*Original Research Article*

# Retention of Knowledge and Skills After a Basic Life Support Course for Schoolchildren: A Prospective Study

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## Abstract

Courses on basic life support (BLS) and automated external defibrillator (AED) in schools lead to increase in knowledge but its retention is less well explored. We aimed to explore the long-term retention of knowledge and practical skills among schoolchildren after a BLS and AED course to be able to tailor future courses accordingly. Study was conducted in 3 parts and included 823 seventh and ninth graders from different elementary schools in Maribor, Slovenia. In Study 1 (n=611) we assessed students' baseline knowledge and immediate knowledge gain after our BLS and AED course with a validated questionnaire; in Study 2 (n=116) we assessed retention of gained knowledge and skills after 5 months with a modified Cardiff test and Little Anne QCPR manikin; in Study 3 (n=96) we assessed retention of knowledge 2 years after the course. Mean differences in knowledge before and after the course in Study 1 and between studies were analyzed using paired t-tests and independent t-tests. Differences between individual question scores at different time points were compared using Mann – Whitney *U* test. A two-sided P<0,05 was considered significant. Practical skills retention was presented with descriptive statistics. Knowledge gain was significant immediately after the course with 83% correct answers compared to 60% at baseline. Scores dropped significantly after 5 months (73%) and after 2 years (75%), but remained significantly better than at baseline (P<0.001). Practical skills perfomance score as per Cardiff test after 5 months was 63%. Overall BLS performance score as per QCPR app was 59%, with an overall cardio score of 77% (average compression rate: 124/min and depth: 52 mm) and ventilation score of 44%. This study showed that long term retention of theoretical knowledge was satisfying whereas poor practical skills performance after 5 months calls for a more intense practical training on repeat courses.

## Keywords

automated external defibrillator, cardiopulmonary resuscitation, knowledge, out-of-hospital cardiac arrest, schoolchildren, teaching

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**What do we already know about this topic?**

A well-established fact is that knowledge and skills decline over time and there are suggested time intervals for repeat courses but there is no definitive data on how to conduct repeat courses on basic life support (BLS) and use of automated external defibrillators (AED).

**How does your research contribute to the field?**

Our findings add valuable data to scarce existing literature on retention of knowledge and skills after BLS and AED courses for schoolchildren.

**What are your research's implications towards theory, practice, or policy?**

Our findings suggest that repeat BLS and AED courses should be more focused on practical skills training as retention of theoretical knowledge is satisfactory.

## Introduction

The importance of educating a wide population and of imparting a positive attitude towards cardiopulmonary resuscitation (CPR) has been recognized for some time now.[1,2] CPR training in schools is an effective and vital part of disseminating knowledge, skills, and positive attitude towards CPR among laypersons.[3,4] Schoolchildren are particularly susceptible and motivated for learning CPR and can be easily accessed and quickly taught.[5-7] They serve not only as potential rescuers but also as multipliers of CPR knowledge and positive attitude towards action in cases of OHCA in their environment.[8,9]

It has long been established that BLS and AED courses improve knowledge immediately after the course whereas retention of knowledge and skills is less well explored.[10-12] Existing studies advocate annual training.[3,7,10,13] The »Kids save lives« statement endorsed by The World Health Organization recommends 2 hours of BLS and AED training annually from the age of 12 years.[14] However, implementation of such initiatives and other solutions depend on the motivation of individual countries. Unfortunately, only 5 European Union countries (Belgium, Denmark, France, Italy, and Portugal) have CPR education in schools mandated by law, whereas in 16 countries (including Slovenia), CPR education is merely a suggestion.[15]

In our study we aimed to explore the longitude of knowledge retention and the magnitude of practical skills retention among schoolchildren after our BLS and AED course to be able to tailor future and repeat courses to make them more efficient and accessible.

## Methods

Our study was divided into 3 parts. In Study 1 we assessed students' baseline knowledge and immediate knowledge gain after our BLS and AED course; In Study 2 we assessed retention of knowledge and practical skills after 5 months in a smaller sample of the population from Study 1; In Study 3 we assessed long-term retention of knowledge in a sample of students that completed our BLS and AED course 2 years ago.

