback Reflective-questions
4. SELF-LEARNING App-instruction Pre-web education Reflective-questions	8. SELF-LEARNING Film-instruction Pre-web education Reflective-questions	12. INSTRUCTOR-LED Film-instruction Pre-web education Reflective-questions	16. INSTRUCTOR-LED Film-instruction Comp-feedback Pre-web education Reflective-questions

Fig. 1 – Design for the basic life support (BLS) with cardio-pulmonary resuscitation (CPR) and automated external defibrillation (AED) research project in workplaces for lay people in Sweden, 2014-2016. The training was based on the 2010 European Resuscitation Council (ERC) guidelines. The main objectives were self-learning training compared with instructor-led training and a preparatory web-based (pre-web) education in addition to the BLS training compared with no preparatory web-based education. Additional training interventions included instructions from a mobile-application (App), reflective questions and a device for feedback on compression depth (Comp-feedback). All training options included practical training on a manikin and a paperboard training AED.

and says, I have chest pain and then suddenly collapses in front of you. Act as if it was a real-life situation!". In the scenario, the assessor was silent, only helped to call 112 if asked and brought the AED to the scene three minutes from start. After one shock and the resumption of CPR, the assessor terminated the scenario.

At data collection, the variables have been structured according to the modified Cardiff Test 3.1[22] (submitted to Data in Brief), scoring adherence to the BLS algorithm (19–70 points). As validation, previous studies [12,14,23–25] were adapted and modified to the 2010 ERC guidelines.[19] The variables in the test comprised checking for responsiveness and breathing, calling for help, asking for an AED, starting CPR, using the AED and resumption of CPR after shock with direct observation and with the SkillReporting system for CPR quality skills, connected to the manikin. Individual variables related to compressions, ventilations, time to start of CPR and time to first shock have been collected from the SkillReporting system. The questionnaire for the present trial included variables on theoretical knowledge of first action if OHCA, i.e. call to 112, self-assessed knowledge, confidence and willingness to act as if a relative or an unknown person had suffered an OHCA (submitted to Data in Brief).

Outcomes

The primary outcome was the total points, scored using the Cardiff Test for adherence to the BLS algorithm, six months after the intervention. The secondary outcomes included the total score directly after the intervention and quality of individual variables, theoretical knowledge of first action, i.e. call to 112, self-assessed knowledge, confidence and willingness to act in a real-life OHCA situation, directly and six months after the intervention.

Analysis

All the available data were included in the analysis (i.e. post-test data were included in the analysis regardless of whether data at retention-test were available and correspondingly for the retention-test, where data were used regardless of whether the post-test was performed). The results are presented as crude numbers and proportions (percent) or as crude medians with 25th, 75th percentiles.

To detect a two-point difference in the mean of the total score for the modified Cardiff Test at the retention-test after six months (primary outcome), with an assumed standard deviation of five points, a significance level of 0.05 (two-sided test) and a power of 95%, an effective sample size of 163 participants in each of the two training groups was needed. The intraclass correlation coefficient was 0.080. Based on an average cluster size of 23.2, the design effect caused by the cluster randomisation was calculated to be 2.78. In our two training groups, 670 and 561 respectively performed the retention-test, which corresponds to an effective sample size of 241 and 202 respectively, i.e. well above the 163 needed to reach a power of 95%.

To account for a potential cluster effect in the training groups, mixed linear regression models were applied for comparisons of the total score and other continuous measurements. For comparisons of proportions, generalized estimation equations (GEE) analysis with logit link function was applied. When proportions were very small (<1.0%), the comparison was performed using Fisher's exact test (i.e. without accounting for clustering).

Due to the imbalance between the two groups regarding some of the participant characteristics, all comparisons between the training groups were adjusted for the possible confounding influence of gender, educational level and previous CPR training. We also accounted for the possible effect of additional interventions (i.e. web education and reflective questions).

All tests are two-sided and p-values below 0.05 were considered statistically significant. All analyses were performed using SAS for Windows, version 9.4.

Results

A total of 1,301 individuals were cluster randomised to self-learning training or instructor-led training. Of these, 15 self-learning and 28 instructor-led individuals did not participate in any of the two tests due to physical or mental reasons or shortage of time, and were thus excluded from the analysis, leaving 1258 study participants (Table 1). Due to technical or logistical reasons, data from 17 self-learning participants and 40 instructor-led participants were incomplete or missing at post-test but were available for the retention-test six months later. Due to physical and other reasons, e.g., experiencing stress and/or a shortage of time, 8 self-learning participants and 19 instructor-led participants did only perform the post-test and not the retention-test at six months. Thus, for the primary outcome, total modified Cardiff Test score at six months, 1231 participants were included in the analysis (Fig. 2).

Total score from the Cardiff Test

There was no statistically significant difference regarding adherence to the BLS algorithm in the total score between the self-learning group (median 59, IQR 55–62) and the instructor-led group (median 59, IQR 55–63) at six months after training ($p = 0.44$) (Table 2).

