ABCS HEALTH SCIENCES

REVIEW ARTICLE

OPEN ACCESS

Basic life support training in schools

Romualdo Parente de Souza[1], João Carlos Pina Faria[2]

[1]Departamento de Morfologia e Fisiologia, Programa de Pós-Graduação de Fisiologia Humana, Centro Universitário FMABC – Santo André (SP), Brazil.
[2]Departamento de Pediatria, Setor de Urgências e Emergências Pediátricas, FMABC – Santo André (SP), Brazil.

ABSTRACT

Older children and adolescents are able to learn and perform cardiopulmonary resuscitation maneuvers in a satisfactory manner. Schools are places where training in basic life support can be carried out. This narrative review was carried out to assess the effectiveness of training in basic life support in schools, analyzing different learning methodology, age groups, and gaining confidence in performing cardiopulmonary resuscitation in a real situation. The search was conducted in the MEDLINE database. Articles published from 01/01/2014 to 12/31/2019, with children under 18 years of age, published in English, Portuguese and Spanish, were selected. Three hundred and nine articles were found, of which 15 met the inclusion criteria in the study. There was great heterogeneity in the methodologies evaluated, making it difficult to compare some studies. Cardiopulmonary resuscitation taught to school children has resulted in the retention of skills and knowledge. There was a direct relationship between age group and quality of cardiopulmonary resuscitation. Learning cardiopulmonary resuscitation can also change the stigma and fear associated with procedures. We conclude that the teaching of cardiopulmonary resuscitation by different methodologies is effective in the learning of children and adolescents and improves their confidence in doing it. Although older than 12 years of age have a greater ability for depth of compression, other points of basic life support can be developed in younger children.

Keywords: cardiopulmonary resuscitation; training; schools; child; adolescent.

INTRODUCTION

Cardiac arrest is defined by the loss of the contractile function of the heart muscle, with the absence of blood circulation[1]. Extrahospital cardiac arrest is more frequent than intrahospital arrest, being one of the main causes of death in the world[2,3]. The chance of survival is related to the etiology of cardiac arrest[4]. When the cause is clinical (non-traumatic), survival varies between 5% and 10%[5]. When the victim in an extrahospital environment receives immediate assistance from lay people trained in cardiopulmonary resuscitation (CPR), survival increases to 40%[6]. In cases of traumatic Cardiac arrest, survival is shorter, between 1% and 7%, with little benefit for those who receive immediate care[7].

The training of laypeople, including children, increases the survival of cases in cardiac arrest[8]. In 2015, through a joint declaration involving the European Resuscitation Council, the European Foundation for Patient Safety, the International Committee on Resuscitation, the World Federation of Societies of Anesthesiologists, and the World

How to cite this article: Souza et al. Basic life support training in schools. ABCS Health Sci. 2021;46:e021303. https://doi.org/10.7322/abcshs.2020051.1499

Received: May 21, 2020
Revised: Sep 29, 2020
Approved: Oct 08, 2020

Correspondign author: João Carlos Pina Faria - Centro Universitário FMABC – Departamento de Pediatria – Setor de Urgências e Emergências Pediátricas – Avenida Lauro Gomes, 2000 - Vila Sacadura Cabral - CEP: 09060-870 - Santo André (SP), Brazil - E-mail: jocapf79@gmail.com

Declaration of interests: nothing to declare

Health Organization, the project "*Kids Save Lives*" recommending the training of two hours per year in CPR from 12 years of age[9]. Based on this recommendation, new studies began to evaluate the effectiveness of different teaching methods on basic life support (BLS) for the pediatric age group.

The American Heart Association (AHA) recommends that during CPR in adults, chest compression of five to six centimeters should be performed with a frequency of 100 to 120 compressions per minute[10]. During CPR, the chest must be returned and minimized interruptions[10]. After each cycle of two minutes of CPR, it should be evaluated if there is a return of central pulse and ventilatory movements, soon interruption. If there is no return from spontaneous circulation, restart the CPR[11] maneuvers. Adequate ventilation is important during CPR. However, its teaching is more complex and reserved mainly for health professionals and first responders[11].