### *Description of the Course*

The course was organized by the Emergency Medical Services Unit of the Maribor Community Healthcare Center in cooperation with the City of Maribor Municipality, which financed the courses for all interested public elementary schools in the Municipality of Maribor. Maribor is the second biggest city in Slovenia with approximately 110.000 inhabitants.

The course was designed for individual classes consisting of up to 30 seventh- and ninth-grade students of Slovenian compulsory 9 year basic school. It was divided into 2 parts, each lasting 1 academic hour (45 minutes). In the first part, an emergency physician gave students an interactive lecture on principles of BLS and AED. The course was continued with a practical workshop, led by emergency technicians (paramedics) and physicians, where each student practiced on their own training torso manikin (Prestan Professional Adult Manikin, Prestan, Mayfield Village, OH, USA) with an AED prop – a cardboard sample with adhesive paper electrodes. A single real training AED (Defibtech Trainer AED, Defibtech, Guilford, CT, USA) was used for guidance and cardiac arrest simulation.

### *Sample*

Sampling in all 3 studies was based on the incidental application of any of the twenty eligible schools in the predetermined time frame of the studies: from October to December 2018 for Study 1 and in March and April 2019 for Study 2. Study 3 was conducted in October and November 2019 with students that completed the same BLS and AED course 2 years prior and were not included in Studies 1 or 2.

In Study 1 we investigated schoolchildren's knowledge of BLS and AED before and immediately after the course ($t_0$ and $t_1$, respectively). The sample consisted of 623 students from 9 elementary schools but only 611 of them (283 seventh- and 328 ninth graders) fulfilled both the pre- and post-course questionnaire and were therefore eligible to be included in the study. Of those, 310 were boys and 299 were girls, two students refrained from stating their gender. Only 148 students have received any prior BLS training.

In Study 2, we conducted a knowledge and skills test 5 months after the course ($t_2$) in 2 elementary schools that had previously been included in Study 1. Only students that had attended the course 5 months prior were included. One hundred and sixteen students from 2 seventh and 2 ninth grades correctly fulfilled questionnaires and completed practical testing. Of those, 67 were seventh graders and 49 ninth graders and 63 girls and 53 boys, respectively. The average age of children in seventh and ninth grade of the 9 years compulsory elementary schools in Slovenia is 12 and 14 years, respectively.

In the third study, we investigated long-term retention of knowledge after our BLS and AED course at 2 years ($t_3$). Five ninth grades from 3 different schools that completed our BLS and AED course 2 years prior were included. Only students that attended the course 2 years ago (in seventh grade), completed the questionnaire. Forty-nine girls and 47 boys were included. Study design is presented in Figure 1.

## Measuring Instrument

The first part of the instrument contained demographic data (gender, school grade, attendance to any previous BLS courses). The second part was a validated knowledge test consisting of ten multiple-choice questions about BLS and AED. Each question offered 5 answers of which only 1 was correct, therefore allowing students to achieve a maximal score of ten points.[11]

Questionnaires were handed out immediately before the lecture and immediately after the practical workshop in Study 1. In Study 2, they were handed out and fulfilled before the practical evaluation. In Study 3, they were handed out before the repeat BLS and AED course. The content of the paper and pencil test was identical throughout all studies. It did not require provision of a name to assure anonymity. In Study 1, students were asked to come up with individual codes that were used on the pre- and post-course test for the purpose of pairing tests of the same individuals for further analyses. A written informed consent was obtained from each student prior to fulfilling the questionnaires in each study. As per Slovenian rules for such type of educational research general written consent of parents is collected in advance at the beginning of each school year. Request for approval of the National Medical Ethics Committee had been filed and granted (dated October 23, 2018; filed under 0120-549/2017/9).