The instructor-led group had however a statistically significant higher total score than the self-learning group directly after training (median 61, interquartile range (IQR) 58–63 versus median 59, IQR 56–62, $p < 0.0001$).

Table 1 – Characteristics of the participants.

Variables	All participants (n = 1258)	Self-learning training (SLT) (n = 678)	Instructor-led training (ILT) (n = 580)
Age (years)	45.6 ± 12.5	45.2 ± 11.8	46.1 ± 13.3%
Gender			
Male	537 (42.7)	219 (32.3)	318 (54.8)
Female	721 (57.3)	459 (67.7)	262 (45.2)
BMI (kg)	25.6 ± 4.0	25.6 ± 4.2	25.6 ± 3.7
Mother tongue (0/1)[a]			
Swedish	1097 (87.3)	581 (85.7)	516 (89.1)
Other	160 (12.7)	97 (14.3)	63 (10.9)
Educational level at training (1/1)			
Elementary school	109 (8.7)	41 (6.1)	68 (11.7)
High school	585 (46.6)	284 (41.9)	301 (52.0)
College/university	562 (44.7)	352 (52.0)	210 (36.3)
Occupation at training (0/1)			
Blue collar	516 (41.1)	280 (41.3)	236 (40.8)
White collar	492 (39.1)	262 (38.6)	230 (39.7)
Both	249 (19.8)	136 (20.1)	113 (19.5)
Previous CPR training (2/3)			
No previous training	474 (37.8)	229 (33.9)	245 (42.5)
>5 years ago	779 (62.2)	447 (66.1)	332 (57.5)
Previous training on AED use (4/2)			
No previous training	1025 (81.9)	553 (82.0)	472 (81.7)
>5 years ago	227 (18.1)	121 (18.0)	106 (18.3)
Experienced SCA (23/24)			
Yes	100 (8.3)	49 (7.5)	51 (9.2)
No	1111 (91.7)	606 (92.5)	505 (90.8)

Groups with self-learning training (SLT) and instructor-led training (ILT), 5–12 are included (Figs. 1 and 2). Data are presented as the mean ± SD or n (%).
BMI = Body mass index; CPR = Cardiopulmonary resuscitation; AED = Automated external defibrillation; SCA = Sudden cardiac arrest.
[a] Number of participants where information was missing in the two training groups, respectively.