The aim of this study was to conduct a review on the effectiveness of training in basic life support for children and adolescents in a school environment, analyzing different teaching methodologies, age groups, and gaining confidence in performing cardiopulmonary resuscitation in a real situation.

METHODS

This is a narrative review using articles from the MEDLINE database. The descriptors "cardiopulmonary resuscitation", "training," and "schools" were used, combined with the Boolean operator "AND".

Then, four Pubmed filters were used: period (Publication date from 2014/01/01 to 2019/12/31), studies in humans (Humans), articles in English, Portuguese and Spanish (English, Portuguese, Spanish), and age group from 0 to 18 years old (Child: birth-18 years).

The selected articles had their title and summary evaluated. Studies were included that evaluated the effectiveness of different methodologies in teaching BLS maneuvers in children and adolescents in a school environment and analyzed at least one of the following three topics: theoretical knowledge, ability to perform CPR, and the gain of confidence to apply the knowledge acquired in a real situation.

RESULTS AND DISCUSSION

309 articles were found, and of these, 238 were excluded in the initial analysis using four Pubmed filters: 170 studies published before January 1, 2014; 27 animal studies; 41 studies carried out in adults; 2 articles with different languages than the selected ones.

The remaining 69 articles had their titles and abstracts evaluated. Of these, 54 articles were excluded, as they did not address the topic of training students in BLS (Figure 1).

15 studies from 13 countries were selected[12-26] (Table 1).

Five studies were randomized controlled trials, and 10 were observational. All were available in the English language.

The reviewed studies showed great heterogeneity in relation to the target population and the experimented method. Considering the articles selected from the MEDLINE database, the relevant aspects of being compared are as follows.

Teaching methodology

Four prospective observational studies have shown that students have improved knowledge of how to perform CPR after a class on the topic. Training based on a 13-minute video prepared by the AHA, followed by a practical class with a mannequin for 15 minutes, proved to be effective in learning BLS maneuvers. This study was conducted in Costa Rica with 308 students aged 11 to 18 years. The overall score of students (average percentage correct) on multiple-choice questions more than doubled after training (40.9±1.4% before training versus 92.5±0.9% after training, $p<0.001$)[12]. Brazilian research compared the BLS learning of 14- and 15-year-old students from a public school and a private one, with similar income in ENEM (national high school exam). All showed improvement in knowledge, with greater use of students from the private school ($p<0.001$)[13].

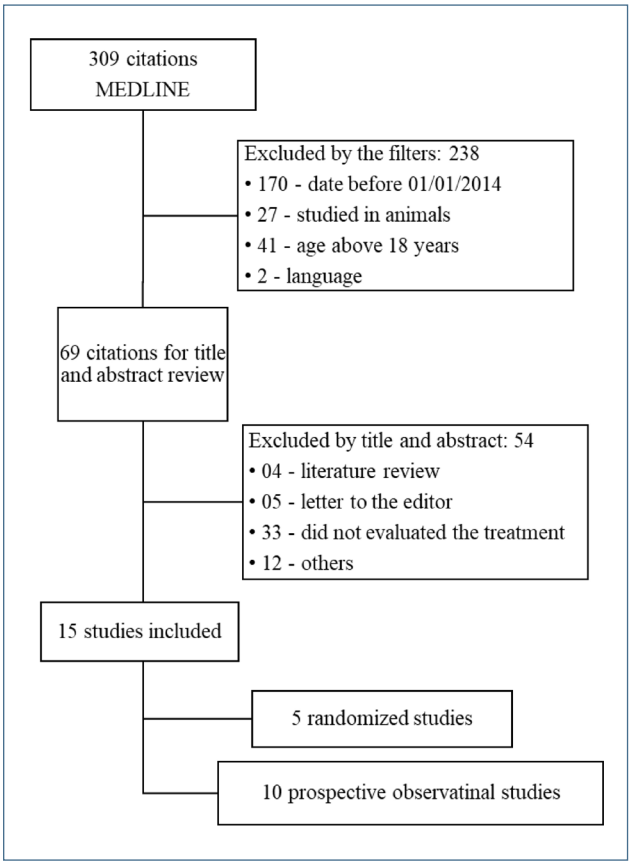

Figure 1: Method of selection of articles.

