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Complete List of Authors:	Nord, Anette; Linköping University, Department of Medical and Health Sciences Hult, Håkan; Karolinska Institute, Department of Clinical Science, Intervention and Technology Kreitz-Sandberg, Susanne; Linköping University, Department of Behavioural Sciences and Learning Herlitz, Johan; Borås University, The Prehospital Research Centre of Western Sweden Svensson, Leif; Karolinska Institute, Department of Medicine Nilsson, Lennart; Linköping University, Department of Medical and Health Sciences
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Effect of test including feedback and reflection added to standard CPR training on students' practical CPR skills and willingness to act: a cluster randomized study

Anette Nord[a], Håkan Hult[b], Susanne Kreitz-Sandberg[c], Johan Herlitz[d], Leif Svensson[e] , Lennart Nilsson[a]

[a]Department of Medical and Health Sciences, Linköping University, Linköping, Sweden

[b]Department of Clinical Science, Intervention and Technology, Karolinska Institute, Stockholm, Sweden

[c]Department of Behavioural Sciences and Learning, Linköping University, Linköping, Sweden

[d]The Prehospital Research Centre of Western Sweden, Borås University, Borås, Sweden

[e]Department of Medicine, Karolinska Institute, Stockholm, Sweden

Corresponding author:
Lennart Nilsson, Department of Medical and Health Sciences, Linköping University, S-58183 Linköping, Sweden. Email: lennart.nilsson@liu.se

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ABSTRACT

Objectives: To investigate if two additional interventions, test and reflection, after standard CPR training facilitate learning by comparing 13-year-old students' practical skills and willingness to act.

Settings: Seventh grade students in two Swedish municipalities.

Design: The classes were randomized to *CPR training only* (O), *CPR training with a practical Test including feedback* (T) or *CPR training with Reflection* and *a practical Test including feedback* (RT). Outcome measures of practical skills and willingness to act were assessed directly after training and at six months using a PC skill reporting system and a survey. Data on CPR skills were registered in a modified version of the Cardiff test and scores were given in 12 categories (12–48 points). Training and measurements were performed from December 2013 to October 2014, according to European Resuscitation Council guidelines 2010.

Participants: Twenty-nine classes or 587 seventh grade students were included in the study.

Primary and secondary outcome measures: Primary endpoint was the total score of the modified Cardiff test. The individual variables of the test and self-reported willingness to make a life-saving intervention were secondary endpoints.

Results: At six months the T and O group scored 32 (30–35) versus 30 (27–33) points ($p<0.001$), while the RT group scored 31 (29–35) points (not significant when compared with T). There were no significant differences in willingness to act between the groups after six months.

Conclusions: A practical test including feedback directly after training improved the students' acquisition of practical CPR skills. Reflection did not increase CPR skills. At six-month follow-up, no intervention effect was found regarding willingness to make a lifesaving effort.

Keywords: CPR training; Skill test; Reflection; Willingness; Feedback; Students

Strengths and limitations of this study

- Key concepts in educational science, the effect of test including feedback and reflection as additional interventions after standard CPR training, were evaluated in a cluster randomized trial.
- Outcome measures of practical CPR skills and willingness to act were assessed directly after training and at six months follow up.
- The intervention was carried out in two major municipalities with schools from all socioeconomic areas.
- The study was not designed to explain the cause of any potential differences observed.

INTRODUCTION

Sudden unexpected cardiac arrest is one of the most common causes of death in Europe.[1] Early identification of the cardiac arrest and prompt initiation of bystander cardiopulmonary resuscitation (CPR) are the cornerstones of resuscitation and crucial for survival in out-of-hospital cardiac arrest (OHCA),[2]. Early CPR increases the chance of survival two to three times,[3-4]. If all students receive practical CPR training in school, a large proportion of the population will have basic skills within a few decades. Such a situation could potentially increase the lay resuscitation rate,[2, 5-7].

Education in CPR can be delivered in different formats. There is a knowledge gap regarding what is the optimal method of CPR training to acquire CPR skills,[8]. Participants' CPR skills after training are limited and decrease within months after training,[2, 9-10].

Learning is a complex process, influenced by several factors,[11-12]. Key concepts in educational science are e.g. test, feedback and reflection. Studies show that tests in various formats can increase learning outcomes,[13-15]. Feedback has a powerful influence on performance,[16]. According to the Swedish school curriculum, students are expected to reflect on different situations and events and on their learning,[11]. A core content in CPR training for the public is practical training; reflection and discussion with the other participants are limited.

The aim of this study was to investigate if two additional interventions, test and reflection, after standard CPR training facilitate learning by comparing 13-year-old students' practical skills and willingness to act. We hypothesized that both the test and the reflection would provide an additional learning session and contribute to improved knowledge,[12-13].

METHODS

Study population and design

All council schools with seventh grade students (13 years of age) in two Swedish municipalities were invited to participate in the study. Four schools did not respond and two had CPR education only in grade 9. In the framework of this study, the intervention methods have been applied in 13 schools. Before study participation, students and their guardians received a letter with study information. Participation of individual students was voluntary and all participants gave oral informed consent.

Seventh grade students in participating schools were eligible for inclusion. Students were excluded if they did not want to participate or had a physical handicap that limited their physical performance; classes of students with development disabilities (these classes are age-integrated with fewer students per class) were also excluded.

The study used a cluster randomized design,[17], where each school class were allocated to one of three groups using a randomization list generated by an independent statistician. The interventions of the groups were based on core concepts in pedagogy; test, feedback and reflection. To evaluate the effect of test including feedback and reflection, the groups were as follows:

- CPR training only (O)
- CPR training with a practical skill test including feedback (T)
- CPR training with reflection and a practical skill test including feedback (RT).

It was important that the design of the interventions facilitated implementation, that the education was brief enough to fit into one lesson, could be given to the whole class at the same time and that training could be provided by teachers at the school (less costly, facilitates scheduling),[6, 9, 18-19]. Outcome, were assessed directly after training and at six months. Training and measurements were performed from December 2013 to October 2014.

Standard CPR training applied in all groups

All intervention groups (O, T and RT) received standardized practical CPR training and the participants used an individual training manikin, MiniAnne, during training. The CPR education was performed in accordance with the European Resuscitation Council guidelines 2010,[20]. Training was given to the entire class. Classes consisted of 14–29 students. Teachers at the schools, who all were CPR instructors, were responsible for the CPR training,[6, 9, 18]. All teachers obtained individual oral and written information to ensure that they were up to date with the present interventions. The training was either mobile application or DVD-based,[21], evenly distributed in the intervention groups (Table 1). The teachers acted as facilitators; they introduced the lesson, gave advice on the fly, answered questions and completed the course. After the standardized practical CPR training, the additional interventions, test and reflection, were performed.

Table 1. Characteristics of the students.

	CPR only (O) (*n*=171)	CPR + test and feedback (T) (*n*=224)	O vs T p-value	CPR + reflection + test and feedback (RT) (*n*=192)	T vs RT p-value
Male	88 (52)	116 (52)	NS	79 (41)	0.03
Previous compression training	49 (29)	54 (24)	NS	49 (26)	NS
Previous ventilation training	34 (20)	41 (18)	NS	39 (20)	NS
DVD method	99 (58)	111 (50)	NS	97 (50)	NS
App method	72 (42)	113 (50)	NS	95 (50)	NS
Number of schools in which methods were applied	8	7		9	

A total of 587 participants were included in the analyses, distributed in three groups. Values are presented as *n* (%). Differences in proportions between groups were analysed by Pearson's χ^2 test. NS, not significant.

Additional intervention with a practical test including feedback

To compare learning outcomes, the students performed a practical test for three minutes directly after the CPR training. Tests can increase learning outcomes, therefore we chose to investigate if the test contributed to the learning session,[13-15]. All tests were conducted at the schools, one student at a time. The student was introduced to the test by the following story: 'You see an adult, someone you know, who collapsed in front of you. There is no one more on site. Show how you would act in a real life situation'. The test leader answered questions about the victim's condition only if relevant actions had already been carried out. The optimal conduct was 30 seconds to check responsiveness, check respiration and call for help, followed by 2.5 minutes of CPR. During the CPR, participants' were expected to perform at least five cycles of 30 compressions and two ventilations.

Laerdal PC skill reporting system version 2.4, linked to resuscitation manikin ResusciAnne, was used to automatically measure quantitative data; compression/ventilation ratio, hand-position, compression depth, total number of compressions and ventilations, ventilation volume and hands-off time. The participants' actions regarding checking

responsiveness, checking respiration and calling for help were assessed by direct observation. Data were recorded directly into a scoring sheet, a modified version of the validated Cardiff test,[22]. A score was given in each category and added up to a total score of 12–48 points. All categories on the scoring sheet are described in detail in Supplementary File 1.

After the test, the investigator gave individual feedback for two minutes. The feedback was partly based on Hattie and Timperley's model, which addresses the following questions: "where am I going" (the goals), "how am I going?" (feedback) and "where to next?" (advice on progress),[24].

Additional intervention with reflection

After the CPR training, the students discussed three reflective questions for 15 minutes. The teacher asked one question at a time. The students discussed and reflected on each question pairwise. The pairs then shared what they had discussed with the whole class. The teacher summarized the answers and asked the next question. In the present study, the aim of the reflection was afterthought,[25-26]. Reflections were based on the students' experience, understanding and knowledge and could be enriched with interpretations from a person with more experience,[27]. The three questions were (1) Imagine yourself in a situation where you see a person suffering from a cardiac arrest. Reflect on which factors influence if you would intervene in a real situation? Remember that your actions may be the difference between life and death. (2) You are alone when a person suffers from a cardiac arrest. According to the guidelines, you should first call 112 and then start CPR, why this order? (3) Place your hands on the correct compression position on yourself. Reflect on the compression position. Why should the heel of the hand be placed in the centre of the victims' chest? The selection of questions were based on the following: we wanted the students to think about performing a lifesaving intervention so that during the training they would consider how they would act in a real-life situation; in a pre-study, most students failed to call 112; and previous studies have shown that a large proportion of participants apply an incorrect hand position during chest compression,[23, 28-29].

Assessment

Directly after training and after six months, all students in all intervention groups answered a fixed-response questionnaire, which included questions on background factors and willingness to act (Supplementary File 2). Before our study, comprehension of the questionnaire was tested and found satisfactory in a separate cohort of 175 students.

At the six-month follow-up, all participants in all intervention groups individually performed a practical CPR test (retention test). The retention test was carried out without prior notice and was conducted in same way as the "additional intervention with a practical test including feedback ". All measurements were carried out by one investigator (AN) experienced in the modified Cardiff test and blinded to the training method of the students.

Study outcome measures

The primary endpoint was the total score for the modified Cardiff test. The scores in the individual test categories and self-reported willingness to make a lifesaving intervention were secondary endpoints.

Statistical plan and analyses

Sample size calculations were based on data from a pre-study,[28]. In order to detect a two-point difference in the total score of the modified Cardiff test, at a significance level of 0.05, an effective sample size of 76 students was needed to test for superiority with a power

of 80%. The intraclass correlation coefficient (95% CI) was 0.26 (0.24, 0.29),[17, 30]. The design effect, caused by the cluster randomization, was 5.99. A total of 587 and 549 students performed the first and the second test, respectively. This corresponds to an effective sample size of 98 and 92, respectively, which is above the 76 needed to reach a power of 80%.

To evaluate the effect of test including feedback, group O was compared to group T. To assess the effect of reflection, group T was compared to group RT. Data were presented as proportions (percent) or median (interquartile range). Differences in proportions were analysed with Pearson's χ^2 test. Differences in median total score between the intervention groups were assessed using Mann-Whitney U test. By calculating the (individual total score – 12)/(maximum total score – 12) × 100, we obtained a measure of CPR quality in relation to optimal CPR. $p<0.05$ was considered statistically significant. Analyses were performed using IBM SPSS version 21 and STATA version 13.1.

RESULTS

Twenty-nine classes involving 587 students were included in the measurements directly after training; 549 (94%) of these students completed the retest at six months (Fig. 1). The students' characteristics are summarized in Table 1.

CPR only (O) versus CPR with a practical test including feedback (T)

At six months, group T (n=224) performed better than group O (n=171) in terms of total score: 32 (30–35) points (56% of maximum score) versus 30 (27–33) points (50% of maximum score), $p<0.001$. For the individual variables, group T performed significantly better in eight of 12 variables. Results of the modified Cardiff test are summarized in Table 2.

Table 2. Assessment of CPR skills at the 6-month follow-up.