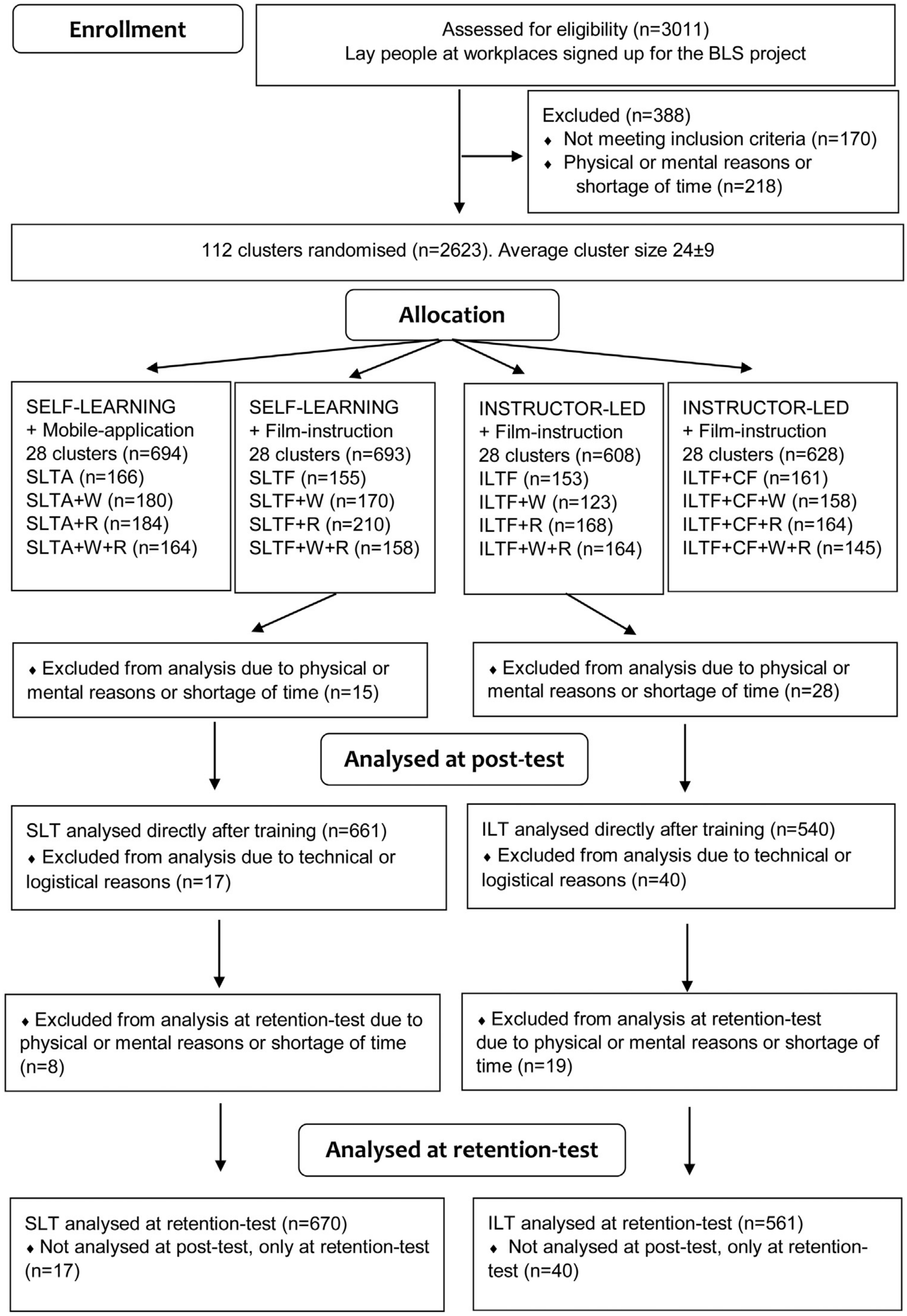

Fig. 2 – Consort flow-chart for comparing self-learning training (SLT) with instructor-led training (ILT) for basic life support (BLS) in a cluster randomised trial. Analysed clusters (groups) used film instructions (Film) for the BLS training. The analysis was adjusted for the clusters who was allocated to the preparatory web-based education (W) and the reflective questions (R). The subgroups with mobile-application instruction (App) and the device for feedback on compression depth (CF) was excluded before analysis.

Individual variables from the SkillReporting system

Retention for checking responsiveness was higher in the instructor-led group than in the self-learning group six months after training. The proportion of participants asking for an AED was significantly higher after the instructor-led training than after the self-learning training at both measurements. The proportion of correct compressions was below 42% and did not differ significantly between the groups either after six months or directly after training (Table 3). There was a more rapid start of CPR and shock delivery in the

Table 2 – Total score from the Cardiff Test of basic life support and external defibrillation, at post-test directly after intervention, and at retention-test six months after intervention.

Variables	BLS %			BLS %		
	Directly after intervention			Six months after intervention		
Min 1 point – max 6 points	SLT (n = 661)	ILT (n = 540)	p-Value	SLT (n = 670)	ILT (n = 561)	p-Value
Checks responsiveness—by talking						
2p. Yes	97	98	0.07	94.2	96.4	0.004
1p. No	3	2		5.8	3.6	
Checks responsiveness—by shaking						
3p. Yes	96.1	96.3	0.21	94.2	95.4	0.04
2p. No	3.8	3.7		5.7	4.1	
1p. Potentially dangerous	0.2	0		0.1	0.5	
Opens airway—by head tilt and chin lift						
5p. Perfect as instructed	49.3	59.3	0.003	38.1	38.3	0.38
4p. Acceptable	5.3	8.1		5.2	8.7	
3p. Attempted other	0.6	1.5		0.3	2.1	
2p. Attempted visible but fails	19.4	13.9		29.6	15.5	
1p. No	25.4	17.2		26.9	35.3	
Checks breathing—by look, listen and feel						
2p. Yes	87.3	93	0.0004	84.3	80.6	0.65
1p. No	12.7	7		15.7	19.4	
Call 112 or asks for call to 112						
2p. Yes	93.6	97.4	0.006	96.3	93.2	0.21
1p. No	6.4	2.6		3.7	6.8	
Asks for an AED						
2p. Yes	76.9	88.5	<0.0001	81.2	85.2	0.05
1p. No	23.1	11.5		18.8	14.8	
Starts CPR—compression/ventilation ratio						
4p. 30:2 (28–32:2)	89.9	90.9	0.17	76	71.7	0.35
3p. Other ratio	9.5	8.1		23.3	27.6	
2p. Compressions only	0.6	0.9		0.7	0.7	
1p. Ventilations only	0	0		0	0	
Hand placement compressions						
4p. Correct	25	23.7	0.57	20.1	26.9	0.07
3p. Other wrong	49.2	48.5		50.1	43.3	
2p. Too low	25.9	27.8		29.7	29.8	
1p. Not attempted	0	0		0	0	
Average compression depth						
6p. 50–59 mm	50.7	56.9	0.51	56	61.1	0.52
5p. ≥60 mm	11	12.8		8.8	10.5	
4p. 35–49 mm	30.4	24.4		30.1	25	
2p. <35 mm	7.9	5.9		5.1	3.4	
1p. Not attempted	0	0		0	0	
Average compression rate						
6p. 100–120	37.1	40.9	0.35	39	39.6	0.52
5p. 121–140	9.7	8		12.1	12.3	
4p. 80–99	34.3	33.7		30.3	29.2	
3p. >140	1.7	0.6		3.6	2	
2p. <80	17.2	16.9		15.1	16.9	
1p. Not attempted	0	0		0	0	