Table 1: Studies selected for review

Reference	Study	Location	Sample	Objective	Conclusion
Schmid et al.[12]	Prospective observational	Costa Rica	4 schools 308 students aged 11 to 18	To assess whether an AHA-based video and dummy program is effective in teaching schoolchildren to perform chest compressions.	The application of video associated with training on a mannequin was effective in teaching chest compressions and boosts student confidence in performing CPR.
Fernandes et al.[13]	Prospective observational	Brazil	2 schools 60 students aged 14 and 15	To compare prior knowledge and the degree of immediate and late learning among students from a public school and a private school after BLS training.	There was an improvement in knowledge, especially for students from the private school.
Aaberg et al.[14]	Prospective observational	Denmark	1 school 651 students aged 17 to 21	To assess the current knowledge about BLS in Danish high school students and the benefits of a single training session taught by resident physicians.	After BLS training, there was an improvement in knowledge and confidence to apply CPR.
Magid et al.[15]	Prospective observational	US	1131 schools 334,610 students aged 12 and 13	To assess the feasibility of teaching CPR to schoolchildren by teachers guided by AHA training kits and resources.	Teaching BLS by school professionals previously trained by AHA kits is effective in learning and increases student confidence in performing CPR.
Yeung et al.[16]	Randomized	United Kingdom	3 schools 81 students aged 12 and 13	To compare the effectiveness of the exclusive training with the game "Lifesaver", the exclusively practical F2F training applied to mannequins and the mixed training (game + F2F).	The mixed training (game "Lifesaver" + F2F) showed better performance when compared to training performed exclusively with game or practice.
Semeraro et al.[17]	Prospective observational	Italy	2 schools 65 students aged 15 to 17	To assess whether the use of the "Relive" game allows students to improve their CPR knowledge and skills.	Training with the game "Relive" was effective in learning the frequency and depth of chest compressions. However, after 6 months, there was a decrease in the efficiency in the compression frequency.
Wingen et al.[18]	Randomized	Germany	4 schools 424 students aged 14 to 18	To assess the impact of CPR training on resuscitation knowledge and high school students' self-confidence.	There was a significant improvement in responses and self-confidence in the intervention group immediately and 6 months after training.
Nord et al.[19]	Randomized	Sweden	7 schools 587 students 13 year old	To assess whether two additional interventions (practical test with feedback and reflection) after standard CPR training facilitate learning.	Associating a skills test with feedback after practical CPR training improves performance. Associating the reflection test has no additional benefits. The 3 methods increased the degree of confidence of the student to perform CPR.
Pozo et al.[20]	Randomized	Spain	2 schools 122 students aged 12 to 14	To evaluate the effectiveness of a "cardiopulmonary resuscitation song" in improving the basic life support skills of high school students.	The incorporation of music in the teaching of cardiopulmonary resuscitation increased its effectiveness and the ability to remember the algorithm of cardiopulmonary resuscitation.
Beskind et al.[21]	Randomized	US	1 school 179 students aged 14 to 18	To assess whether a short video is as effective as classroom instruction for CPR training only with chest compression in high school students.	There was an improvement in the compression frequency in the 2 groups. However, the depth of compression was performed more effectively in the group that received training in the classroom, demonstrating that practical training is essential.
Hori et al.[22]	Prospective observational	Japan	8 schools 6352 students aged 10 to 16	To compare satisfaction rates and willingness to perform CPR on students who received BLS training at school.	Students aged 10 and 11 showed a better evaluation of BLS training and confidence gain to perform CPR than older children.
Kitamura et al.[23]	Prospective observational	Japan	17 schools 2047 students aged 10 to 12	To compare the knowledge and attitude of students before and after receiving BLS training.	Most students said they understood how to perform the BLS and showed greater confidence in performing CPR.
He et al.[24]	Prospective observational	China	6 schools 360 students aged 6 to 16	To assess which is the ideal age to start CPR training.	Children aged 6 years perform CPR with a frequency of compression and complete relaxation of the chest properly. However, the depth of compression and positioning of the hands are performed with greater efficiency from the age of 12.