	CPR only (O) (n=152)	CPR + test and feedback (T) (n=213)	p-value
Checks responsiveness by talking			
2: Yes	23 (15)	53 (25)	0.024
1: No	129 (85)	160 (75)	
Checks responsiveness by shaking			
3: Yes	25 (16)	59 (28)	0.012
2: No	127 (84)	154 (72)	
3: Potentially dangerous	0	0	
Open airway – chin lift, head tilt			
5: Perfect	0	1 (1)	NS
4: Acceptable	2 (1)	6 (3)	
3: Attempted other	0	0	
2: Only one element	8 (5)	21 (10)	
1: No	142 (94)	185 (87)	
Checks respiration – see, listen, feel			
2: Yes	49 (32)	97 (46)	0.011
1: No	103 (68)	116 (54)	
Call 112			
2: Yes	80 (53)	171 (80)	<0.001
1: No	72 (47)	42 (20)	
Compression/ventilation ratio			
4: 30:2 (28-32:2)	28 (18)	67 (32)	0.011
3: Other ratio	104 (68)	129 (61)	
2: Compressions only	20 (13)	17 (8)	
1: Ventilations only	0	0	
Hand position during compression			
4: Correct	8 (5)	7 (3)	NS
3: Other wrong	59 (39)	107 (50)	
2: Too low	85 (56)	99 (46)	

1: Not attempted	0	0	
Average compression depth			
6: 50–59 mm	55 (36)	79 (37)	0.030
5: ≥ 60 mm	0	6 (3)	
4: 35–49 mm	61 (40)	97 (46)	
2: 1–34 mm	36 (24)	31 (15)	
1: Not attempted	0	0	
Total compression counted			
6: 140–190	52 (34)	75 (35)	NS
5: ≥191	62 (41)	100 (47)	
4: 121–139	11 (7)	19 (9)	
3: 81–120	21 (14)	14 (7)	
2: 1–80	6 (4)	5 (2)	
1: Not attempted	0	0	
Average ventilation volume			
5: 500–600 ml	5 (3)	7 (3)	<0.001
4: 1–499 ml	11 (7)	21 (10)	
3: ≥601 ml	27 (18)	91 (43)	
2: 0 ml	87 (57)	77 (36)	
1: Not attempted	22 (14)	17 (8)	
Total ventilation counted			
5: 8–12	15 (10)	34 (16)	<0.001
4: 1–7	13 (9)	44 (21)	
3: ≥13	15 (10)	41 (19)	
2: 0	87 (57)	77 (36)	
1: Not attempted	22 (14)	17 (8)	
Total hands-off time			
4: 0–60 s	55 (36)	62 (29)	0.024
3: 61–90 s	62 (41)	120 (56)	
2: 91–135 s	33 (22)	30 (14)	
1: 136–180 s	2 (1)	1 (1)	
Total score	30 (27–33)	32 (30–35)	<0.001

Results are presented as *n* (%) or median (25th–75th percentile). Differences in proportions between groups were analysed by Pearson's χ^2 test. Differences in total score between intervention groups were analysed by Mann-Whitney U test. *P*-values <0.05 were considered statistically significant. NS, not significant. The table lists the variable's best option at the top. All numbers are rounded to the nearest whole number.

CPR with a practical test including feedback (T) versus CPR with reflection and a practical test including feedback (RT)

Directly after training and at the six-month follow-up, there were no significant differences between group RT (*n*=192) and group T (*n*=224) with regard to the total score of the modified Cardiff test, calling 112 or hand-position during compressions (Table 3). Directly after CPR training, both groups scored 34 (31–37) points (61% of maximum score); and at the six-month follow-up, group RT scored 31 (29–35) points (53% of maximum score) and group T scored 32 (30–35) points (56% of maximum score). Table 3 includes the variables of the practical test that are direct linked to the intervention of reflection as well as the total score of the test. All other variables of the test showed no significant differences between the two groups (T versus RT) and have not been included in the table.

Table 3. Assessment of CPR skills directly after training and at 6 months.

	CPR + test and feedback (T), directly after (*n*=224)	CPR + reflection + test and feedback (RT), directly after (*n*=192)	*p*-value	CPR + test and feedback (T), 6 months (*n*=213)	CPR + reflection + test and feedback (RT), 6 months (*n*=184)	*p*-value
Call 112						
2: Yes	161 (72)	152 (79)	NS	171 (80)	147 (80)	NS

1: No	63 (28)	40 (21)		42 (20)	37 (20)	
Hand position during compression						
4: Correct	21 (9)	15 (8)	NS	7 (3)	7 (4)	NS
3: Other wrong	130 (58)	115 (60)		107 (50)	95 (52)	
2: Too low	73 (33)	62 (32)		99 (46)	82 (45)	
1: Not attempted	0	0		0	0	
Total score	34 (31–37)	34 (31–37)	NS	32 (30–35)	31 (29–35)	NS
How to act if at friend suffer cardiac arrest?						
Compression and ventilation	178 (80)	155 (81)	NS	155 (73)	143 (78)	NS
Compressions only	35 (16)	33 (17)		41 (19)	37 (20)	
Ventilations only	2 (1)	1 (1)		1 (<1)	0	
Not dare to act	9 (4)	2 (1)		14 (7)	4 (2)	
Missing	0	1 (1)		2 (1)	0	
How to act if at stranger suffer cardiac arrest?						
Compression and ventilation	71 (32)	67 (35)	0.006	66 (31)	53 (29)	NS
Compressions only	116 (52)	113 (59)		111 (52)	106 (58)	
Ventilations only	3 (1)	0		0	1 (1)	
Not dare to act	34 (15)	11 (6)		34 (16)	24 (13)	
Missing	0	1 (1)		2 (1)	0	

Results are presented as *n* (%) or median (25th–75th percentile). Differences in proportions between groups were analysed by Pearson's χ^2 test. Differences in total score between intervention groups were analysed by Mann-Whitney U test. *p* values <0.05 were considered statistically significant. NS, not significant. All numbers are rounded to the nearest whole number.

Willingness to act

Directly after training, a lower proportion of the students in group O versus group T stated that they felt more confident about acting compared with before training (73% versus 88%; p=0.002) and at retest (73% versus 82%; p=0.025). There were also differences in how the students considered that they had enough knowledge to do chest compressions, 60% (O) versus 81% (T, p<0.001), and to do rescue breathing, 57% versus 75% (p<0.001). At six months, 84% (O) versus 91% (T, not significant) considered they had enough knowledge to do chest compressions and 59% (O) versus 74% (T, p=0.007) to do rescue breathing. There were no significant differences between group T and group RT regarding confidence about acting or self-rated knowledge either after training or at six months.

Directly after training, most students responded that they would do both compressions and ventilations if a friend suffered OHCA; 72% (O), 80% (T) and 81% (RT). If a stranger suffered OHCA, there was a significant difference between group T and group RT in how the students would act, with a more positive attitude in group RT (Table 3) but there was no significant difference between groups O and T.

At six-month follow-up, there were no significant differences between the three intervention groups with regard to how they would act in OHCA situations; 76% (O), 73% (T) and 78% (RT) would do both compressions and ventilations if a friend suffered a cardiac arrest. Only 31% (O and T) versus 29% (RT) were prepared to do compressions and ventilations if a stranger suffered a cardiac arrest.

DISCUSSION

The main findings of the present study are threefold. First, adding a practical test with feedback after CPR training resulted in significantly improved practical skills at the six-month follow-up. Second, reflection added to CPR training did not influence the practical skills. Third, adding a practical test with feedback or reflection to CPR training did not affect long-term willingness to make a lifesaving effort. The study was carried out in schools from all

socioeconomic areas and each intervention was applied in 7–9 different schools, strengthening the generalizability of our findings.

The group with a practical test including feedback (T) added after CPR training showed superior practical skills at six months compared with the group with CPR training only (O). However, the clinical relevance of the two-point difference in the total score for the modified Cardiff test is unclear. We discuss possible reasons for the outcome linked to learning theories. The result may be due to a further three minutes of hands-on training under the supervision of the investigator, or due to the individual feedback the students received after the test,[14]. Previous studies indicate that testing can increase learning outcome compared with an equal amount of time spent on training,[13, 15]. The test was not only a tool to assess skills but also an opportunity to give the students feedback,[31]. The feedback aimed to reduce discrepancies between present understanding and the goal,[24]. Qi et al,[16] indicate that a pre-test and feedback can inspire learners to develop strategies to minimize their dependence on feedback from the instructors, which improve skill acquisition and skill retention. At feedback, the question "where to next?" was assumed to be the most important question, while praise for a task seems to be less effective,[24, 32]. A limitation is that the feedback to the students was given when the training was completed. In a pre-study, some students indicated that feedback helped to strengthen their self-esteem,[28]. According to Bandura,[33] and social cognitive theory, an individual's self-efficacy may affect a person's performance. Self-efficacy is about a person's confidence in their own ability (not actual ability) in a given situation. Self-efficacy can be affected by verbal persuasion,[34]. Further studies are needed to elucidate whether the results were caused by the additional training during supervision or by the feedback given to the students. Use of a feedback device is another form of feedback that may improve skill acquisition,[2]. A feedback device was not tested in this study.

According to the Swedish school curriculum, knowledge "can be expressed in a variety of forms, as facts, understanding, skills, familiarity and accumulated experience",[11]. Reflection and practical training are two teaching methods that can contribute to understanding, skills and familiarity. There are many definitions of reflection, which implies that there are many different models,[26-27]. In this study, the aim of the reflection was afterthought,[25-26]. Adding reflection to CPR training did not influence the students' practical skills. In particular, reflection did not improve calling 112 and hand positioning during compressions, despite both being included in the reflective questions. Directly after training, a higher proportion of students in the reflection group were willing to intervene if a stranger suffered a cardiac arrest, but this difference could not be observed at six months. This result might, at least in part, be explained by the content and the framing of the reflective questions. The first question, concerning how the students would act in an OHCA situation, is based on ethical considerations, which may provoke emotions and empathy in students,[35]. These emotions might have affected the participants close to the training but not in the long term. Question two (calling 112) and question three (hand positioning during compressions) were a cognitive complement to the practical training. Thus, the students might have discussed and answered these questions as knowledge questions, rather than questions to reflect upon. Perhaps the outcome would have been different if these reflective questions had been asked when the action was practiced, so-called reflection on action,[27]. Mann et al,[26] stated that there is no evidence to support or refute the assumption that reflection will enhance competence. Ixer,[36] stated that we do not know enough about reflection or how it can enhance learning. Further research is needed to clarify whether and how reflection can be used as a successful teaching tool in CPR training.

Practical training increases willingness to intervene in a real situation,[2, 37]. At the six-month follow-up, the three intervention groups did not differ with regard to willingness to make a lifesaving effort. Regardless of the intervention method, we found, in accordance with previous studies, a huge difference in willingness to intervene in an OHCA situation involving a friend compared with a situation involving a stranger,[37-39].

Study limitations

First, we cannot exclude that students who performed a test directly after training were more familiar with the test manikin at the retention test at six months. However, during the test the participants do not take part of the technical feedback received from the full-body Resusci-Anne and should thus not have any advantage. The same design has also been used in other studies,[14, 23].

Second, it is a risk that the instructors' experience and/or enthusiasm affect learning. Therefore, the methods were standardized to ensure equivalent education; the teacher only had a role as a facilitator and the practical exercises were based on instructions from the app and the DVD.

Third, the intervention was carried out in two major municipalities. We do not know how applicable the results are for other locations, but a strength of the present study is that schools from all socioeconomic areas were included.

CONCLUSIONS

This study contributes to knowledge on the efficiency of two additional CPR training interventions. A practical test with feedback in connection with CPR training is an efficient strategy to increase learning outcome, both practical skills and self-rated knowledge, when teaching seventh grade students. Further studies are needed to find alternative methods for testing and feedback, and to elucidate how feedback works most effectively in the CPR learning process. Reflective questions, in the format applied in this study, did not increase the participants' practical CPR skills. Most students, regardless of the intervention applied, indicated they would intervene in an OHCA situation.

Competing interests

None declared.

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Contributors

AN contributed to the study design, developed the modified Cardiff test and the questionnaire, conducted all measurements, analysed results and wrote the initial draft of the manuscript. LS and JH contributed to the study design, developed the modified Cardiff test and revised the manuscript. HH and SKS contributed to the study design and revised the manuscript. LN contributed to the study design, developed the modified Cardiff test and the questionnaire, analysed results and revision of the manuscript.

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Ethics approval

The study was approved by the Regional Ethical Review Board of Linköping, Sweden (2013/358-31).

Data sharing statement

No additional unpublished data is available.

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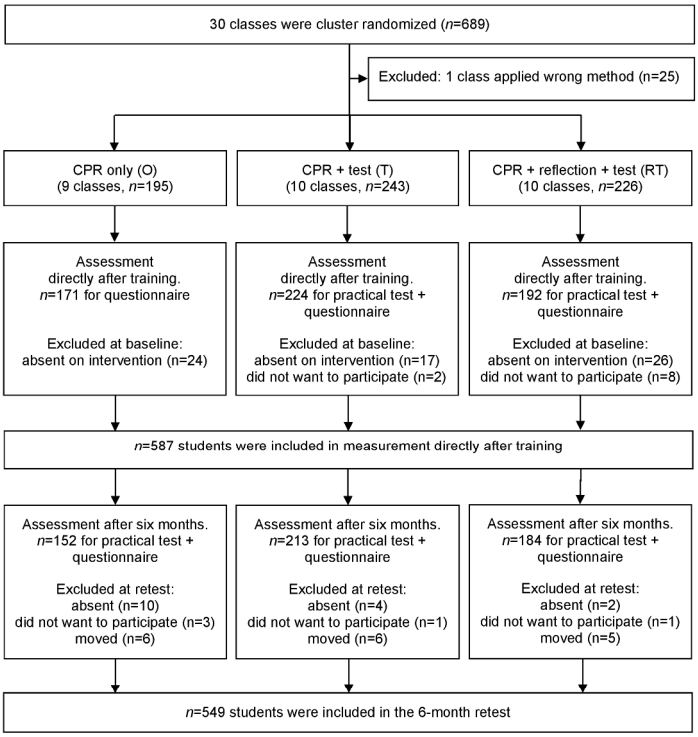
Figure 1 Flow chart on randomization and inclusion.