(continued on next page)

Table 2 *(continued)*

Variables	BLS %			BLS %		
	Directly after intervention			Six months after intervention		
Min 1 point – max 6 points	SLT (n = 661)	ILT (n = 540)	p-Value	SLT (n = 670)	ILT (n = 561)	p-Value
Total compressions counted						
6p. 140–190	51	58	0.005	56.3	58.8	0.18
5p. >190	10.1	15		13.4	15.3	
4p. 121–139	19.2	13		13.1	10.7	
3p. 81–120	15.6	12.2		13.1	11.8	
2p. ≤80	4.1	1.9		4	3.4	
1p. Not attempted	0	0		0	0	
Average ventilation volume						
5p. 500–600 ml	8.9	8.5	0.8	8.7	8.6	0.89
4p. 1–499 ml	10.4	11.1		12.1	13	
3p. >600 ml	72.6	74.6		69.7	67	
2p. 0 ml	7.4	4.8		8.8	10.7	
1p. Not attempted	0.6	0.9		0.7	0.7	
Total ventilations counted						
5p. 8–12	59.8	68.5	0.002	57.2	55.6	0.97
4p. 1–7	26	19.1		20.7	17.8	
3p. >12	6.2	6.7		12.5	15.2	
2p. 0	7.4	4.8		8.8	10.7	
1p. Not attempted	0.6	0.9		0.7	0.7	
Total hands-off time						
4p. ≤ 60 s	3.3	2.8	0.55	6.1	4.3	0.06
3p. 61–90 s	49.3	65.9		61.6	61.5	
2p. 91–135 s	44.8	30.7		31.3	32.3	
1p. >135 s	2.6	0.6		0.9	2	
Switches on the AED						
2p. Yes	99.4	99.4	1.00*	100	100	1.00*
1p. No	0.6	0.6		0	0	
Attaches electrode pads						
6p. Both pads completely in areas	89.9	92.4	0.02	91.9	85.9	0.08
5p. One in area, one crossing border of area	5.1	3.3		2.4	5.5	
4p. One in area, one outside area	1.4	2.4		3.4	4.6	
3p. Both crossing border of area	0.3	0		0.4	1.8	
2p. Both outside areas	2.7	1.1		1.8	2.1	
1p. Not attached or not plugged into AED	0.6	0.7		0	0.2	
Checks safety						
2p. Yes	53.9	81.7	<0.0001	48.1	58.8	0.008
1p. No	46.1	18.3		51.9	41.2	
Delivers shock as directed by the AED						
2p. Yes	98.9	99.3	0.76*	99.9	99.6	0.59*
1p. No	1.1	0.7		0.1	0.4	
Resumes CPR immediately after shock						
2p. Yes	91.7	97	0.0002	87.9	89.3	0.2
1p. No	8.3	3		12.1	10.7	
Total score						
Min 19 points – max 70 points						
Median	59	61	<0.0001	59	59	0.44
25th,75th percentile	56,62	58,63		55,62	55,63	
Min, max	37,69	44,68		37,68	40,69	

Data collected from the Resusci Anne manikin, the PC SkillReporting system (Laerdal Medical, Stavanger, Norway) and observations. All available data were used. Groups with self-learning training (SLT) and instructor-led training (ILT), 5–12 are included (Figs. 1 and 2). Except for total score, where mixed linear regression was used, all comparisons were performed using generalized estimation equations (GEE) analysis or, when proportions were very small or very high (<1.0% or >99.0%, '*' in the table), Fisher's exact test, without adjustment for clustering and covariates, was used. All tests are two-sided and p-values below 0.05 were considered statistically significant.

Table 3 – Individual variables for quality of practical skills for cardiopulmonary resuscitation and external defibrillation (CPR-AED), at post-test directly after intervention and at retention-test six months after intervention.