Continue...

Table 1: Continuation

Reference	Study	Location	Sample	Objective	Conclusion
Mpotos et al.[25]	Prospective observational	Belgium	1 school 265 students aged 12 to 18	To investigate the variability in the compression depth for three age groups according to physical characteristics.	A minimum level of excellence of 25% is achieved by boys from 12 to 14 years old and girls from 14 to 16 years old and can be gradually improved. Children weighing more than 50 kg found it easier to perform adequate CPR.
Banfai et al.[26]	Prospective observational	Hungary	1 school 582 students aged 7 to 14	To evaluate the effectiveness of a three-day first aid course for all age groups in a primary school (7 to 14 years old).	Children from 7 years old are able to learn BLS maneuvers. Children with older age, weight, height and body mass index showed greater efficiency in the depth of compression.

AHA: American Heart Association; CPR: Cardiopulmonary Resuscitation; BLS: Basic Life Support; F2F: Face-to-face

A Danish study evaluated the benefits of a single training session given by resident doctors to students aged 17 to 21. It demonstrated that there was an improvement in knowledge after training ($p<0.001$)[14]. In 2018, the study with the largest sample of this review was published, with the participation of 334,610 students aged 12 and 13 years from 1131 schools. This study was carried out in the United States in a partnership between AHA and the Ross Dress for Less store chain. Employees from participating schools learned BLS from AHA volunteers using AHA CPR training kits. Subsequently, these employees trained the practice of CPR with students using mannequins. There was a significant improvement in the post-test responses when compared to the pre-test (84% x 50% - $p<0.001$), which proves the feasibility of training facilitators to spread the knowledge of BLS teaching to students[15]. These studies are in agreement with others, demonstrating that short training sessions performed by previously trained professionals or laypeople significantly improve the efficiency of those who perform the BLS[27-29].

Two studies evaluated the effectiveness of using a game to train students in BLS. In the United Kingdom, a randomized three-arm survey was carried out with 81 students aged 12 and 13 years. The practical face-to-face training (F2F) associated with the game "Lifesaver"[30] for smartphones and tablets, available for free, showed superior results in the first evaluation when compared only to the practical training or the game ($p=0.001$)[16]. A sample of adolescents aged 15 to 17 years received CPR training based on the 3D game "Relive", associated with Kinect®. The students visualized its effectiveness through a television monitor. Training with the game was effective in learning the frequency and depth of chest compressions. However, after six months, there was a decrease in efficiency in the compression frequency[17]. Game learning can be an effective alternative for places where, despite the recommendation, BLS teaching for schoolchildren has not yet been implemented[31]. Another advantage of games is to increase student interest in the method used.

Studies carried out with undergraduate students in the first-year medical course have shown better results in CPR after video classes, but the students said they prefer the game-based method as a form of self-training[32]. Another study carried out with second-year students, compared the practical training in BLS with the same training associated with a 3D game "Staying Alive" and found no difference in learning between the groups[33]. Although these two studies were carried out with students at the beginning of higher education, it is possible that similar results occur in high school students. Special attention should be paid to the game model and the frequency of training. Whenever possible, practical training should be carried out.

Four randomized trials compared classic BLS training with other methods. A German study carried out with 424 students aged 14 to 18 years showed that the group that received 90 minutes of theoretical-practical training had a significantly higher level of knowledge when compared to the group that was not trained ($p<0.001$)[18]. In Sweden, 587 13-year-old children were randomized into three groups. One group received theoretical and practical BLS training (45 to 60 minutes). Another group received the same training associated with extra 2-minute practice with immediate individual feedback, correcting errors in CPR. The third group received the same treatment as the second, added to a period of reflection, when the group of students debated issues related to the theme for 15 minutes. The group that received feedback without the reflection period showed better results, demonstrating that longer workouts are not necessarily more effective[19].