Figure 1. Flowchart on randomization and inclusion.



209x297mm (300 x 300 DPI)

Supplementary file: the modified Cardiff test.

The modified version of the Cardiff test, adapted to the ERC guidelines of 2010,[20, 22]. The duration of the practical test was 3 minutes. The optimal conduct was 30 seconds for check responsiveness, check respiration and call for help, followed by 2.5 minutes of CPR. During the CPR, the participants were expected to perform at least 5 cycles of 30 compressions and 2 ventilations (30:2). The rules of assessment were pre-specified as follows:

Check responsiveness by talking
2. Yes, if some form of verbal communication as “are you ok” or “how are you”?
1. No, if no attempt at verbal communication was performed
Method: direct observation and real-time registration in the observation schedule by the test leader.

Check responsiveness by shaking
3. Yes, if the rescuer gently shake the victim shoulders.
2. No, if no attempt to shake the victim shoulders occurred.
1. Potentially dangerous, if the rescuer violently shakes the victim´s shoulders so the head lifted up and down against the ground, which can damage the head or the neck.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Open the airway - chin lift, head tilt.
5. Perfect, if one hand on the forehead, two fingertips on the jawbone (not soft tissue) and gently lifted the chin and bent the head back ie by ERC guidelines.
4 Acceptable/partially correct if several indicators are performed, but not all.
3. Attempted other, if the rescuer tried in other ways than ERC recommendation.
2. Only one element is performed or if the rescuer tries but fails.
1. No, if no attempt to open the airway was performed.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Checks respiration - see, listen, feel
2. Yes, if the rescuer did attempts of breath control, even if not all three actions see, listen and feel were performed and although if the total time of the control was less than 10 seconds.
1. No, if no attempt to check for breathing was performed.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Dials 112
2. Yes, dials 112 within the first minute. A call for help without dialling 112 was not enough, since students were instructed they were alone at the site.
1. No, if no attempt to get help was performed.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Compression/ventilation ratio
4. 30:2 (28-32:2), if the rescuer practical applied compressions and ventilations with the relationship 28-32:2 during the whole test. Participants unable to ventilate the manikin but who attempted a ratio of 28-32:2 were registered as such, as they apparently had learned the skill ratio.
3. Other ratio, if the rescuer applied different ratio of compressions and ventilations than 28-32:2.
2. Compressions only.
1. Ventilations only.
Method: Direct observation and real-time registration in combination with data from Laerdal PC Skill Reporter Systems transferred to the scoring sheet after the test.

Hand-position during compression
Incorrect hand-position was recorded if one compression was in the wrong place, since one wrong compression can cause rib fracture or fracture the xiphoid process of sternum.
4. Correct, if the rescuer place the heel of one hand in the centre of the victim’s chest and with the other hand above.
3. Other wrong, if the rescuer performs chest compressions too high up on the sternum or to the side of the sternum.
2. Too low, if the rescuer performs chest compressions too low on the sternum.
1. Not attempted, if no compressions were performed.

Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Average compression depth
The ERC guidelines recommend a compression depth of 50-60 mm,[20]. The PC Skill Reporter system version 2.4 measures up to 60 mm compression depth. To avoid that those who compress >60 mm obtain the highest score, highest score was given for an average compression depth of 50-59 mm. Those who compressed ≥60 mm received 5 points. We chose to retain the 6-point scale, as in previous studies,[23] even though no one could receive 3 points, which would corresponded to a >65 mm compression depth.
6. 50-59 mm.
5. ≥ 60 mm
4. 35-49 mm
2. 1-34 mm
1. Not attempted, if no compressions were performed.
Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Total compression counted
6. 140-190
5. ≥ 191
4. 121-139
3. 81-120
2. 1-80
1. Not attempted, if no compressions were performed.
Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Average ventilation volume
5. 500-600 ml
4. 1-499 ml
3. ≥ 601 ml
2. 0 ml, if the rescuer tried to do rescue breaths but failed.
1. Not attempted, if no rescue breaths were performed.
Method: Direct observation and real-time registration if the rescuer tried to do rescue breath. Exact volume, from Laerdal PC Skill Reporter Systems, was transferred to the scoring sheet after the test.

Total ventilation counted
5.8-12
4. 1-7
3. ≥ 13
2. 0, if the rescuer tried to do rescue breaths but failed.
1. Not attempted, if no rescue breaths were performed.
Method: Direct observation and real-time registration if the rescuer tried to do rescue breath. Exact number, from Laerdal PC Skill Reporter Systems, was transferred to the scoring sheet after the test.

Total ”hands-off” time
Total hands-off time was the total time when compressions were not being performed (i.e. also includes time for check responsiveness, check respiration and dial 112).
4. 0-60 s
3. 61-90 s
2. 91-135 s
1. 136-180 s
Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Supplementary file: questionnaires used directly after training and at six months follow-up

Questionnaire directly after training

Have you previously practiced

chest compressions?	Yes ☐	No ☐
ventilations?	Yes ☐	No ☐

Do you think that your skills are sufficient to perform

chest compressions?	Yes ☐	No ☐	Do not know ☐
ventilations?	Yes ☐	No ☐	Do not know ☐

Are you more confident now than before the training to act and start CPR?	Yes ☐	No ☐	Do not know ☐

You are at home. How would you act if a friend or relative suffered a sudden cardiac arrest? Tick one answer:

I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would give ventilations only ☐
I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?

Lack of knowledge ☐
Afraid to hurt the person ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?

Lack of knowledge ☐
Afraid to hurt the person ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

You are standing at a bus stop. How would you act if an unknown person suffered a sudden cardiac arrest? Tick one answer:

I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would give ventilations only ☐

I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?

Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?

Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Questionnaire at six months follow-up

Have you done a lifesaving intervention in real life after the CPR training? Yes ☐ No ☐

If yes, please describe your lifesaving intervention and the situation:_____

Do you think it is important to learn cardiopulmonary resuscitation in school? Yes ☐ No ☐ Do not know ☐

Do you think that your skills are sufficient to perform

chest compressions? Yes ☐ No ☐ Do not know ☐

ventilations? Yes ☐ No ☐ Do not know ☐

Are you more confident now than before the training to act and start CPR? Yes ☐ No ☐ Do not know ☐

You are at home. How would you act if a friend or relative suffered a sudden cardiac arrest? Tick one answer:

I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would give ventilations only ☐
I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?

Lack of knowledge ☐
Afraid to hurt the person ☐

Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?
Lack of knowledge ☐
Afraid to hurt the person ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

You are standing at a bus stop. How would you act if an unknown person suffered a sudden cardiac arrest? Tick one answer:
I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would only give ventilations ☐
I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?
Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?
Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

How many times have you used/read on the app "Save the heart" (including any lesson in school)?
1 ☐
2-3 ☐
4-5 ☐
> 5 ☐
Do not know ☐

Have you shown the app for someone else? Yes ☐ No ☐ Do not know ☐

CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	1
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	2
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	4
	2b	Specific objectives or hypotheses	4
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	4-5
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	N/A
Participants	4a	Eligibility criteria for participants	4
	4b	Settings and locations where the data were collected	4
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	4-6
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	6
	6b	Any changes to trial outcomes after the trial commenced, with reasons	N/A
Sample size	7a	How sample size was determined	6-7
	7b	When applicable, explanation of any interim analyses and stopping guidelines	N/A
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	4
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	4
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	4
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	4, 6
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those	6

		assessing outcomes) and how	
	11b	If relevant, description of the similarity of interventions	5-6
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	6-7
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	N/A
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	7-8 and Figure 1
	13b	For each group, losses and exclusions after randomisation, together with reasons	Figure 1
Recruitment	14a	Dates defining the periods of recruitment and follow-up	5
	14b	Why the trial ended or was stopped	N/A
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	Table 1
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	7-9 and Figure 1
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	7-9
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	N/A
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	N/A
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	N/A
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	3, 10, 11
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	9-10
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	10-11
Other information			
Registration	23	Registration number and name of trial registry	N/A
Protocol	24	Where the full trial protocol can be accessed, if available	N/A
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	12

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

BMJ Open

Effect of test including feedback and reflection added to standard CPR training on students' practical CPR skills and willingness to act: a cluster randomized study

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Keywords:	CPR training, Skill test, Reflection, Willingness, Feedback, Students

Effect of test including feedback and reflection added to standard CPR training on students' practical CPR skills and willingness to act: a cluster randomized study

Anette Nord[a], Håkan Hult[b], Susanne Kreitz-Sandberg[c], Johan Herlitz[d], Leif Svensson[e] , Lennart Nilsson[a]

[a]Department of Medical and Health Sciences, Linköping University, Linköping, Sweden

[b]Department of Clinical Science, Intervention and Technology, Karolinska Institute, Stockholm, Sweden

[c]Department of Behavioural Sciences and Learning, Linköping University, Linköping, Sweden

[d]The Prehospital Research Centre of Western Sweden, Borås University, Borås, Sweden

[e]Department of Medicine, Karolinska Institute, Stockholm, Sweden

Corresponding author:
Lennart Nilsson, Department of Medical and Health Sciences, Linköping University, S-58183 Linköping, Sweden. Email: lennart.nilsson@liu.se

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ABSTRACT

Objectives: To investigate if two additional interventions, test and reflection, after standard CPR training facilitate learning by comparing 13-year-old students' practical skills and willingness to act.

Settings: Seventh grade students in two Swedish municipalities.

Design: The classes were randomized to *CPR training only* (O), *CPR training with a practical Test including feedback* (T) or *CPR training with Reflection and a practical Test including feedback* (RT). Outcome measures of practical skills and willingness to act were assessed directly after training and at six months using a PC skill reporting system and a survey. Data on CPR skills were registered in a modified version of the Cardiff test and scores were given in 12 categories (12–48 points). Training and measurements were performed from December 2013 to October 2014, according to European Resuscitation Council guidelines 2010.

Participants: Twenty-nine classes for a total of 587 seventh grade students were included in the study.

Primary and secondary outcome measures: Primary endpoint was the total score of the modified Cardiff test at six months. Total score directly after training, the individual variables of the test and self-reported willingness to make a life-saving intervention were secondary endpoints.

Results: At six months the T and O group scored 32 (3.9) and 30 (4.0) points respectively (p<0.001), while the RT group scored 32 (4.2) points (not significant when compared with T). There were no significant differences in willingness to act between the groups after six months.

Conclusions: A practical test including feedback directly after training improved the students' acquisition of practical CPR skills. Reflection did not increase further CPR skills. At six-month follow-up, no intervention effect was found regarding willingness to make a lifesaving effort.

Keywords: CPR training; Skill test; Reflection; Willingness; Feedback; Students

Strengths and limitations of this study

- The best method to teach CPR in school is unknown, therefore we evaluate key concepts in educational science in a cluster randomized trial.
- Outcome measures of practical CPR skills and willingness to act were assessed directly after training and at six months follow up.
- The intervention was carried out in two major municipalities with schools from all socioeconomic areas.
- The study was not designed to explain the cause of any potential differences observed.
- The questionnaire used to evaluate willingness to act contains only hypothetical questions, we do not fully answer how the students would act in a real situation.

INTRODUCTION

Sudden unexpected cardiac arrest is one of the most common causes of death in Europe,[1]. Early identification of the cardiac arrest, call to emergency medical service and prompt initiation of bystander cardiopulmonary resuscitation (CPR) are the cornerstones of resuscitation and crucial for survival in out-of-hospital cardiac arrest (OHCA),[2]. Early CPR increases the chance of survival two to three times,[3-4]. If all students receive practical CPR training in school, a large proportion of the population will have basic skills within a few decades. Such a situation could potentially increase the lay resuscitation rate,[2, 5-8].

Education in CPR can be delivered in different formats. There is a knowledge gap regarding what is the optimal method of CPR training to acquire CPR skills,[2]. Participants' CPR skills after training are limited and decrease within months after training,[2, 9-10].

Learning is a complex process, influenced by several factors,[11-12]. Key concepts in educational science are e.g. test, feedback and reflection. Studies show that tests in various formats can increase learning outcomes,[13-15]. Feedback has a powerful influence on performance,[16]. According to the Swedish school curriculum, students are expected to reflect on different situations and events and on their learning,[11]. A core content in CPR training for lay people is practical training; reflection and discussion with the other participants are limited.

The aim of this study was to investigate if two additional interventions, test and reflection, after standard CPR training facilitate learning by comparing 13-year-old students' practical skills and willingness to act. We hypothesized that both the test and the reflection would provide an additional learning session and contribute to improved knowledge,[12-13].

METHODS

Study population and design

All council schools with seventh grade students (13 years of age) in two Swedish municipalities (Linköping and Norrköping) were invited to participate in the study. Four schools did not respond and two had CPR education only in grade 9. In the framework of this study, the intervention methods have been applied in 13 schools. Before study participation, students and their guardians received a letter with study information. Participation of individual students was voluntary and all participants gave oral informed consent.