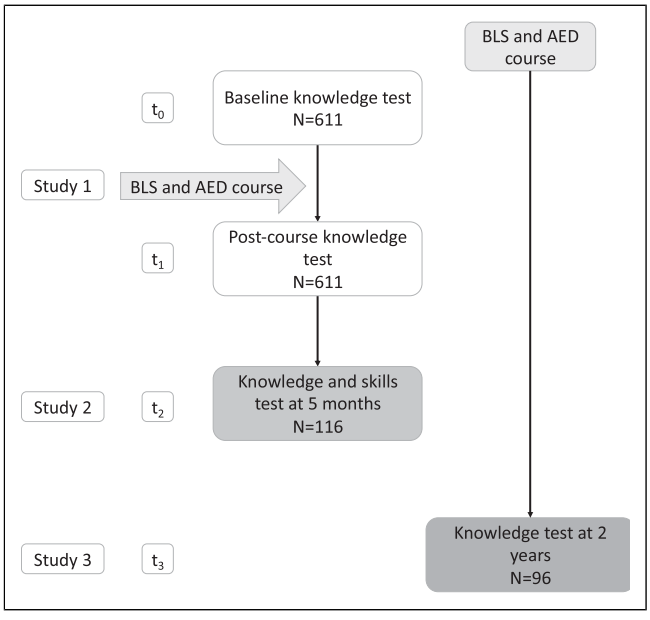


**Figure 1.** Flowsheet summarizing study design and timeline.

## Practical Skills Testing

Practical skills were tested only in Study 2. Students were presented with a theoretical cardiac arrest scenario - they were witnesses to someone collapsing. Practical skills evaluation was conducted on analytical manikins (Little Anne QCPR, Laerdal Medical, Stavanger, Norway). They were connected via Bluetooth connection to a registered application on smartphones (Little Anne QCPR Instructor App, version 3.4.11, Laerdal Medical, Stavanger, Norway). Two instructors (emergency medicine specialists) observed and evaluated their skills with the use of a modified Cardiff test.[16]

## Statistical Analyses

Statistical significance of the mean differences in knowledge before and after the course in Study 1 were calculated using paired t-test. Differences between unpaired test scores from Study 2 and 3 were compared using independent t-tests. Differences between individual question scores before and after intervention and at different time points were compared using Mann – Whitney *U* test. A two-sided $P < 0,05$ was considered significant.

SPSS software (SPSS Inc, Chicago, IL, USA) was used for statistical analysis.

# Results

As expected, knowledge gain was significant immediately after a BLS and AED course (Table 1). Although the overall level of knowledge significantly decreased after 5 months and also after 2 years (test score declined from 83% to 73% and

**Table 1.** Comparison of scores on knowledge tests at all time points (no missing data).

| | | N | Mean Score (SD) |
|---|---|---|---|
| Study 1 | $t_0$ | 611 | 6.02 (2.06) |
| | $t_1$ | 611 | 8.27 (1.61)* |
| Study 2 | $t_2$ | 116 | 7.33 (2.19)*** |
| Study 3 | $t_3$ | 96 | 7.51 (1.54)*** |

Notes: *, $P < 0.001$ compared to $t_0$; **, $P < 0.001$ compared to $t_1$.

75%, respectively) it was still significantly better than at baseline (60% before the course). Level of knowledge did not change significantly from 5 months to 2 years after the course (Table 1). Recognition of cardiac arrest remained at a comparable level 2 years after the course compared to baseline (66% vs 68%, respectively). Even in case of uncertainty whether a person was in a cardiac arrest or not most of the students that provided an answer would theoretically act correctly (95% compared to 32% at baseline). However, the difference was not statistically significant. After 2 years, almost 80% of students theoretically remembered how to check breathing and deliver artificial breaths which was significantly better than at baseline when about 65% knew the correct answer. Theoretical recognition of agonal breathing was also significantly better than at baseline (89% after 2 years compared to 64% at baseline). They remained knowledgeable about the correct ratio of chest compression to artificial breaths (69% after 2 years compared to 52% at baseline) and the location of chest compressions (around 67% after 2 years vs 48% at baseline). Most of the students were still familiar with the use of an AED after 5 months and 2 years (75% and 85% compared to 45% at baseline). Scores on individual questions on the knowledge tests are shown in Supplementary material.