	CPR-AED			CPR-AED		
	Directly after intervention			Six months after intervention		
Individual variables	SLT (n = 661)	ILT (n = 540)	p-Value	SLT (n = 670)	ILT (n = 561)	p-Value
Correct compressions (%) (5/3/0/0)[a]						
Median	34	42	0.15	33	41	0.10
25th, 75th percentile	4,74	8,80		4,74	9,77	
Compressions with insufficient depth (%) (5/3/0/0)						
Median	16	9	0.68	18	9	0.43
25th, 75th percentile	2,81	1,58		2,73	1,51	
Compressions with incorrect hand-position (%) (5/3/0/0)						
Median	20	16	0.12	23	24	0.21
25th, 75th percentile	1,57	1,60		2,67	0,70	
Compressions with incomplete release (%) (5/3/0/0)						
Median	0	0		0	0	
25th, 75th percentile	0,1	0,1		0,0	0,0	
>0 (%)	26.2	29.6	0.47	21.3	25.0	0.47
Average compression depth (mm) (0/0/0/0)						
Median	53	54	0.79	53	54	0.49
25th, 75th percentile	45,58	48,59		46,57	48,58	
Average compression rate (per minute) (0/0/0/0)						
Median	99	99	0.28	102	101	0.08
25th, 75th percentile	84,112	85,110		88,115	86,114	
Correct ventilations (%) (4/2/0/0)						
Median	1	0		1	1	
25th, 75th percentile	0,3	0,2		0,3	0,3	
>0 (%)	52.7	50.2	0.73	53.9	55.4	0.36
Average ventilation volume (ml) (0/0/0/0)						
Median	859	985	0.72	808	780	0.03
25th, 75th percentile	580,1230	587,1302		547,1172	506,1158	
Time to start of CPR (seconds) (0/0/0/0)						
Median	30	27	0.008	27	27	0.32
25th, 75th percentile	23,41	21,35		21,36	20,35	
Time to first shock (seconds) (4/2/0/1)						
Median	68	65	<0.0001	66	69	0.12
25th, 75th percentile	59,83	57,75		58,78	59,82	

Data collected from the Resusci Anne manikin and the PC SkillReporting system (Laerdal Medical, Stavanger, Norway). All available data were used. Groups with self-learning training (SLT) and instructor-led training (ILT), 5–12 are included (Figs. 1 and 2). Mixed linear regression was used, except when the distribution was too scewed. In the latter cases, the comparisons were performed on the dichotomized variable 0/>0, using generalized estimation equations (GEE) analysis. All tests are two-sided and p-values below 0.05 were considered statistically significant.

[a] Number of participants where information was missing in the two training groups at the post-test and retention test, respectively.

instructor-led group as compared with the self-learning group directly after training, but the difference did not remain statistically significant after six months.

Self-assessed knowledge, confidence and willingness

Self-assessed knowledge to be able to perform compressions, ventilations, use of an AED and confidence were statistically significantly higher in the instructor-led group than in the self-learning group directly after training and to perform ventilations as well as using an AED also after six months (Table 4).

Assuming that a relative had suffered an OHCA, more participants in the instructor-led group (98% versus 95%) would give both compressions and ventilations directly after training than in the self-learning group, but no such difference was found after six months. For helping an unknown person suffering an OHCA, fewer participants would give both compressions and ventilations and there was no statistically significant difference between the groups.

Table 4 – Participants self-assessed theoretical knowledge, confidence and willingness to act in a real-life out-of-hospital cardiac arrest (OHCA) situation, directly after intervention and six months after intervention.

	Self-assessment			Self-assessment		
	Directly after intervention			Six months after intervention		
Variables (%)	SLT (n = 661)	ILT (n = 540)	p-Value	SLT (n = 670)	ILT (n = 561)	p-Value
Self-assessed theoretical knowledge and practical skills to be able to perform compressions (95/34/118/78)[a]	95.4	98.2	0.009	97.3	98.3	0.19
Self-assessed theoretical knowledge and practical skills to be able to perform ventilations (93/38/118/84)	94.9	98.6	0.0005	96.9	98.7	0.03
Self-assessed theoretical knowledge and practical skills to be able to use an AED (138/49/144/92)	85.9	97.1	<0.0001	93.7	97.0	0.03
Self-assessed confidence after training (45/22/39/41)	97.4	99.6	0.02	97.8	98.5	0.49
Self-assessed willingness to act if a relative suffers an OHCA (0/0/0/4)						
Would not dare or want to intervene	1.7	0.4	0.05*	1.2	0.5	0.36*
Would give ventilations only	0.6	0.0	0.13*	0.7	0.2	0.23*
Would give chest compressions only	2.7	1.7	0.13	1.6	2.5	0.29
Would give both chest compressions and ventilations	95.0	98.0	0.002	96.4	96.8	0.81
Self-assessed willingness to act if an unknown person suffers an OHCA (5/0/1/5)						
Would not dare or want to intervene	4.4	1.7	0.02	3.9	2.3	0.11
Would give ventilations only	0.5	0.6	1.00*	0.3	0.4	1.00*
Would give chest compressions only	30.5	26.9	0.72	33.5	31.3	0.80
Would give both chest compressions and ventilations	64.6	70.9	0.23	62.3	66.0	0.85
Theoretical knowledge of first action if cardiac arrest, i.e. call to 112 (7/2/9/5)	83.9	84.9	0.55	73.5	68.2	0.39

Data collected from questionnaires. All available data were used. Groups with self-learning training (SLT) and instructor-led training (ILT), 5–12 are included (Figs. 1 and 2). Comparisons were performed using generalized estimation equations (GEE) analysis or, when proportions were very small or very high (<1.0% or >99.0%, '*' in the table), Fisher's exact test, without adjustment for clustering and covariates, was used. All tests are two-sided and p-values below 0.05 were considered statistically significant.