Seventh grade students in participating schools were eligible for inclusion. Students were excluded if they did not want to participate or had a physical handicap that limited their physical performance; classes of students with development disabilities (these classes are age-integrated with fewer students per class) were also excluded.

The study used a cluster randomized design,[17], where each school class were allocated to one of three groups using a randomization list generated by an independent statistician. The interventions of the groups were based on core concepts in pedagogy; test, feedback and reflection. To evaluate the effect of test including feedback and reflection, the groups were as follows:

- CPR training only (O)
- CPR training with a practical skill test including feedback (T)
- CPR training with reflection and a practical skill test including feedback (RT).

It was important that the design of the interventions facilitated implementation, that the education was brief enough to fit into one lesson, that the lesson could be given to the

whole class at the same time and that training could be provided by teachers at the school (less costly, facilitates, scheduling),[6, 9, 18-19]. Outcomes, were assessed directly after training and at six months. Training and measurements were performed from December 2013 to October 2014.

Standard CPR training applied in all groups

All intervention groups (O, T and RT) received standardized practical CPR training and the participants used an individual training manikin, MiniAnne (manufactured by Laerdal, Norway), during training. The CPR education was performed in accordance with the European Resuscitation Council guidelines 2010,[20]. Training was given to the entire class. Classes consisted of 14–29 students. Teachers at the schools, who all were CPR instructors, were responsible for the CPR training,[6, 9, 18]. All teachers obtained individual oral and written information to ensure that they were up to date with the present interventions. CPR training was carried out during a 45-60 minute lesson. The training was either mobile application or DVD-based,[21], evenly distributed in the intervention groups (Table 1). The teachers acted as facilitators; they introduced the lesson, gave advice on the fly, answered questions and completed the course. After the standardized practical CPR training, the additional interventions, test and reflection, were performed.

Table 1. Characteristics of the students.

	CPR only (O) (*n*=171)	CPR + test and feedback (T) (*n*=224)	O vs T p-value	CPR + reflection + test and feedback (RT) (*n*=192)	T vs RT p-value
Male	88 (52)	116 (52)	NS	79 (41)	0.03
Previous compression training	49 (29)	54 (24)	NS	49 (26)	NS
Previous ventilation training	34 (20)	41 (18)	NS	39 (20)	NS
DVD method	99 (58)	111 (50)	NS	97 (50)	NS
App method	72 (42)	113 (50)	NS	95 (50)	NS
Number of schools in which methods were applied	8	7		9	

A total of 587 participants were included in the analyses, distributed in three groups. Values are presented as *n* (%). Differences in proportions between groups were analysed by Pearson's χ^2 test. NS, not significant.

Additional intervention with a practical test including feedback

To compare learning outcomes, the students in group T and RT performed a practical test for three minutes directly after the CPR training. Tests can increase learning outcomes, therefore we chose to investigate if the test contributed to the learning session,[13-15]. All tests were conducted at the schools, one student at a time. The student was introduced to the test by the following story: 'You see an adult, someone you know, who collapsed in front of you. There is no one else on site. Show how you would act in a real life situation'. The test leader answered questions about the victim's condition only if relevant actions had already been carried out. The optimal conduct was 30 seconds to check responsiveness, check respiration and call for help, followed by 2.5 minutes of CPR. During the CPR, participants' were expected to perform at least five cycles of 30 compressions and two ventilations.

Laerdal PC skill reporting system version 2.4, linked to resuscitation manikin ResusciAnne, was used to automatically measure quantitative data; compression/ventilation ratio, hand-position, compression depth, total number of compressions and ventilations, ventilation volume and hands-off time. The participants' actions regarding checking

responsiveness, checking respiration and calling for help were assessed by direct observation. Data were recorded directly into a scoring sheet, a modified version of the validated Cardiff test,[22]. A score was given in each category and added up to a total score of 12–48 points. All categories on the scoring sheet are described in detail in Supplementary File 1.

After the test, the investigator gave individual feedback for two minutes. The feedback was partly based on Hattie and Timperley's model, which addresses the following questions: "where am I going" (the goals), "how am I going?" (feedback) and "where to next?" (advice on progress),[24].

Additional intervention with reflection

After the CPR training, the students in group RT discussed three reflective questions for 15 minutes. The teacher asked one question at a time. The students discussed and reflected on each question pairwise. The pairs then shared what they had discussed with the whole class. The teacher summarized the answers and asked the next question. In the present study, the aim of the reflection was afterthought,[25-26]. Reflections were based on the students' experience, understanding and knowledge and could be enriched with interpretations from a person with more experience,[27]. The three questions were (1) Imagine yourself in a situation where you see a person suffering from a cardiac arrest. Reflect on which factors influence if you would intervene in a real situation? Remember that your actions may be the difference between life and death. (2) You are alone when a person suffers from a cardiac arrest. According to the guidelines, you should first call 112 and then start CPR, why this order? (3) Place your hands on the correct compression position on yourself. Reflect on the compression position. Why should the heel of the hand be placed in the centre of the victims' chest? The selection of questions were based on the following: we wanted the students to think about performing a lifesaving intervention so that during the training they would consider how they would act in a real-life situation; in a pre-study, most students failed to call 112; and previous studies have shown that a large proportion of participants apply an incorrect hand position during chest compression,[23, 28-29].

Assessment

Directly after training and after six months, all students in all intervention groups answered a fixed-response questionnaire, which included questions on background factors and willingness to act (Supplementary File 2). Before our study, comprehension of the questionnaire was tested and found satisfactory in a separate cohort of 175 students.

At the six-month follow-up, all participants in all intervention groups individually performed a practical CPR test (retention test). The retention test was carried out without prior notice and was conducted in same way as the "additional intervention with a practical test including feedback ". All measurements were carried out by one investigator (AN) experienced in the modified Cardiff test and blinded to the training method of the students.

Study outcome measures

The primary endpoint was the total score for the modified Cardiff test at six months. Total score directly after training, the scores in the individual test categories and self-reported willingness to make a lifesaving intervention were secondary endpoints.

Statistical plan and analyses

Sample size calculations were based on data from a pre-study,[28]. In order to detect a two-point difference in the mean of the total score of the modified Cardiff test, with an assumed standard deviation (SD) of 2.5 points, a significance level of 0.05 and a power of

80%, an effective total sample size of 75 students was needed [30]. The intraclass correlation coefficient (95% CI) was 0.26 (0.24, 0.29),[17, 31]. Based on an average cluster size of 20.2, the design effect caused by the cluster randomization was calculated to be 5.99. A total of 587 and 549 students performed the first and the second test, respectively. This corresponds to an effective sample size of 98 and 92, respectively, which is above the 75 needed to reach a power of 80%.

To evaluate the effect of test including feedback, group O was compared to group T. To assess the effect of reflection, group T was compared to group RT. These comparisons were pre-specified and based on separate research questions, and thus no adjustment for multiple testing was performed. Data were presented as proportions (percent) or mean (SD). Differences in proportions were analysed with Pearson's x^2 test. Differences in mean total score between the intervention groups were assessed using unpaired t-test. To account for a potential cluster effect of the school classes, a mixed models linear test was also applied for comparisons of the total score [17]. By calculating the (individual total score − 12)/(maximum total score − 12) × 100, we obtained a measure of CPR quality in relation to optimal CPR. $p<0.05$ was considered statistically significant. Analyses were performed using IBM SPSS version 21 and STATA version 13.1.

RESULTS

Twenty-nine classes involving 587 students were included in the measurements directly after training; 549 (94%) of these students completed the retest at six months (Fig. 1). The students' characteristics are summarized in Table 1.

CPR only (O) versus CPR with a practical test including feedback (T)

At six months, group T (n=224) performed better than group O (n=171) in terms of total score: 32 (3.9) points (56% of maximum score) versus 30 (4.0) points (50% of maximum score), $p<0.001$. For the individual variables, group T performed significantly better in eight of 12 variables. Results of the modified Cardiff test are summarized in Table 2.

Table 2. Assessment of CPR skills at the 6-month follow-up.

	CPR only (O) (n=152)	CPR + test and feedback (T) (n=213)	p-value
Checks responsiveness by talking			
2: Yes	23 (15)	53 (25)	0.024
1: No	129 (85)	160 (75)	
Checks responsiveness by shaking			
3: Yes	25 (16)	59 (28)	0.012
2: No	127 (84)	154 (72)	
3: Potentially dangerous	0	0	
Open airway – chin lift, head tilt			
5: Perfect	0	1 (1)	NS
4: Acceptable	2 (1)	6 (3)	
3: Attempted other	0	0	
2: Only one element	8 (5)	21 (10)	
1: No	142 (94)	185 (87)	
Checks respiration – see, listen, feel			
2: Yes	49 (32)	97 (46)	0.011
1: No	103 (68)	116 (54)	
Call 112			
2: Yes	80 (53)	171 (80)	<0.001
1: No	72 (47)	42 (20)	
Compression/ventilation ratio			
4: 30:2 (28-32:2)	28 (18)	67 (32)	0.011

3: Other ratio	104 (68)	129 (61)	
2: Compressions only	20 (13)	17 (8)	
1: Ventilations only	0	0	
Hand position during compression			
4: Correct	8 (5)	7 (3)	NS
3: Other wrong	59 (39)	107 (50)	
2: Too low	85 (56)	99 (46)	
1: Not attempted	0	0	
Average compression depth			
6: 50–59 mm	55 (36)	79 (37)	0.030
5: ≥ 60 mm	0	6 (3)	
4: 35–49 mm	61 (40)	97 (46)	
2: 1–34 mm	36 (24)	31 (15)	
1: Not attempted	0	0	
Total compression counted			
6: 140–190	52 (34)	75 (35)	NS
5: ≥191	62 (41)	100 (47)	
4: 121–139	11 (7)	19 (9)	
3: 81–120	21 (14)	14 (7)	
2: 1–80	6 (4)	5 (2)	
1: Not attempted	0	0	
Average ventilation volume			
5: 500–600 ml	5 (3)	7 (3)	<0.001
4: 1–499 ml	11 (7)	21 (10)	
3: ≥601 ml	27 (18)	91 (43)	
2: 0 ml	87 (57)	77 (36)	
1: Not attempted	22 (14)	17 (8)	
Total ventilation counted			
5: 8–12	15 (10)	34 (16)	<0.001
4: 1–7	13 (9)	44 (21)	
3: ≥13	15 (10)	41 (19)	
2: 0	87 (57)	77 (36)	
1: Not attempted	22 (14)	17 (8)	
Total hands-off time			
4: 0–60 s	55 (36)	62 (29)	0.024
3: 61–90 s	62 (41)	120 (56)	
2: 91–135 s	33 (22)	30 (14)	
1: 136–180 s	2 (1)	1 (1)	
Total score	30 (4.0)	32 (3.9)	<0.001*□

Results are presented as *n* (%) or mean (SD). Differences in proportions between groups were analysed by Pearson's χ^2 test. Differences in total score between intervention groups were analysed by mixed models linear test* and unpaired t-test□. *P*-values <0.05 were considered statistically significant. NS, not significant. The table lists the variable's best option at the top. All numbers are rounded to the nearest whole number.

CPR with a practical test including feedback (T) versus CPR with reflection and a practical test including feedback (RT)

Directly after training and at the six-month follow-up, there were no significant differences between group RT (*n*=192) and group T (*n*=224) with regard to the total score of the modified Cardiff test, calling 112 or hand-position during compressions (Table 3). Directly after CPR training, both groups scored 34 points (61% of maximum score); and at the six-month follow-up, group RT scored 31 (4.2) points (53% of maximum score) and group T scored 32 (3.9) points (56% of maximum score). Table 3 includes the variables of the practical test that are directly linked to the intervention of reflection as well as the total score of the test. All other variables of the test showed no significant differences between the two groups (T versus RT) and have not been included in the table.

Table 3. Assessment of CPR skills directly after training and at 6 months.

	CPR + test and feedback	CPR + reflection +	*p*-value	CPR + test and feedback	CPR + reflection + test	*p*-value

	(T), directly after (*n*=224)	test and feedback (RT), directly after (*n*=192)		(T), 6 months (*n*=213)	and feedback (RT), 6 months (*n*=184)	
Call 112						
2: Yes	161 (72)	152 (79)	NS	171 (80)	147 (80)	NS
1: No	63 (28)	40 (21)		42 (20)	37 (20)	
Hand position during compression						
4: Correct	21 (9)	15 (8)	NS	7 (3)	7 (4)	NS
3: Other wrong	130 (58)	115 (60)		107 (50)	95 (52)	
2: Too low	73 (33)	62 (32)		99 (46)	82 (45)	
1: Not attempted	0	0		0	0	
Total score	34 (4.4)	34 (4.3)	NS*¤	32 (3.9)	32 (4.2)	NS*¤
How to act if at friend suffer cardiac arrest?						
Compression and ventilation	178 (80)	155 (81)	NS	155 (73)	143 (78)	NS
Compressions only	35 (16)	33 (17)		41 (19)	37 (20)	
Ventilations only	2 (1)	1 (1)		1 (<1)	0	
Not dare to act	9 (4)	2 (1)		14 (7)	4 (2)	
Missing	0	1 (1)		2 (1)	0	
How to act if at stranger suffer cardiac arrest?						
Compression and ventilation	71 (32)	67 (35)	0.006	66 (31)	53 (29)	NS
Compressions only	116 (52)	113 (59)		111 (52)	106 (58)	
Ventilations only	3 (1)	0		0	1 (1)	
Not dare to act	34 (15)	11 (6)		34 (16)	24 (13)	
Missing	0	1 (1)		2 (1)	0	

Results are presented as *n* (%) or mean (SD). Differences in proportions between groups were analysed by Pearson's χ^2 test. Differences in total score between intervention groups were analysed by mixed models linear test* and unpaired t-test¤. *p* values <0.05 were considered statistically significant. NS, not significant. All numbers are rounded to the nearest whole number.