Retention of practical skills, however, did not reflect the satisfying retention of theoretical knowledge about certain skills (Table 2). The average total score on the modified Cardiff test was 28 out of 44 total (63%). A lot of the steps of the BLS and AED algorithm were neglected or omitted. The subjective and objective assessment of chest compressions (with the modified Cardiff test and QCPR app, respectively) was outstanding compared to other steps, especially ventilations. Hand location was well adapted. Compression rate was mostly out of desired range (too slow on average). However, the quality of chest compressions was satisfying

**Table 2.** Correct performance of practical skills 5 months after the course as per modified Cardiff test ($t_2$; n = 116).

| | | Performance, N (%) | |
|---|---|---|---|
| BLS Step | Activity | Correct | Incorrect/None |
| Safety | Ensure safety for self, victim, and bystanders | 5 (4.3) | 111 (95.7) |
| Responsiveness | Gently shake victim | 59 (50.9) | 57 (49.1) |
| | Look for help | 8 (6.9) | 108 (93.1) |
| Airway and breathing | Open airway: Tilt head and lift chin | 20 (17.2) | 63 (54.3) |
| | Check airway | 24 (20.7) | 92 (79.3) |
| | Check breathing (look, listen, feel) ≤10s | 23 (19.8) | 63 (54.3) |
| Shout for help, call 112 | Phone EMS | 6 (5.2) | 110 (94.8) |
| | Shout for help, send for AED | 5 (4.3) | 111 (95.7) |
| CPR (2 minutes; 5 × 30:2) | Hand position | 89 (76.7) | 7 (6) |
| | Open airway: Tilt head and lift chin | 39 (33.6) | 39 (33.6) |
| | Close nostrils | 63 (54.3) | 53 (45.7) |
| | Blow in victim's mouth and check for chest rise | 25 (21.6) | 91 (78.4) |
| AED | Open/turn on AED | 92 (79.3) | 24 (20.7) |
| | Attach adhesive pads on skin | 92 (79.3) | 0 (0) |
| | Visual and verbal hands-off check during AED analysis | 45 (38.8) | 71 (61.2) |
| | Visual and verbal hands-off check before pushing button and pushing button | 34 (29.3) | 63 (54.3) |

**Table 3.** Quality of BLS as per Little Anne QCPR app (sample size = 116).

| | | N | Mean (SD) | Min | Max |
|---|---|---|---|---|---|
| Overall score | Overall score* (%) | 116 | 59 (19.67) | 0 | 99 |
| | Flow fraction (%) | 116 | 74 (9.89) | 54 | 100 |
| | Compressions per cycle | 108 | 33 (7.44) | 11 | 68 |
| | Ventilations per cycle | 34 | 1 (.82) | 0 | 2 |
| Cardio score | Overall (%) | 116 | 77 (23.46) | 0 | 99 |
| | Compressions fully released (%) | 116 | 96 (10.75) | 34 | 100 |
| | Average depth (mm) | 116 | 50 (3.35) | 30 | 51 |
| | Adequate depth (%) | 116 | 80 (31.31) | 0 | 100 |
| | Average rate (/min) | 116 | 124 (14.95) | 82 | 171 |
| | Adequate rate (%) | 116 | 29 (32.67) | 0 | 98 |
| Ventilation score | Overall (%) | 34 | 44 (32.33) | 7 | 100 |
| | Ventilations with adequate chest rise (%) | 34 | 99 (5.21) | 75 | 100 |
| | Too much chest rise (%) | 34 | 1 (5.21) | 0 | 25 |

Notes: N, number of recorded and analyzed actions by the application; *, based on compressions, ventilations and flow.

with adequate depth and release in more than 80% (Table 3). They were also confident about AED use, but mostly forgot about safety measures.

Ventilations were omitted by most students. Consequently, the ventilation score (based on quality and quantity of ventilations) was below 50%. However, the few ventilations that were delivered and detected by the app were adequate (Table 3).