[a] Number of participants where information was missing in the two training groups at the post-test and retention test, respectively.

Discussion

In this trial, we found no statistical evidence of any difference in terms of effectiveness between self-learning training and instructor-led training for BLS, six months after intervention. This result is in accordance with the majority of previous studies,[8–15] apart from one study which resulted in higher retention three months after self-directed training.[16] Self-training kits for BLS have been partially used both in facilitated training and for personal use and have been evaluated as effective.[8,12,21,26] One should also bear in mind that an absence of evidence of a difference is not the same as an evidence of no difference.

We found, using the Cardiff Test as a percentage of the total score that was possible to achieve six months after training, a figure of 78% for both self- and instructor-led learning. We consider this figure to be low. However, previous studies[12,14,24,25] based on the Cardiff Test, have reported the corresponding figures to be as low as 60% and some below 50% of the total score for BLS.

We also evaluated some secondary questions. We found indications that instructor-led training may have some advantages over self-learning training.

Firstly, we found that the total Cardiff Test score for BLS directly after training was higher, when the participants were facilitated by an instructor. It is not known for how long within a period of six months this effect remained. Skills decay after three to six months[7,20] and the retention-test was therefore designed to be performed at six months. If it had been measured after three months, we might have had another result.

Secondly, we found individual variables in favour of the instructor-led training. In this trial actions for recognising of an OHCA, calling for help, asking for an AED, total compressions and ventilations, attaching electrode pads, checking for safety, time to start CPR, time to deliver a shock and resuming CPR after shock were more effectively performed directly after the training when facilitated by an instructor.

Thirdly, we found that, when the participants self-assessed their own theoretical knowledge of compressions, ventilations and using an AED, the instructor-led training resulted in greater self-assessed knowledge directly after and for AED even six months after training. This is in relation to findings from Pedersen et al.[16] Previous research has shown that competence, confidence and willingness increase regardless of self- or instructor-led education.[15,27,28] In our study the instructor-led group self-assessed their own willingness to act with compressions and ventilations on a relative in a real-life OHCA situation higher than in the self-learning group, directly after training. Responses from the self-learning group showed fear of panic and paralysis or that they would only provide compressions (submitted to Data in brief).

Owing to the above indications, this could be understood as meaning that interaction and communication with a human is important when learning. Moreover, reflection by an instructor and combining digital and teaching methods, can further provide more efficient learning.[29–31] As a complement to teaching, self-learning may challenge the participants to experiment and regulate their own learning.[32] However, the statistically significant difference must be interpreted in relation to the clinical relevance.

Medical science emphasises early high-quality CPR and the use of an AED when a victim suffers an OHCA[33,34] and the survival rate increases when medical personnel start CPR outside hospital when compared with lay people.[35] For the quality of practical skills in CPR, there was no statistically significant difference between the groups after six months. Nevertheless, the overall quality level was low. In particular, the proportion of correct compressions was extremely low in both groups. Potential causes may be limitations of the manikin, the duration of the training and that the participants were lay people without or with limited BLS experience. Our results are low when compared with those reported by Pedersen et al.,[16] who reported a median of 47% correct compressions for self-learning three months after training. Their participants were medical students and younger than those in our study and that could be one explanation. Undoubtedly, the proportion of correct compressions must be much higher to meet clinically relevant requirements.

In terms of quality, we found that, for using an AED, only 77% in the self-learning group and 88% in the instructor-led group asked for an AED directly after training. This is remarkably low as both educations contain AED training with instructions from the same national standardised film. This need to be considered for further educational material. Regarding the time to deliver a shock, the instructor-led group acted more rapidly at post-test, but at the retention-test there was no significant difference. The use of an on-site AED increases survival dramatically.[3,36,37] Self-directed training may be an easily available way of learning how to use an AED,[16] despite the fact that the feedback from the instructor appears to be beneficial.[29,38]

Finally, for increased early high-quality CPR-AED, lay people must improve their practical skills. More effective training options,[7] easily accessible for frequent training, should be evaluated.

Limitations

Our trial differed from other studies, which created limitations and difficulties in the comparisons, although individual variables were comparable. All the training was performed on the Mini-Anne manikin whereas the test was on a full-body manikin. The result at six months could have been influenced by the small training manikin and the same film for both groups, and the post-test[39] and some learning on the full-body manikin. Regarding some of the significant differences, the clinical relevance may be argued.