One study compared the effectiveness of BLS training with the same training associated with a song on the basis of CPR. The rhythm also helped to keep the compression rate within the ideal range. The simple association of music with training resulted in greater efficiency of CPR eight months after training[20]. A randomized study compared 3 groups: Practical CPR Training; CPR Video-Class; Video not related to CPR. There was an improvement in the compression frequency in the first two groups. However, the depth of compression was performed more effectively in the group that received training in the classroom, demonstrating that practical training is essential[21]. These studies demonstrate

that several methods are efficient and can be used without increasing the time or cost of training. The choice of the ideal method can vary with the population, the age group of the student, and the availability of materials[34]. Places with few resources can carry out training through the improvisation of materials, such as PET bottles simulating a mannequin, a method that has already proved to be effective ($p<0.01$)[35]. A 2019 systematic review evaluated 34 articles on BLS training for adults and concluded that different types of training are effective in gaining knowledge and skills. Skills deteriorate after a few months. Training associated with music resulted in greater permanence of CPR skills[36].

Comfort in applying cardiopulmonary resuscitation in a real situation after training

Seven studies asked the participant to answer if they would apply CPR in a real PCR and if the training increased the degree of confidence. All concluded that the course, regardless of the child's age and the teaching method used, increased the degree of confidence and the willingness to perform CPR (between 72 and 90%, $p<0.001$)[12,14,15,18,19,22,23]. A study carried out in the United Kingdom with 2084 laypeople showed that, regardless of the method, BLS training significantly increases the intention and confidence in performing CPR in a real situation[37].

Best time to start basic life support training

Three prospective observational studies assessed age and physical characteristics.

A study carried out in China with 360 students from six to 16 years old demonstrated that all age groups have evolved in the ability to perform CPR after BLS class. Six-year-old children underwent CPR with a frequency of compression and complete relaxation of the chest adequately. Still, the depth of compression and hand positioning are performed with greater efficiency from the age of 12[24]. In Belgium, a minimum level of excellence of 25% is achieved by boys from 12 to 14 years old and girls from 14 to 16 years old and can be gradually improved. Among the physical characteristics, the weight above 50kg was related to greater efficiency in CPR[25]. Hungarian study with children aged seven to 14 years concluded that from the age of seven, children are able to learn BLS maneuvers. Children with older age, weight, height, and body mass index showed greater efficiency in the depth of compression[26]. The greater adequacy in cardiopulmonary resuscitation by adolescents may be related to physical characteristics. However, younger children can develop some of the techniques performed in CPR.

A survey with children from 10 to 16 years old from Japan evaluated at what age the students were more interested in participating in a BLS course. The youngest students (10 to 11 years old) were the ones with the greatest interest[22]. These data are similar to those found in other studies[38,39]. However, other studies have shown that children under 10 years of age are also interested and are able to learn BLS, despite the difficulty of performing compression at the correct depth[40]. Therefore, BLS teaching could be instituted before the current recommendations of the World Health Organization (12 years old)[9].

We cite as limitations of the study the fact that the heterogeneity of the studied population and the evaluated methods make greater comparisons between groups impossible. No review was performed for bases other than PubMed®/MEDLINE®.

CONCLUSION

Different methods of teaching basic life support have been tested in children. All of them showed a significant gain in the knowledge of the maneuvers, in the acquired skills, and also in the degree of confidence in performing cardiopulmonary resuscitation in a real situation. Although the greatest efficacy in cardiopulmonary resuscitation is achieved by older children, this difference may be related to physical characteristics. Older children can compress the chest more deeply. However, younger children can learn other stages of basic life support effectively.