Willingness to act

In the questionnaire, students were asked how confident they felt to act in a cardiac arrest situation after participating in the CPR training session compared to prior to training. A lower proportion of the students in group O versus group T stated they felt more confident to act after participating in the training session, when asked directly after training (73% versus 88%; *p*=0.002) and at 6 months follow up (73% versus 82%; *p*=0.025). There were also differences in how the students considered that they had enough knowledge to do chest compressions, 60% (O) versus 81% (T, *p*<0.001), and to do rescue breathing, 57% versus 75% (*p*<0.001). At six months, 84% (O) versus 91% (T, not significant) considered they had enough knowledge to do chest compressions and 59% (O) versus 74% (T, *p*=0.007) to do rescue breathing. There were no significant differences between group T and group RT regarding confidence about acting or self-rated knowledge either after training or at six months.

Directly after training, most students responded that they would do both compressions and ventilations if a friend suffered OHCA; 72% (O), 80% (T, p=NS when comparing O and T) and 81% (RT, Table 3). If a stranger suffered OHCA, there was a significant difference between group T and group RT in how the students would act, with a more positive attitude in group RT (Table 3) but there was no significant difference between groups O and T (27% and 32% would do both compressions and ventilations).

At six-month follow-up, there were no significant differences between the three intervention groups with regard to how they would act in OHCA situations; 76% (O), 73% (T) and 78% (RT) would do both compressions and ventilations if a friend suffered a cardiac arrest. Only 31% (O and T) versus 29% (RT) were prepared to do compressions and ventilations if a stranger suffered a cardiac arrest .

DISCUSSION

The main findings of the present study are threefold. First, adding a practical test with feedback after CPR training resulted in significantly improved practical skills at the six-month follow-up. Second, reflection added to CPR training did not influence the practical skills. Third, adding a practical test with feedback or reflection to CPR training did not affect long-term willingness to make a lifesaving effort. The study was carried out in schools from all socioeconomic areas and each intervention was applied in 7–9 different schools, strengthening the generalizability of our findings.

The group with a practical test including feedback (T) added after CPR training showed superior practical skills at six months compared with the group with CPR training only (O). However, the clinical relevance of the two-point difference in the total score for the modified Cardiff test is unclear. We discuss possible reasons for the outcome linked to learning theories. The result may be due to a further three minutes of hands-on training under the supervision of the investigator, or due to the individual feedback the students received after the test,[14]. Previous studies indicate that testing can increase learning outcomes compared with an equal amount of time spent on training,[13, 15]. The test was not only a tool to assess skills but also an opportunity to give the students feedback,[32]. The feedback aimed to reduce discrepancies between present understanding and the goal,[24]. Qi et al,[32] indicate that a pre-test and feedback can inspire learners to develop strategies to minimize their dependence on feedback from the instructors, which improve skill acquisition and skill retention. At feedback, the question “where to next?” was assumed to be the most important question, while praise for a task seems to be less effective,[24, 33]. A limitation is that the feedback to the students was given when the training was completed. In a pre-study, some students indicated that feedback helped to strengthen their self-esteem,[28]. According to Bandura,[34] and social cognitive theory, an individual's self-efficacy may affect a person's performance. Self-efficacy is about a person's confidence in their own ability (not actual ability) in a given situation. Self-efficacy can be affected by verbal persuasion,[35]. Further studies are needed to elucidate whether the results were caused by the additional training during supervision or by the feedback given to the students. Use of a feedback device is another form of feedback that may improve skill acquisition,[2]. A feedback device was not tested in this study.

According to the Swedish school curriculum, knowledge “can be expressed in a variety of forms, as facts, understanding, skills, familiarity and accumulated experience”,[11]. Reflection and practical training are two teaching methods that can contribute to understanding, skills and familiarity. There are many definitions of reflection, which implies that there are many different models,[26-27]. In this study, the aim of the reflection was afterthought,[25-26]. Adding reflection to CPR training did not influence the students’ practical skills. In particular, reflection did not improve calling 112 and hand positioning during compressions, despite both being included in the reflective questions. Directly after training, a higher proportion of students in the reflection group were willing to intervene if a stranger suffered a cardiac arrest, but this difference could not be observed at six months. This result might, at least in part, be explained by the content and the framing of the reflective questions. The first question, concerning how the students would act in an OHCA situation, is based on ethical considerations, which may provoke emotions and empathy in students,[36]. These emotions might have affected the participants close to the training but not in the long term. Question two (calling 112) and question three (hand positioning during compressions) were a cognitive complement to the practical training. Thus, the students might have discussed and answered these questions as knowledge questions, rather than questions to

reflect upon. Perhaps the outcome would have been different if these reflective questions had been asked when the action was practiced, so-called reflection on action,[27]. Mann et al,[26] stated that there is no evidence to support or refute the assumption that reflection will enhance competence. Ixer,[37] stated that we do not know enough about reflection or how it can enhance learning. Further research is needed to clarify whether and how reflection can be used as a successful teaching tool in CPR training.

Practical training increases willingness to intervene in a real situation,[2, 38]. At the six-month follow-up, the three intervention groups did not differ with regard to willingness to make a lifesaving effort. Regardless of the intervention method, we found, in accordance with previous studies, a huge difference in willingness to intervene in an OHCA situation involving a friend compared with a situation involving a stranger,[38-41].

Study limitations

First, we cannot exclude that students who performed a test directly after training were more familiar with the test manikin at the retention test at six months. However, during the test the participants do not take part of the technical feedback received from the full-body Resusci-Anne and should thus not have any advantage. The same design has also been used in other studies,[14, 23].

Second, it is a risk that the instructors' experience and/or enthusiasm affect learning. Therefore, the methods were standardized to ensure equivalent education; the teacher only had a role as a facilitator and the practical exercises were based on instructions from the app and the DVD.

Third, the intervention was carried out in two major municipalities. We do not know how applicable the results are for other locations, but a strength of the present study is that schools from all socioeconomic areas were included.

Forth, the questionnaire used to evaluate willingness to act contains only hypothetical questions. They do not fully answer how the students would act in a real situation.

CONCLUSIONS

This study contributes to knowledge on the efficiency of two additional CPR training interventions. A practical test with feedback in connection with CPR training is an efficient strategy to increase learning outcome, both practical skills and self-rated knowledge, when teaching seventh grade students. Further studies are needed to find alternative methods for testing and feedback, and to elucidate how feedback works most effectively in the CPR learning process. Reflective questions, in the format applied in this study, did not increase the participants' practical CPR skills. Importantly, regardless of the intervention applied, most students indicated they would intervene in an OHCA situation.

Competing interests

None declared.

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Contributors

AN contributed to the study design, developed the modified Cardiff test and the questionnaire, conducted all measurements, analysed results and wrote the initial draft of the manuscript. LS and JH contributed to the study design, developed the modified Cardiff test and revised the manuscript. HH and SKS contributed to the study design and revised the manuscript. LN contributed to the study design, developed the modified Cardiff test and the questionnaire, analysed results and revision of the manuscript.

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Ethics approval

The study was approved by the Regional Ethical Review Board of Linköping, Sweden (2013/358-31).

Data sharing statement

No additional unpublished data is available.

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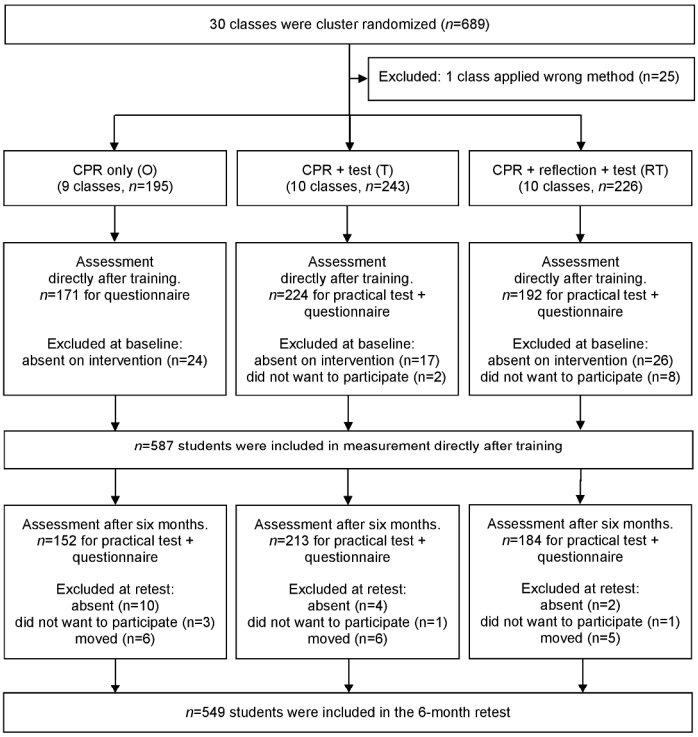
Figure 1 Flow chart on randomization and inclusion.

Figure 1. Flowchart on randomization and inclusion.



209x297mm (300 x 300 DPI)

Supplementary file: the modified Cardiff test.

The modified version of the Cardiff test, adapted to the ERC guidelines of 2010,[20, 22]. The duration of the practical test was 3 minutes. The optimal conduct was 30 seconds for check responsiveness, check respiration and call for help, followed by 2.5 minutes of CPR. During the CPR, the participants were expected to perform at least 5 cycles of 30 compressions and 2 ventilations (30:2). The rules of assessment were pre-specified as follows:

Check responsiveness by talking
2. Yes, if some form of verbal communication as “are you ok” or “how are you”?
1. No, if no attempt at verbal communication was performed
Method: direct observation and real-time registration in the observation schedule by the test leader.

Check responsiveness by shaking
3. Yes, if the rescuer gently shake the victim shoulders.
2. No, if no attempt to shake the victim shoulders occurred.
1. Potentially dangerous, if the rescuer violently shakes the victim´s shoulders so the head lifted up and down against the ground, which can damage the head or the neck.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Open the airway - chin lift, head tilt.
5. Perfect, if one hand on the forehead, two fingertips on the jawbone (not soft tissue) and gently lifted the chin and bent the head back ie by ERC guidelines.
4 Acceptable/partially correct if several indicators are performed, but not all.
3. Attempted other, if the rescuer tried in other ways than ERC recommendation.
2. Only one element is performed or if the rescuer tries but fails.
1. No, if no attempt to open the airway was performed.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Checks respiration - see, listen, feel
2. Yes, if the rescuer did attempts of breath control, even if not all three actions see, listen and feel were performed and although if the total time of the control was less than 10 seconds.
1. No, if no attempt to check for breathing was performed.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Dials 112
2. Yes, dials 112 within the first minute. A call for help without dialling 112 was not enough, since students were instructed they were alone at the site.
1. No, if no attempt to get help was performed.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Compression/ventilation ratio
4. 30:2 (28-32:2), if the rescuer practical applied compressions and ventilations with the relationship 28-32:2 during the whole test. Participants unable to ventilate the manikin but who attempted a ratio of 28-32:2 were registered as such, as they apparently had learned the skill ratio.
3. Other ratio, if the rescuer applied different ratio of compressions and ventilations than 28-32:2.
2. Compressions only.
1. Ventilations only.
Method: Direct observation and real-time registration in combination with data from Laerdal PC Skill Reporter Systems transferred to the scoring sheet after the test.

Hand-position during compression
Incorrect hand-position was recorded if one compression was in the wrong place, since one wrong compression can cause rib fracture or fracture the xiphoid process of sternum.
4. Correct, if the rescuer place the heel of one hand in the centre of the victim’s chest and with the other hand above.
3. Other wrong, if the rescuer performs chest compressions too high up on the sternum or to the side of the sternum.
2. Too low, if the rescuer performs chest compressions too low on the sternum.
1. Not attempted, if no compressions were performed.

Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Average compression depth
The ERC guidelines recommend a compression depth of 50-60 mm,[20]. The PC Skill Reporter system version 2.4 measures up to 60 mm compression depth. To avoid that those who compress >60 mm obtain the highest score, highest score was given for an average compression depth of 50-59 mm. Those who compressed ≥60 mm received 5 points. We chose to retain the 6-point scale, as in previous studies,[23 even though no one could receive 3 points, which would corresponded to a >65 mm compression depth.
6. 50-59 mm.
5. ≥ 60 mm
4. 35-49 mm
2. 1-34 mm
1. Not attempted, if no compressions were performed.
Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Total compression counted
6. 140-190
5. ≥ 191
4. 121-139
3. 81-120
2. 1-80
1. Not attempted, if no compressions were performed.
Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Average ventilation volume
5. 500-600 ml
4. 1-499 ml
3. ≥ 601 ml
2. 0 ml, if the rescuer tried to do rescue breaths but failed.
1. Not attempted, if no rescue breaths were performed.
Method: Direct observation and real-time registration if the rescuer tried to do rescue breath. Exact volume, from Laerdal PC Skill Reporter Systems, was transferred to the scoring sheet after the test.