Strengths

The controlled randomisation with lay people and a large sample size was a strength and may provide new knowledge of BLS training at a workplace environment. The training, the organisation with co-ordinators and the group of instructors were stable. The Mini-Anne kit and the instruction film were standardised and included in both groups. There was only one single assessor who was blinded to the types of training alternative. The assessments were filmed and carried out equally in a real-life environment in a remade motorhome which was stationed near the workplaces.

Conclusions

There was no statistically significant difference in practical skills or willingness to act in a real-life OHCA situation when comparing self-learning training with instructor-led training, six months after training in BLS. However, directly after the intervention, practical skills were better when the training was led by an instructor.

Conflict of interest statement

None declared.

Contributors

All the co-authors have made a substantial contribution to the trial. HB, JH, TK and JL developed the study design and power calculation. HB collected the data. JL programmed the database and support for all variables. TK performed the statistical analyses. All co-authors contributed to the interpretation of data and the critical revision of the manuscript. JH was the responsible super-visor. HB wrote the manuscript and was the main author. All authors approved the submitted final version.

Data statement

Additional data is available on request.

Acknowledgements

The trial was supported financially by the Swedish Heart-Lung Foundation (20130629), the Foundation for Cardio-pulmonary Resuscitation in Sweden and the Swedish Resuscitation Council. The study was also financed by grants from the Swedish state under the agreement between the Swedish government and the County Council, the ALF agreement (ALFGBG-716901). A special thanks to the participants, workplaces, instructors, co-ordinators and the review of the language.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2019.03.026.

REFERENCES

1. Perkins GD, Handley AJ, Koster RW, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 2. Adult basic life support and automated external defibrillation. Resuscitation 2015;95:81–99.
2. Herlitz J. Swedish registry of cardiopulmonary resuscitation (SRCR). 2017. https://registercentrum.blob.core.windows.net/shlrsjh/r/-rsrapport-2017-Sy1wvd12Z.pdf.
Berdowski TJ, Blom LM, Bardai GPA, Tan WH, Tijssen WJ, Koster WR. Impact of onsite or dispatched automated external defibrillator