## Discussion

Immediate knowledge gain after the course was significant and expected as this has been previously reported.[4,10,12,17] Retention of gained theoretical knowledge was long lasting - up to 2 years after our BLS and AED course. Understandably, there was a decrease in gained knowledge after approximately 5 months compared to immediately after the course but the level of knowledge remained at a comparable level up to 2 years after the course and remained better than at baseline which is similar to reports from other studies.[6,12,17-19] Students had not attended any other official BLS and AED course as part of their school curriculum during the 2 years between the 2 tests. It was actually noted that students after 2 years scored even better percentage wise than after 5 months on some questions. This could be attributed to a better understanding of the matter as the students grow older.[11] We can speculate that the content of the course was well presented and memorable.

Practical skills were more prone to decline. Plotnikoff and Moore had long before reported that good BLS knowledge acquisition does not correlate well with the quality of BLS skills performance.[19] Skills deterioration has repeatedly been reported by numerous authors[1,12,19] and results from our study confirm their findings. Five months after the course safety measures were omitted in most cases. This could partially be due to mental mismatch in the idea of a cardiac arrest scenario and a safe school environment in which testing was conducted. A manikin in place of a real person could be the reason for the low rate of checking responsiveness and breathing in a victim. Namely, students after 5 months and 2 years in theory still knew what to do and how to perform responsiveness and breathing checks according to the results of the knowledge test. Most students were focused on performing chest compressions and using an AED and their performance of this segment remained adequate in theory and practice throughout the entire study and comparable to reports from other studies.[9,20] A rather poor retention of overall skills 5 months after the course (mean score on Cardiff test was 63% and overall score of BLS performance on the QCPR app was 59%) indicate an important decline in practical skills with time. This finding conforms to the European Resuscitation Council's (ERC) consensus on education for resuscitation.[21] That is to be expected as practical skills in any activity need regular training for adequate performance. The ERC guidelines summarize evidence that frequent training improves CPR skills but the actual retraining periods are yet to be determined.[21,22]

### *Limitations*

Courses were led by 3 different instructors and their assistants (registered nurses working as paramedics) which was a potential limitation of the study. The content of the course was predetermined and based strictly on the latest resuscitation guidelines with which the instructors, all of which are emergency physicians - and their paramedic assistants are perfectly familiar with as per their profession. Therefore, there could not be any inter-instructor variability in this respect. Practical evaluation was performed by 2 emergency physicians and was done only in Study 2. Lack of objective testing of practical skills immediately after the course and re-testing for retention of skills after 2 years are great limitations of this study.

Even though the authors have acquired all reasonable measures to alleviate possible bias, the sole process of educating and training includes a variety of uncontrollable factors, such as personal attractiveness, assertiveness, communication skills of the instructor on 1 hand, and students' momentary and general attentiveness on the other. However, the sum of all factors' variability reflects the real-life situation where a number of instructors will be involved in the process.

Unfortunately, it has been rather challenging to include even a free BLS and AED course on schools' busy schedules, let alone include such a course in official school curricula on a national level. Based on our findings and considering the current organizational situation, a valid suggestion for educators designing BLS and AED courses for schoolchildren would be to place more emphasis on practical training on repeat courses after 2 years (where annual courses are not feasible). Given the satisfactory knowledge retention even after 2 years, repeat courses could potentially be shorter in duration - less than 2 hours as is suggested by the "Kids save lives" initiative.[23] The theoretical lecture could be shortened to an overview of key aspects of BLS and AED and more emphasis given to practical training. Thereby, the least amount of valuable pedagogical time would be taken from schools, but the children would nevertheless get the optimal amount of training needed for adequate performance of BLS and AED skills.

## Conclusion

Baseline knowledge of participating schoolchildren improved significantly after the BLS and AED course. Level of knowledge expectedly decreased after 5 months but remained at a comparable level even after 2 years. Drop in retention of practical skills after 5 months, however, calls for a more intense training of practical skills on the repeat courses. Therefore, we suggest that on repeat courses on BLS and AED the instructors put greater emphasis on practical training, with only a quick theoretical overview of key BLS and AED steps.

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## Ethics approval and consent to participate

Approval from the National Medical Ethics Committee (Ministry of Health of republic of Slovenia) has been granted (dated October 23, 2018; filed under 0120-549/2017/9).

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## Supplemental Material

Supplemental material for this article is available online.

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