Total ventilation counted
5.8-12
4. 1-7
3. ≥ 13
2. 0, if the rescuer tried to do rescue breaths but failed.
1. Not attempted, if no rescue breaths were performed.
Method: Direct observation and real-time registration if the rescuer tried to do rescue breath. Exact number, from Laerdal PC Skill Reporter Systems, was transferred to the scoring sheet after the test.

Total ”hands-off” time
Total hands-off time was the total time when compressions were not being performed (i.e. also includes time for check responsiveness, check respiration and dial 112).
4. 0-60 s
3. 61-90 s
2. 91-135 s
1. 136-180 s
Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Supplementary file: questionnaires used directly after training and at six months follow-up

Questionnaire directly after training

Have you previously practiced

chest compressions?	Yes ☐	No ☐
ventilations?	Yes ☐	No ☐

Do you think that your skills are sufficient to perform

chest compressions?	Yes ☐	No ☐	Do not know ☐
ventilations?	Yes ☐	No ☐	Do not know ☐

Are you more confident now than before the training to act and start CPR?	Yes ☐	No ☐	Do not know ☐

You are at home. How would you act if a friend or relative suffered a sudden cardiac arrest? Tick one answer:

I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would give ventilations only ☐
I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?

Lack of knowledge ☐
Afraid to hurt the person ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?

Lack of knowledge ☐
Afraid to hurt the person ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

You are standing at a bus stop. How would you act if an unknown person suffered a sudden cardiac arrest? Tick one answer:

I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would give ventilations only ☐
I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?

Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?

Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Questionnaire at six months follow-up

Have you done a lifesaving intervention in real life after the CPR training? Yes ☐ No ☐

If yes, please describe your lifesaving intervention and the situation:_____

Do you think it is important to learn cardiopulmonary resuscitation in school? Yes ☐ No ☐ Do not know ☐

Do you think that your skills are sufficient to perform

chest compressions? Yes ☐ No ☐ Do not know ☐

ventilations? Yes ☐ No ☐ Do not know ☐

Are you more confident now than before the training to act and start CPR? Yes ☐ No ☐ Do not know ☐

You are at home. How would you act if a friend or relative suffered a sudden cardiac arrest? Tick one answer:

I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would give ventilations only ☐
I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?

Lack of knowledge ☐
Afraid to hurt the person ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?

Lack of knowledge ☐
Afraid to hurt the person ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

You are standing at a bus stop. How would you act if an unknown person suffered a sudden cardiac arrest? Tick one answer:

I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would only give ventilations ☐
I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?

Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?

Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	1
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	2
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	4
	2b	Specific objectives or hypotheses	4
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	4-5
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	N/A
Participants	4a	Eligibility criteria for participants	4
	4b	Settings and locations where the data were collected	4
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	4-6
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	6
	6b	Any changes to trial outcomes after the trial commenced, with reasons	N/A
Sample size	7a	How sample size was determined	6-7
	7b	When applicable, explanation of any interim analyses and stopping guidelines	N/A
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	4
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	4
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	4
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	4, 6
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those	6

		assessing outcomes) and how	
	11b	If relevant, description of the similarity of interventions	5-6
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	6-7
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	N/A
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	7-8 and Figure 1
	13b	For each group, losses and exclusions after randomisation, together with reasons	Figure 1
Recruitment	14a	Dates defining the periods of recruitment and follow-up	5
	14b	Why the trial ended or was stopped	N/A
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	Table 1
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	7-9 and Figure 1
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	7-9
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	N/A
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	N/A
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	N/A
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	3, 10, 11
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	9-10
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	10-11
Other information			
Registration	23	Registration number and name of trial registry	N/A
Protocol	24	Where the full trial protocol can be accessed, if available	N/A
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	12

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

BMJ Open

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 randomized trial

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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 randomized trial

Anette Nord[a], Håkan Hult[b], Susanne Kreitz-Sandberg[c], Johan Herlitz[d], Leif Svensson[e] , Lennart Nilsson[a]

[a]Department of Medical and Health Sciences, Linköping University, Linköping, Sweden

[b]Department of Clinical Science, Intervention and Technology, Karolinska Institute, Stockholm, Sweden

[c]Department of Behavioural Sciences and Learning, Linköping University, Linköping, Sweden

[d]The Prehospital Research Centre of Western Sweden, Borås University, Borås, Sweden

[e]Department of Medicine, Karolinska Institute, Stockholm, Sweden

Corresponding author:
Lennart Nilsson, Department of Medical and Health Sciences, Linköping University, S-58183 Linköping, Sweden. Email: lennart.nilsson@liu.se

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ABSTRACT

Objectives: To investigate if two additional interventions, test and reflection, after standard CPR training facilitate learning by comparing 13-year-old students' practical skills and willingness to act.

Settings: Seventh grade students in two Swedish municipalities.

Design: The classes were randomized to *CPR training only* (O), *CPR training with a practical Test including feedback* (T) or *CPR training with Reflection and a practical Test including feedback* (RT). Outcome measures of practical skills and willingness to act were assessed directly after training and at six months using a PC skill reporting system and a survey. Data on CPR skills were registered in a modified version of the Cardiff test and scores were given in 12 categories (12–48 points). Training and measurements were performed from December 2013 to October 2014, according to European Resuscitation Council guidelines 2010.

Participants: Twenty-nine classes for a total of 587 seventh grade students were included in the study.

Primary and secondary outcome measures: Primary endpoint was the total score of the modified Cardiff test at six months. Total score directly after training, the individual variables of the test and self-reported willingness to make a life-saving intervention were secondary endpoints.

Results: At six months the T and O group scored 32 (3.9) and 30 (4.0) points respectively (p<0.001), while the RT group scored 32 (4.2) points (not significant when compared with T). There were no significant differences in willingness to act between the groups after six months.

Conclusions: A practical test including feedback directly after training improved the students' acquisition of practical CPR skills. Reflection did not increase further CPR skills. At six-month follow-up, no intervention effect was found regarding willingness to make a lifesaving effort.

Keywords: CPR training; Skill test; Reflection; Willingness; Feedback; Students

Strengths and limitations of this study

- The best method to teach CPR in school is unknown, therefore we evaluate key concepts in educational science in a cluster randomized trial.
- Outcome measures of practical CPR skills and willingness to act were assessed directly after training and at six months follow up.
- The intervention was carried out in two major municipalities with schools from all socioeconomic areas.
- The study was not designed to explain the cause of any potential differences observed.
- The questionnaire used to evaluate willingness to act contains only hypothetical questions, we do not fully answer how the students would act in a real situation.

INTRODUCTION

Sudden unexpected cardiac arrest is one of the most common causes of death in Europe,[1]. Early identification of the cardiac arrest, call to emergency medical service and prompt initiation of bystander cardiopulmonary resuscitation (CPR) are the cornerstones of resuscitation and crucial for survival in out-of-hospital cardiac arrest (OHCA),[2]. Early CPR increases the chance of survival two to three times,[3-4]. If all students receive practical CPR training in school, a large proportion of the population will have basic skills within a few decades. Such a situation could potentially increase the lay resuscitation rate,[2, 5-8].

Education in CPR can be delivered in different formats. There is a knowledge gap regarding what is the optimal method of CPR training to acquire CPR skills,[2]. Participants' CPR skills after training are limited and decrease within months after training,[2, 9-10].

Learning is a complex process, influenced by several factors,[11-12]. Key concepts in educational science are e.g. test, feedback and reflection. Studies show that tests in various formats can increase learning outcomes,[13-15]. Feedback has a powerful influence on performance,[16]. According to the Swedish school curriculum, students are expected to reflect on different situations and events and on their learning,[11]. A core content in CPR training for lay people is practical training; reflection and discussion with the other participants are limited.

The aim of this study was to investigate if two additional interventions, test and reflection, after standard CPR training facilitate learning by comparing 13-year-old students' practical skills and willingness to act. We hypothesized that both the test and the reflection would provide an additional learning session and contribute to improved knowledge,[12-13].

METHODS

Study population and design

All council schools with seventh grade students (13 years of age) in two Swedish municipalities (Linköping and Norrköping) were invited to participate in the study. Four schools did not respond and two had CPR education only in grade 9. In the framework of this study, the intervention methods have been applied in 13 schools. Before study participation, students and their guardians received a letter with study information. Participation of individual students was voluntary and all participants gave oral informed consent.

Seventh grade students in participating schools were eligible for inclusion. Students were excluded if they did not want to participate or had a physical handicap that limited their physical performance; classes of students with development disabilities (these classes are age-integrated with fewer students per class) were also excluded.

The study used a cluster randomized design,[17], where each school class were allocated to one of three groups using a randomization list generated by an independent statistician. The interventions of the groups were based on core concepts in pedagogy; test, feedback and reflection. To evaluate the effect of test including feedback and reflection, the groups were as follows:

- CPR training only (O)
- CPR training with a practical skill test including feedback (T)
- CPR training with reflection and a practical skill test including feedback (RT).

It was important that the design of the interventions facilitated implementation, that the education was brief enough to fit into one lesson, that the lesson could be given to the

whole class at the same time and that training could be provided by teachers at the school (less costly, facilitates scheduling),[6, 9, 18-19]. Outcomes, were assessed directly after training and at six months. Training and measurements were performed from December 2013 to October 2014.

Standard CPR training applied in all groups

All intervention groups (O, T and RT) received standardized practical CPR training and the participants used an individual training manikin, MiniAnne (manufactured by Laerdal, Norway), during training. The CPR education was performed in accordance with the European Resuscitation Council guidelines 2010,[20]. Training was given to the entire class. Classes consisted of 14–29 students. Teachers at the schools, who all were CPR instructors, were responsible for the CPR training,[6, 9, 18]. All teachers obtained individual oral and written information to ensure that they were up to date with the present interventions. CPR training was carried out during a 45-60 minute lesson. The training was either mobile application or DVD-based,[21], evenly distributed in the intervention groups (Table 1). The teachers acted as facilitators; they introduced the lesson, gave advice on the fly, answered questions and completed the course. After the standardized practical CPR training, the additional interventions, test and reflection, were performed.

Table 1. Characteristics of the students.

	CPR only (O) (*n*=171)	CPR + test and feedback (T) (*n*=224)	O vs T p-value	CPR + reflection + test and feedback (RT) (*n*=192)	T vs RT p-value
Male	88 (52)	116 (52)	NS	79 (41)	0.03
Previous compression training	49 (29)	54 (24)	NS	49 (26)	NS
Previous ventilation training	34 (20)	41 (18)	NS	39 (20)	NS
DVD method	99 (58)	111 (50)	NS	97 (50)	NS
App method	72 (42)	113 (50)	NS	95 (50)	NS
Number of schools in which methods were applied	8	7		9	

A total of 587 participants were included in the analyses, distributed in three groups. Values are presented as *n* (%). Differences in proportions between groups were analysed by Pearson's χ^2 test. NS, not significant.

Additional intervention with a practical test including feedback

To compare learning outcomes, the students in group T and RT performed a practical test for three minutes directly after the CPR training. Tests can increase learning outcomes, therefore we chose to investigate if the test contributed to the learning session,[13-15]. All tests were conducted at the schools, one student at a time. The student was introduced to the test by the following story: 'You see an adult, someone you know, who collapsed in front of you. There is no one else on site. Show how you would act in a real life situation'. The test leader answered questions about the victim's condition only if relevant actions had already been carried out. The optimal conduct was 30 seconds to check responsiveness, check respiration and call for help, followed by 2.5 minutes of CPR. During the CPR, participants' were expected to perform at least five cycles of 30 compressions and two ventilations.

Laerdal PC skill reporting system version 2.4, linked to resuscitation manikin ResusciAnne, was used to automatically measure quantitative data; compression/ventilation ratio, hand-position, compression depth, total number of compressions and ventilations, ventilation volume and hands-off time. The participants' actions regarding checking

responsiveness, checking respiration and calling for help were assessed by direct observation. Data were recorded directly into a scoring sheet, a modified version of the validated Cardiff test,[22]. A score was given in each category and added up to a total score of 12–48 points. All categories on the scoring sheet are described in detail in Supplementary File 1.

After the test, the investigator gave individual feedback for two minutes. The feedback was partly based on Hattie and Timperley's model, which addresses the following questions: "where am I going" (the goals), "how am I going?" (feedback) and "where to next?" (advice on progress),[24].

Additional intervention with reflection

After the CPR training, the students in group RT discussed three reflective questions for 15 minutes. The teacher asked one question at a time. The students discussed and reflected on each question pairwise. The pairs then shared what they had discussed with the whole class. The teacher summarized the answers and asked the next question. In the present study, the aim of the reflection was afterthought,[25-26]. Reflections were based on the students' experience, understanding and knowledge and could be enriched with interpretations from a person with more experience,[27]. The three questions were (1) Imagine yourself in a situation where you see a person suffering from a cardiac arrest. Reflect on which factors influence if you would intervene in a real situation? Remember that your actions may be the difference between life and death. (2) You are alone when a person suffers from a cardiac arrest. According to the guidelines, you should first call 112 and then start CPR, why this order? (3) Place your hands on the correct compression position on yourself. Reflect on the compression position. Why should the heel of the hand be placed in the centre of the victims' chest? The selection of questions were based on the following: we wanted the students to think about performing a lifesaving intervention so that during the training they would consider how they would act in a real-life situation; in a pre-study, most students failed to call 112; and previous studies have shown that a large proportion of participants apply an incorrect hand position during chest compression,[23, 28-29].