3. use on survival after out-of-hospital cardiac arrest. Circulation 2011;124:2225–32.
4. Hasselqvist-Ax I, Riva G, Herlitz J, et al. Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. N Engl J Med 2015;372:2307–15.
5. Perkins GD, Olasveengen TM, Maconochie I, et al. European Resuscitation Council Guidelines for Resuscitation: 2017 update. Resuscitation 2018;123:43–50.
6. Olasveengen TM, de Caen AR, Mancini ME, et al. 2017 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations summary. Resuscitation 2017;121:201–14.
7. Greif R, Lockey AS, Conaghan P, Lippert A, De Vries W, Monsieurs KG. European Resuscitation Council Guidelines for Resuscitation 2015: Section 10. Education and implementation of resuscitation: Section 10. Education and implementation of resuscitation. Resuscitation 2015;95:288–301.
8. Lynch B, Einspruch EL, Nichol G, Becker LB, Aufderheide TP, Idris A. Effectiveness of a 30-min CPR self-instruction program for lay responders: a controlled randomized study. Resuscitation 2005;67:31–43.
9. Einspruch EL, Lynch B, Aufderheide TP, Nichol G, Becker L. Retention of CPR skills learned in a traditional AHA Heartsaver course versus 30-min video self-training: a controlled randomized study. Resuscitation 2007;74:476–86.
10. Roppolo LP, Pepe PE, Campbell L, et al. Prospective, randomized trial of the effectiveness and retention of 30-min layperson training for cardiopulmonary resuscitation and automated external defibrillators: the American Airlines Study. Resuscitation 2007;74:276–85.
11. Chung CH, Siu AY, Po LL, Lam CY, Wong PC. Comparing the effectiveness of video self-instruction versus traditional classroom instruction targeted at cardiopulmonary resuscitation skills for laypersons: a prospective randomised controlled trial. Hong Kong Med J 2010;16:165–1670.
12. Nielsen AM, Henriksen MJV, Isbye DL, Lippert FK, Rasmussen LS. Acquisition and retention of basic life support skills in an untrained population using a personal resuscitation manikin and video self-instruction (VSI). Resuscitation 2010;81:1156.
13. Mpotos N, Lemoyne S, Calle PA, Deschepper E, Valcke M, Monsieurs KG. Combining video instruction followed by voice feedback in a self-learning station for acquisition of Basic Life Support skills: a randomised non-inferiority trial. Resuscitation 2011;82:896–901.
14. Nielsen AM, Isbye DL, Lippert F, Rasmussen LS. Distributing personal resuscitation manikins in an untrained population: how well are basic life support skills acquired? Emerg Med J 2012;29:587.
15. Mardegan KJ, Schofield MJ, Murphy GC. Comparison of an interactive CD-based and traditional instructor-led Basic Life Support skills training for nurses. Aust Crit Care 2015;28:160–7.
16. Pedersen TH, Kasper N, Roman H, et al. Self-learning basic life support: a randomised controlled trial on learning conditions. Resuscitation 2018;126:147–53.
17. Bylow H. Educational methods in cardio-pulmonary resuscitation and experiences in meeting with the cardiopulmonary practice. Master 2017:06. University of Skövde; 2017. http://his.diva-portal.org/smash/resultList.jsf?query=Bylow&language=en&searchType=SIMPLE&noOfRows=50&sortOrder=author_sort_asc&sortOrder2=title_sort_asc&onlyFullText=false&sf=all&aq=%5B%5B%5D%5D&aqe=%5B%5D&aq2=%5B%5B%5D%5D&af=%5B%22academicTerm_facet%3A%5C%22VT+2017%5C%22%22%5D.
18. Hansson L, Hedner T, Dahlof B. Prospective randomized open blinded end-point (PROBE) study. A novel design for intervention trials. Prospective randomized open blinded end-point. Blood Press 1992;1:113–9.
19. Koster RW, Baubin MA, Bossaert LL, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 2. Adult basic life support and use of automated external defibrillators. Resuscitation 2010;81:1277–92.
20. Soar J, Monsieurs K, Ballance J, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 9. Principles of education in resuscitation. Notfall Rettungsmed 2010;13:723–36.
21. Thorén A-B, Axelsson ÅB, Herlitz J. DVD-based or instructor-led CPR education—a comparison. Resuscitation 2007;72:333–4.
22. Whitfield RH, Newcombe RG, Woollard M. Reliability of the Cardiff Test of basic life support and automated external defibrillation version 3.1. Resuscitation 2003;59:291–314.
23. Nielsen AM, Isbye DL, Lippert FK, Rasmussen LS. Basic life support and automated external defibrillator skills among ambulance personnel: a manikin study performed in a rural low-volume ambulance setting. Scand J Trauma Resusc Emerg Med 2012;20:34.
24. Nord A, Svensson L, Claesson A, 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;25:93.
25. Nord A, Hult H, Kreitz-Sandberg S, Herlitz J, Svensson L, Nilsson L. Effect of two additional interventions, test and reflection, added to standard cardiopulmonary resuscitation training on seventh grade students' practical skills and willingness to act: a cluster randomised trial. BMJ Open 2017;7:e014230.
26. Todd KH, Braslow A, Brennan RT, et al. Randomized, controlled trial of video self-instruction versus traditional CPR training (Clinical report). Ann Emerg Med 1998;31:364.
27. Lynch B, Einspruch EL. With or without an instructor, brief exposure to CPR training produces significant attitude change. Resuscitation 2010;81:568–75.
28. Nielsen AM, Isbye DL, Lippert FK, Rasmussen LS. Can mass education and a television campaign change the attitudes towards cardiopulmonary resuscitation in a rural community? Scand J Trauma Resusc Emerg Med 2013;21:39.
29. Na JU, Lee TR, Kang MJ, et al. Basic life support skill improvement with newly designed renewal programme: cluster randomised study of small-group-discussion method versus practice-while-watching method. Emerg Med J 2014;31:964.
30. Castillo J, Gallart A, Rodríguez E, Castillo J, Gomar C. Basic life support and external defibrillation competences after instruction and at 6 months comparing face-to-face and blended training. Randomised trial. Nurse Educ Today 2018;65:232–8.
31. Van Raemdonck V, Aerenhouts D, Monsieurs K, De Martelaer K. A pilot study of flipped cardiopulmonary resuscitation training: which items can be self-trained? Health Educ J 2017;76:946–55.
32. Kolb DA. Experiential learning: experience as the source of learning and development. Englewood Cliffs, N.J: Prentice Hall; 1984.
33. Finn JC, Bhanji F, Lockey A, Monsieurs K, Frengley R, Iwami T, et al. Part 8: Education, implementation, and teams: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation 2015;95:e203–24.
34. Abella BS. High-quality cardiopulmonary resuscitation: current and future directions. Curr Opin Crit Care 2016;22:218–24.
35. Nord A, Svensson L, Karlsson T, Claesson A, Herlitz J, Nilsson L. Increased survival from out-of-hospital cardiac arrest when off duty medically educated personnel perform CPR compared with laymen. Resuscitation 2017;120:88–94.
36. Blom MT, Beesems SG, Homma PC, et al. Improved survival after out-of-hospital cardiac arrest and use of automated external defibrillators. Circulation 2014;130:1868–75.
37. Ringh M, Jonsson M, Nordberg P, et al. Survival after public access defibrillation in Stockholm, Sweden—a striking success. Resuscitation 2015;91:1–7.
38. de Vries W, Turner NM, Monsieurs KG, Bierens JJLM, Koster RW. Comparison of instructor-led automated external defibrillation training and three alternative DVD-based training methods. Resuscitation 2010;81:1004–9.
39. Kromann CB, Jensen ML, Ringsted C. The effect of testing on skills learning. Med Educ 2009;43:21–7.