REFERENCES

1. Berdowski J, Berg RA, Tijssen JGP, Koster RW. Global incidences of out-of-hospital cardiac arrest and survival rates: systematic review of 67 prospective studies. Resuscitation. 2010;81(11):1479-87. http://doi.org.br/10.1016/j.resuscitation.2010.08.006

2. Benjamin EJ, Blaha MJ, Chiuve SE, Cushman M, Das SR, Deo R, et al. Heart disease and stroke statistics - 2017 update: a report from the American Heart Association. Circulation. 2017;135(10):e146-603. https://doi.org/10.1161/CIR.0000000000000485

3. Myat A, Song KJ, Rea T. Out-of-hospital cardiac arrest: current concepts. Lancet. 2018;391(10124):970-9. https://doi.org/10.1016/S0140-6736(18)30472-0

4. Panchal AR, Bobrow BJ, Spaite DW, Berg RA, Stolz U, Vadeboncoeur TF, *et al.* Chest compression-only cardiopulmonary resuscitation performed by lay rescuers for adult out-of-hospital cardiac arrest due to non-cardiac aetiologies. Resuscitation. 2013;84(4):435-9. https://doi.org/10.1016/j.resuscitation.2012.07.038

5. Lockey DJ, Lyon RM, Davies GE. Development of a simple algorithm to guide the effective management of traumatic cardiac arrest. Resuscitation. 2013;84(6):738-42. https://doi.org/10.1016/j.resuscitation.2012.12.003

6. Iwami T, Kitamura T, Kawamura T, Mitamura H, Nagao K, Takayama M, *et al.* Chest compression-only cardiopulmonary resuscitation for out-of-hospital cardiac arrest with public-access defibrillation: a nationwide cohort study. Circulation. 2012;126(24):2844-51. https://doi.org/10.1161/CIRCULATIONAHA.112.109504

7. Chien CY, Su YC, Lin CC, Kuo CW, Lin SC, Weng YM. Is 15 minutes an appropriate resuscitation duration before termination of a traumatic cardiac arrest? A case-control study. Am J Emerg Med. 2016;34(3):505-9. https://doi.org/10.1016/j.ajem.2015.12.004

8. Abelsson A, Nygardh A. To enhance the quality of CPR performed by youth layman. Int J Emerg Med. 2019;12(30). https://doi.org/10.1186/s12245-019-0247-6

9. Böttiger BW, van Aken H. Kids save lives-Training school children in cardiopulmonary resuscitation worldwide is now endorsed by the World Health Organization (WHO). Resuscitation. 2015;94:A5-7. https://doi.org/10.1016/j.resuscitation.2015.07.005

10. Neumar RW, Shuster M, Callaway CW, Gent LM, Atkins DL, Bhanji F, *et al*. Part 1: Executive Summary: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2015;132(18 Suppl 2):S315-67. https://doi.org/10.1161/CIR.0000000000000252

11. Bernoche C, Timerman S, Polastri TF, Giannetti NS, Siqueira AWS, Piscopo A, *et al*. Atualização da Diretriz de Ressuscitação Cardiopulmonar e Cuidados Cardiovasculares de Emergência da Sociedade Brasileira de Cardiologia – 2019. Arq Bras Cardiol. 2019;113(3):449-663. https://doi.org/10.5935/abc.20190203

12. Schmid KM, García RQ, Fernandez MM, Mould-Millman NK, Lowenstein SR. Teaching hands-only CPR in schools: A program evaluation in San José, Costa Rica. Ann Glob Health. 2018;84(4):612-7. https://doi.org/10.9204/aogh.2367

13. Fernandes JM, Leite AL, Auto BS, Lima JE, Rivera IR, Mendonça MA. Teaching basic life support to students of public and private high schools. Arq Bras Cardiol. 2014;102(6):593-601. https://doi.org/10.5935/abc.20140071

14. Aaberg AM, Larsen CE, Rasmussen BS, Hansen CM, Larsen JM. Basic life support knowledge, self-reported skills and fears in Danish high school students and effect of a single 45-min training session run by junior doctors; a prospective cohort study. Scand J Trauma Resusc Emerg Med. 2014;22:24. https://doi.org/10.1186/1757-7241-22-24

15. Magid KH, Heard D, Sasson C. Addressing Gaps in Cardiopulmonary Resuscitation Education: Training Middle School Students in Hands-Only Cardiopulmonary Resuscitation. J Sch Health. 2018;88(7):524-30. https://doi.org/10.1111/josh.12634