Assessment

Directly after training and after six months, all students in all intervention groups answered a fixed-response questionnaire, which included questions on background factors and willingness to act (Supplementary File 2). Before our study, comprehension of the questionnaire was tested and found satisfactory in a separate cohort of 175 students.

At the six-month follow-up, all participants in all intervention groups individually performed a practical CPR test (retention test). The retention test was carried out without prior notice and was conducted in same way as the "additional intervention with a practical test including feedback ". All measurements were carried out by one investigator (AN) experienced in the modified Cardiff test and blinded to the training method of the students.

Study outcome measures

The primary endpoint was the total score for the modified Cardiff test at six months. Total score directly after training, the scores in the individual test categories and self-reported willingness to make a lifesaving intervention were secondary endpoints.

Statistical plan and analyses

Sample size calculations were based on data from a pre-study,[28]. In order to detect a two-point difference in the mean of the total score of the modified Cardiff test, with an assumed standard deviation (SD) of 2.5 points, a significance level of 0.05 and a power of

80%, an effective total sample size of 75 students was needed [30]. At the first measurement point we included all available classes (more than calculated) since it is difficult to estimate the size of missing at six month follow up. Cluster randomization implies that the number of participants is not equal in each training method group due to the different size of the classes. Therefore, a higher number needs to be included, to ensure a sufficient number of participants for each method. The intraclass correlation coefficient (95% CI) was 0.26 (0.24, 0.29),[17, 31]. Based on an average cluster size of 20.2, the design effect caused by the cluster randomization was calculated to be 5.99. A total of 587 and 549 students performed the first and the second test, respectively. This corresponds to an effective sample size of 98 and 92, respectively, which is above the 75 needed to reach a power of 80%.

To evaluate the effect of test including feedback, group O was compared to group T. To assess the effect of reflection, group T was compared to group RT. These comparisons were pre-specified and based on separate research questions, and thus no adjustment for multiple testing was performed as this gives no further information about the cause of differences. Data were presented as proportions (percent) or mean (SD). Differences in proportions were analysed with Pearson's χ^2 test. Differences in mean total score between the intervention groups were assessed using unpaired t-test. To account for a potential cluster effect of the school classes, a mixed models linear test was also applied for comparisons of the total score [17]. By calculating the (individual total score − 12)/(maximum total score − 12) × 100, we obtained a measure of CPR quality in relation to optimal CPR. $p<0.05$ was considered statistically significant. Analyses were performed using IBM SPSS version 21 and STATA version 13.1.

RESULTS

Twenty-nine classes involving 587 students were included in the measurements directly after training; 549 (94%) of these students completed the retest at six months (Fig. 1). The students' characteristics are summarized in Table 1.

CPR only (O) versus CPR with a practical test including feedback (T)

At six months, group T (n=224) performed better than group O (n=171) in terms of total score: 32 (3.9) points (56% of maximum score) versus 30 (4.0) points (50% of maximum score), $p<0.001$. For the individual variables, group T performed significantly better in eight of 12 variables. Results of the modified Cardiff test are summarized in Table 2.

Table 2. Assessment of CPR skills at the 6-month follow-up.

	CPR only (O) (n=152)	CPR + test and feedback (T) (n=213)	p-value
Checks responsiveness by talking			
2: Yes	23 (15)	53 (25)	0.024
1: No	129 (85)	160 (75)	
Checks responsiveness by shaking			
3: Yes	25 (16)	59 (28)	0.012
2: No	127 (84)	154 (72)	
3: Potentially dangerous	0	0	
Open airway – chin lift, head tilt			
5: Perfect	0	1 (1)	NS
4: Acceptable	2 (1)	6 (3)	
3: Attempted other	0	0	
2: Only one element	8 (5)	21 (10)	
1: No	142 (94)	185 (87)	
Checks respiration – see, listen, feel			
2: Yes	49 (32)	97 (46)	0.011

1: No	103 (68)	116 (54)	
Call 112			
2: Yes	80 (53)	171 (80)	<0.001
1: No	72 (47)	42 (20)	
Compression/ventilation ratio			
4: 30:2 (28-32:2)	28 (18)	67 (32)	0.011
3: Other ratio	104 (68)	129 (61)	
2: Compressions only	20 (13)	17 (8)	
1: Ventilations only	0	0	
Hand position during compression			
4: Correct	8 (5)	7 (3)	NS
3: Other wrong	59 (39)	107 (50)	
2: Too low	85 (56)	99 (46)	
1: Not attempted	0	0	
Average compression depth			
6: 50–59 mm	55 (36)	79 (37)	0.030
5: ≥ 60 mm	0	6 (3)	
4: 35–49 mm	61 (40)	97 (46)	
2: 1–34 mm	36 (24)	31 (15)	
1: Not attempted	0	0	
Total compression counted			
6: 140–190	52 (34)	75 (35)	NS
5: ≥191	62 (41)	100 (47)	
4: 121–139	11 (7)	19 (9)	
3: 81–120	21 (14)	14 (7)	
2: 1–80	6 (4)	5 (2)	
1: Not attempted	0	0	
Average ventilation volume			
5: 500–600 ml	5 (3)	7 (3)	<0.001
4: 1–499 ml	11 (7)	21 (10)	
3: ≥601 ml	27 (18)	91 (43)	
2: 0 ml	87 (57)	77 (36)	
1: Not attempted	22 (14)	17 (8)	
Total ventilation counted			
5: 8–12	15 (10)	34 (16)	<0.001
4: 1–7	13 (9)	44 (21)	
3: ≥13	15 (10)	41 (19)	
2: 0	87 (57)	77 (36)	
1: Not attempted	22 (14)	17 (8)	
Total hands-off time			
4: 0–60 s	55 (36)	62 (29)	0.024
3: 61–90 s	62 (41)	120 (56)	
2: 91–135 s	33 (22)	30 (14)	
1: 136–180 s	2 (1)	1 (1)	
Total score	30 (4.0)	32 (3.9)	<0.001*□

Results are presented as *n* (%) or mean (SD). Differences in proportions between groups were analysed by Pearson's χ^2 test. Differences in total score between intervention groups were analysed by mixed models linear test* and unpaired t-test□. *P*-values <0.05 were considered statistically significant. NS, not significant. The table lists the variable's best option at the top. All numbers are rounded to the nearest whole number.

CPR with a practical test including feedback (T) versus CPR with reflection and a practical test including feedback (RT)

Directly after training and at the six-month follow-up, there were no significant differences between group RT (*n*=192) and group T (*n*=224) with regard to the total score of the modified Cardiff test, calling 112 or hand-position during compressions (Table 3). Directly after CPR training, both groups scored 34 points (61% of maximum score); and at the six-month follow-up, group RT scored 31 (4.2) points (53% of maximum score) and group T scored 32 (3.9) points (56% of maximum score). Table 3 includes the variables of the practical test that are directly linked to the intervention of reflection as well as the total score of the test. All other variables of the test showed no significant differences between the two groups (T versus RT) and have not been included in the table.

Table 3. Assessment of CPR skills directly after training and at 6 months.

	CPR + test and feedback (T), directly after (*n*=224)	CPR + reflection + test and feedback (RT), directly after (*n*=192)	*p*-value	CPR + test and feedback (T), 6 months (*n*=213)	CPR + reflection + test and feedback (RT), 6 months (*n*=184)	*p*-value
Call 112						
2: Yes	161 (72)	152 (79)	NS	171 (80)	147 (80)	NS
1: No	63 (28)	40 (21)		42 (20)	37 (20)	
Hand position during compression						
4: Correct	21 (9)	15 (8)	NS	7 (3)	7 (4)	NS
3: Other wrong	130 (58)	115 (60)		107 (50)	95 (52)	
2: Too low	73 (33)	62 (32)		99 (46)	82 (45)	
1: Not attempted	0	0		0	0	
Total score	34 (4.4)	34 (4.3)	NS*¤	32 (3.9)	32 (4.2)	NS*¤
How to act if a friend suffer cardiac arrest?						
Compression and ventilation	178 (80)	155 (81)	NS	155 (73)	143 (78)	NS
Compressions only	35 (16)	33 (17)		41 (19)	37 (20)	
Ventilations only	2 (1)	1 (1)		1 (<1)	0	
Not dare to act	9 (4)	2 (1)		14 (7)	4 (2)	
Missing	0	1 (1)		2 (1)	0	
How to act if a stranger suffer cardiac arrest?						
Compression and ventilation	71 (32)	67 (35)	0.006	66 (31)	53 (29)	NS
Compressions only	116 (52)	113 (59)		111 (52)	106 (58)	
Ventilations only	3 (1)	0		0	1 (1)	
Not dare to act	34 (15)	11 (6)		34 (16)	24 (13)	
Missing	0	1 (1)		2 (1)	0	

Results are presented as *n* (%) or mean (SD). Differences in proportions between groups were analysed by Pearson's χ^2 test. Differences in total score between intervention groups were analysed by mixed models linear test* and unpaired t-test¤. *p* values <0.05 were considered statistically significant. NS, not significant. All numbers are rounded to the nearest whole number.

Willingness to act

In the questionnaire, students were asked how confident they felt to act in a cardiac arrest situation after participating in the CPR training session compared to prior to training. A lower proportion of the students in group O versus group T stated they felt more confident to act after participating in the training session, when asked directly after training (73% versus 88%; *p*=0.002) and at 6 months follow up (73% versus 82%; *p*=0.025). There were also differences in how the students considered that they had enough knowledge to do chest compressions, 60% (O) versus 81% (T, *p*<0.001), and to do rescue breathing, 57% versus 75% (*p*<0.001). At six months, 84% (O) versus 91% (T, not significant) considered they had enough knowledge to do chest compressions and 59% (O) versus 74% (T, *p*=0.007) to do rescue breathing. There were no significant differences between group T and group RT regarding confidence about acting or self-rated knowledge either after training or at six months.

Directly after training, most students responded that they would do both compressions and ventilations if a friend suffered OHCA; 72% (O), 80% (T, p=NS when comparing O and T) and 81% (RT, Table 3). If a stranger suffered OHCA, there was a significant difference between group T and group RT in how the students would act, with a more positive attitude in group RT (Table 3) but there was no significant difference between groups O and T (27% and 32% would do both compressions and ventilations).

At six-month follow-up, there were no significant differences between the three intervention groups with regard to how they would act in OHCA situations; 76% (O), 73%

(T) and 78% (RT) would do both compressions and ventilations if a friend suffered a cardiac arrest. Only 31% (O and T) versus 29% (RT) were prepared to do compressions and ventilations if a stranger suffered a cardiac arrest.

DISCUSSION

The main findings of the present study are threefold. First, adding a practical test with feedback after CPR training resulted in significantly improved practical skills at the six-month follow-up. Second, reflection added to CPR training did not influence the practical skills. Third, adding a practical test with feedback or reflection to CPR training did not affect long-term willingness to make a lifesaving effort. The study was carried out in schools from all socioeconomic areas and each intervention was applied in 7–9 different schools, strengthening the generalizability of our findings.

The group with a practical test including feedback (T) added after CPR training showed superior practical skills at six months compared with the group with CPR training only (O). However, the clinical relevance of the two-point difference in the total score for the modified Cardiff test is unclear. We discuss possible reasons for the outcome linked to learning theories. The result may be due to a further three minutes of hands-on training under the supervision of the investigator, or due to the individual feedback the students received after the test,[14]. Previous studies indicate that testing can increase learning outcomes compared with an equal amount of time spent on training,[13, 15]. The test was not only a tool to assess skills but also an opportunity to give the students feedback,[32]. The feedback aimed to reduce discrepancies between present understanding and the goal,[24]. Qi et al,[32] indicate that a pre-test and feedback can inspire learners to develop strategies to minimize their dependence on feedback from the instructors, which improve skill acquisition and skill retention. At feedback, the question “where to next?” was assumed to be the most important question, while praise for a task seems to be less effective,[24, 33]. A limitation is that the feedback to the students was given when the training was completed. In a pre-study, some students indicated that feedback helped to strengthen their self-esteem,[28]. According to Bandura,[34] and social cognitive theory, an individual's self-efficacy may affect a person's performance. Self-efficacy is about a person's confidence in their own ability (not actual ability) in a given situation. Self-efficacy can be affected by verbal persuasion,[35]. Further studies are needed to elucidate whether the results were caused by the additional training during supervision or by the feedback given to the students. Use of a feedback device is another form of feedback that may improve skill acquisition,[2]. A feedback device was not tested in this study.

According to the Swedish school curriculum, knowledge “can be expressed in a variety of forms, as facts, understanding, skills, familiarity and accumulated experience”,[11]. Reflection and practical training are two teaching methods that can contribute to understanding, skills and familiarity. There are many definitions of reflection, which implies that there are many different models,[26-27]. In this study, the aim of the reflection was afterthought,[25-26]. Adding reflection to CPR training did not influence the students’ practical skills. In particular, reflection did not improve calling 112 and hand positioning during compressions, despite both being included in the reflective questions. Directly after training, a higher proportion of students in the reflection group were willing to intervene if a stranger suffered a cardiac arrest, but this difference could not be observed at six months. This result might, at least in part, be explained by the content and the framing of the reflective questions. The first question, concerning how the students would act in an OHCA situation, is based on ethical considerations, which may provoke emotions and empathy in students,[36].

These emotions might have affected the participants close to the training but not in the long term. Question two (calling 112) and question three (hand positioning during compressions) were a cognitive complement to the practical training. Thus, the students might have discussed and answered these questions as knowledge questions, rather than questions to reflect upon. Perhaps the outcome would have been different if these reflective questions had been asked when the action was practiced, so-called reflection on action,[27]. Mann et al,[26] stated that there is no evidence to support or refute the assumption that reflection will enhance competence. Ixer,[37] stated that we do not know enough about reflection or how it can enhance learning. Further research is needed to clarify whether and how reflection can be used as a successful teaching tool in CPR training.

Practical training increases willingness to intervene in a real situation,[2, 38]. At the six-month follow-up, the three intervention groups did not differ with regard to willingness to make a lifesaving effort. Regardless of the intervention method, we found, in accordance with previous studies, a huge difference in willingness to intervene in an OHCA situation involving a friend compared with a situation involving a stranger,[38-41].

Study limitations

First, we cannot exclude that students who performed a test directly after training were more familiar with the test manikin at the retention test at six months. However, during the test the participants do not take part of the technical feedback received from the full-body Resusci Anne and should thus not have any advantage. The same design has also been used in other studies,[14, 23].

Second, it is a risk that the instructors' experience and/or enthusiasm affect learning. Therefore, the methods were standardized to ensure equivalent education; the teacher only had a role as a facilitator and the practical exercises were based on instructions from the app and the DVD.

Third, the intervention was carried out in two major municipalities. We do not know how applicable the results are for other locations, but a strength of the present study is that schools from all socioeconomic areas were included.

Forth, the questionnaire used to evaluate willingness to act contains only hypothetical questions. They do not fully answer how the students would act in a real situation.

CONCLUSIONS

This study contributes to knowledge on the efficiency of two additional CPR training interventions. A practical test with feedback in connection with CPR training is an efficient strategy to increase learning outcome, both practical skills and self-rated knowledge, when teaching seventh grade students. Further studies are needed to find alternative methods for testing and feedback, and to elucidate how feedback works most effectively in the CPR learning process. Reflective questions, in the format applied in this study, did not increase the participants' practical CPR skills. Importantly, regardless of the intervention applied, most students indicated they would intervene in an OHCA situation.

Competing interests

None declared.

Acknowledgments

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Contributors

AN contributed to the study design, developed the modified Cardiff test and the questionnaire, conducted all measurements, analysed results and wrote the initial draft of the manuscript. LS and JH contributed to the study design, developed the modified Cardiff test and revised the manuscript. HH and SKS contributed to the study design and revised the manuscript. LN contributed to the study design, developed the modified Cardiff test and the questionnaire, analysed results and revision of the manuscript.

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Ethics approval

The study was approved by the Regional Ethical Review Board of Linköping, Sweden (2013/358-31).

Data sharing statement

No additional unpublished data is available.

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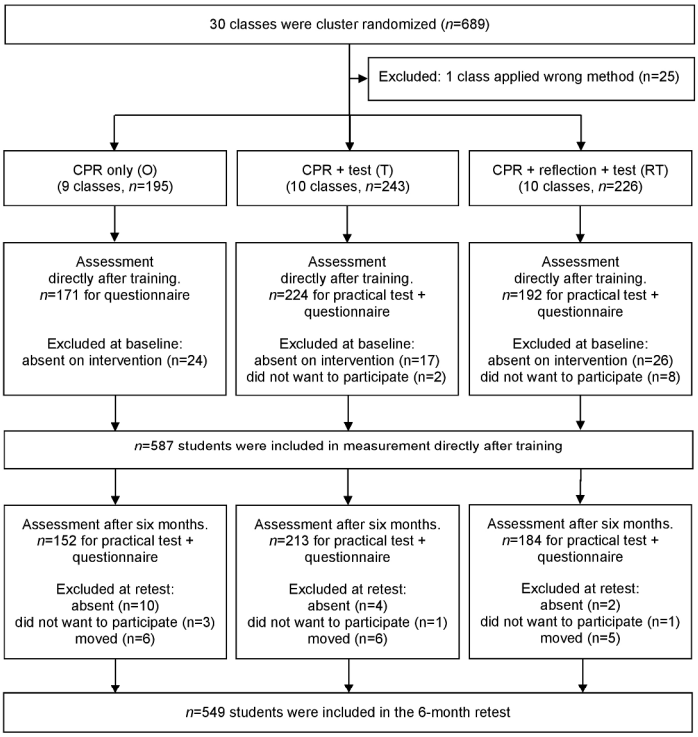
Figure 1 Flow chart on randomization and inclusion.

Figure 1. Flowchart on randomization and inclusion.



209x297mm (300 x 300 DPI)

Supplementary file: the modified Cardiff test.

The modified version of the Cardiff test, adapted to the ERC guidelines of 2010,[20, 22]. The duration of the practical test was 3 minutes. The optimal conduct was 30 seconds for check responsiveness, check respiration and call for help, followed by 2.5 minutes of CPR. During the CPR, the participants were expected to perform at least 5 cycles of 30 compressions and 2 ventilations (30:2). The rules of assessment were pre-specified as follows:

Check responsiveness by talking
2. Yes, if some form of verbal communication as “are you ok” or “how are you”?
1. No, if no attempt at verbal communication was performed
Method: direct observation and real-time registration in the observation schedule by the test leader.

Check responsiveness by shaking
3. Yes, if the rescuer gently shake the victim shoulders.
2. No, if no attempt to shake the victim shoulders occurred.
1. Potentially dangerous, if the rescuer violently shakes the victim´s shoulders so the head lifted up and down against the ground, which can damage the head or the neck.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Open the airway - chin lift, head tilt.
5. Perfect, if one hand on the forehead, two fingertips on the jawbone (not soft tissue) and gently lifted the chin and bent the head back ie by ERC guidelines.
4 Acceptable/partially correct if several indicators are performed, but not all.
3. Attempted other, if the rescuer tried in other ways than ERC recommendation.
2. Only one element is performed or if the rescuer tries but fails.
1. No, if no attempt to open the airway was performed.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Checks respiration - see, listen, feel
2. Yes, if the rescuer did attempts of breath control, even if not all three actions see, listen and feel were performed and although if the total time of the control was less than 10 seconds.
1. No, if no attempt to check for breathing was performed.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Dials 112
2. Yes, dials 112 within the first minute. A call for help without dialling 112 was not enough, since students were instructed they were alone at the site.
1. No, if no attempt to get help was performed.
Method: direct observation and real-time registration in the observation schedule by the test leader.

Compression/ventilation ratio
4. 30:2 (28-32:2), if the rescuer practical applied compressions and ventilations with the relationship 28-32:2 during the whole test. Participants unable to ventilate the manikin but who attempted a ratio of 28-32:2 were registered as such, as they apparently had learned the skill ratio.
3. Other ratio, if the rescuer applied different ratio of compressions and ventilations than 28-32:2.
2. Compressions only.
1. Ventilations only.
Method: Direct observation and real-time registration in combination with data from Laerdal PC Skill Reporter Systems transferred to the scoring sheet after the test.

Hand-position during compression
Incorrect hand-position was recorded if one compression was in the wrong place, since one wrong compression can cause rib fracture or fracture the xiphoid process of sternum.
4. Correct, if the rescuer place the heel of one hand in the centre of the victim’s chest and with the other hand above.
3. Other wrong, if the rescuer performs chest compressions too high up on the sternum or to the side of the sternum.
2. Too low, if the rescuer performs chest compressions too low on the sternum.
1. Not attempted, if no compressions were performed.

Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Average compression depth
The ERC guidelines recommend a compression depth of 50-60 mm,[20]. The PC Skill Reporter system version 2.4 measures up to 60 mm compression depth. To avoid that those who compress >60 mm obtain the highest score, highest score was given for an average compression depth of 50-59 mm. Those who compressed ≥60 mm received 5 points. We chose to retain the 6-point scale, as in previous studies,[23]. even though no one could receive 3 points, which would corresponded to a >65 mm compression depth.
6. 50-59 mm.
5. ≥ 60 mm
4. 35-49 mm
2. 1-34 mm
1. Not attempted, if no compressions were performed.
Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Total compression counted
6. 140-190
5. ≥ 191
4. 121-139
3. 81-120
2. 1-80
1. Not attempted, if no compressions were performed.
Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Average ventilation volume
5. 500-600 ml
4. 1-499 ml
3. ≥ 601 ml
2. 0 ml, if the rescuer tried to do rescue breaths but failed.
1. Not attempted, if no rescue breaths were performed.
Method: Direct observation and real-time registration if the rescuer tried to do rescue breath. Exact volume, from Laerdal PC Skill Reporter Systems, was transferred to the scoring sheet after the test.

Total ventilation counted
5.8-12
4. 1-7
3. ≥ 13
2. 0, if the rescuer tried to do rescue breaths but failed.
1. Not attempted, if no rescue breaths were performed.
Method: Direct observation and real-time registration if the rescuer tried to do rescue breath. Exact number, from Laerdal PC Skill Reporter Systems, was transferred to the scoring sheet after the test.

Total ”hands-off” time
Total hands-off time was the total time when compressions were not being performed (i.e. also includes time for check responsiveness, check respiration and dial 112).
4. 0-60 s
3. 61-90 s
2. 91-135 s
1. 136-180 s
Method: Data from Laerdal PC Skill Reporter Systems was transferred to a scoring sheet after the test.

Supplementary file: questionnaires used directly after training and at six months follow-up

Questionnaire directly after training

Have you previously practiced

chest compressions?	Yes ☐	No ☐
ventilations?	Yes ☐	No ☐

Do you think that your skills are sufficient to perform

chest compressions?	Yes ☐	No ☐	Do not know ☐
ventilations?	Yes ☐	No ☐	Do not know ☐

Are you more confident now than before the training to act and start CPR?	Yes ☐	No ☐	Do not know ☐

You are at home. How would you act if a friend or relative suffered a sudden cardiac arrest? Tick one answer:

I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would give ventilations only ☐
I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?

Lack of knowledge ☐
Afraid to hurt the person ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?

Lack of knowledge ☐
Afraid to hurt the person ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

You are standing at a bus stop. How would you act if an unknown person suffered a sudden cardiac arrest? Tick one answer:

I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would give ventilations only ☐
I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?

Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?

Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Questionnaire at six months follow-up

Have you done a lifesaving intervention in real life after the CPR training? Yes ☐ No ☐

If yes, please describe your lifesaving intervention and the situation:_____

Do you think it is important to learn cardiopulmonary resuscitation in school? Yes ☐ No ☐ Do not know ☐

Do you think that your skills are sufficient to perform

chest compressions? Yes ☐ No ☐ Do not know ☐

ventilations? Yes ☐ No ☐ Do not know ☐

Are you more confident now than before the training to act and start CPR? Yes ☐ No ☐ Do not know ☐

You are at home. How would you act if a friend or relative suffered a sudden cardiac arrest? Tick one answer:

I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would give ventilations only ☐
I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?

Lack of knowledge ☐
Afraid to hurt the person ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?

Lack of knowledge ☐
Afraid to hurt the person ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

You are standing at a bus stop. How would you act if an unknown person suffered a sudden cardiac arrest? Tick one answer:

I would not dare or want to intervene ☐
I would give chest compressions only ☐
I would only give ventilations ☐
I would give both compressions and ventilations ☐

Enter the reason that you do not dare or want to do chest compressions?

Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

Enter the reason that you do not dare or want to do ventilations?

Lack of knowledge ☐
Afraid to hurt the person ☐
I do not want to touch a stranger ☐
Afraid of transmitted disease ☐
Other reasons ☐
Do not know ☐

CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	1
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	2
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	4
	2b	Specific objectives or hypotheses	4
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	4-5
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	N/A
Participants	4a	Eligibility criteria for participants	4
	4b	Settings and locations where the data were collected	4
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	4-6
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	6
	6b	Any changes to trial outcomes after the trial commenced, with reasons	N/A
Sample size	7a	How sample size was determined	6-7
	7b	When applicable, explanation of any interim analyses and stopping guidelines	N/A
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	4
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	4
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	4
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	4, 6
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those	6

		assessing outcomes) and how	
	11b	If relevant, description of the similarity of interventions	5-6
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	6-7
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	N/A
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	7-8 and Figure 1
	13b	For each group, losses and exclusions after randomisation, together with reasons	Figure 1
Recruitment	14a	Dates defining the periods of recruitment and follow-up	5
	14b	Why the trial ended or was stopped	N/A
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	Table 1
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	7-9 and Figure 1
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	7-9
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	N/A
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	N/A
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	N/A
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	3, 10, 11
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	9-10
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	10-11
Other information			
Registration	23	Registration number and name of trial registry	N/A
Protocol	24	Where the full trial protocol can be accessed, if available	N/A
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	12

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.