16. Yeung J, Kovic I, Vidacic M, Skilton E, Higgins D, Melody T, *et al*. The school Lifesavers study-A randomised controlled trial comparing the impact of Lifesaver only, face-to-face training only, and Lifesaver with face-to-face training on CPR knowledge, skills and attitudes in UK school children. Resuscitation. 2017;120:138-45. https://doi.org/10.1016/j.resuscitation.2017.08.010

17. Semeraro F, Frisoli A, Loconsole C, Mastronicola N, Stroppa F, Ristagno G, *et al*. Kids (learn how to) save lives in the school with the serious game Relive. Resuscitation. 2017;116:27-32. https://doi.org/10.1016/j.resuscitation.2017.04.038

18. Wingen S, Schroeder DC, Ecker H, Steinhauser S, Altin S, Stock S, *et al*. Self-confidence and level of knowledge after cardiopulmonary resuscitation training in 14 to 18-year-old schoolchildren: A randomised-interventional controlled study in secondary schools in Germany. Eur J Anaesthesiol. 2018;35(7):519-26. https://doi.org/10.1097/EJA.0000000000000766

19. Nord A, Hult H, Kreitz-Sandberg S, Herlitz J, Svensson L, Nilsson L. Effect of two additional interventions, test and reflection, added to standard cardiopulmonary resuscitation training on seventh grade students' practical skills and willingness to act: a cluster randomised trial. BMJ Open. 2017;7(6):e014230. https://doi.org/10.1136/bmjopen-2016-014230

20. del Pozo FJF, Alonso JV, Velis NBC, Barahona MMA, Siggers A, Lopera E. Basic life support knowledge of secondary school students in cardiopulmonary resuscitation training using a song. Int J Med Educ. 2016;7:237-41. https://doi.org/10.5116/ijme.5780.a207

21. Beskind DL, Stolz U, Thiede R, Hoyer R, Burns W, Brown J, *et al*. Viewing a brief chest-compression-only CPR video improves bystander CPR performance and responsiveness in high school students: A cluster randomized trial. Resuscitation. 2016;104:28-33. https://doi.org/10.1016/j.resuscitation.2016.03.022

22. Hori S, Suzuki M, Yamazaki M, Aikawa N, Yamazaki H. Cardiopulmonary Resuscitation Training in Schools: a comparison of trainee satisfaction among different age groups. Keio J Med. 2016;65(3):49-56. https://doi.org/10.2302/kjm.2015-0009-OA

23. Kitamura T, Nishiyama C, Murakami Y, Yonezawa T, Nakai S, Hamanishi M, *et al*. Compression-only CPR training in elementary schools and student attitude toward CPR. Pediatr Int. 2016;58(8):698-704. https://doi.org/10.1111/ped.12881

24. He DX, Huang KS, Yang YI, Jiang W, Yang NL, Yang H. What is the Optimal Age for Students to Receive Cardiopulmonary Resuscitation Training? Prehosp Disaster Med. 2018;33(4):394-8. https://doi.org/10.1017/S1049023X1800047X

25. Mpotos N, Iserbyt P. Children saving lives: Training towards CPR excellence levels in chest compression based on age and physical characteristics. Resuscitation. 2017;121:135-40. https://doi.org/10.1016/j.resuscitation.2017.10.024

26. Banfai B, Pek E, Pandur A, Csonka H, Betlehem J. 'The year of first aid': effectiveness of a 3-day first aid programme for 7-14-year-old primary school children. Emerg Med J. 2017;34(8):526-32. https://doi.org/10.1136/emermed-2016-206284

27. Woollard M, Whitfield R, Newcombe RG, Colquhoun M, Vetter N, Chamberlain D. Optimal refresher training intervals for AED and CPR skills: a randomised controlled trial. Resuscitation. 2006;71(2):237-47. https://doi.org/10.1016/j.resuscitation.2006.04.005

28. Andresen D, Arntz HR, Grafling W, Hoffmann S, Hofmann D, Kraemer R, *et al*. Public access resuscitation program including defibrillator training for laypersons: a randomized trial to evaluate the impact of training course duration. Resuscitation. 2008;76(3):419-24. https://doi.org/10.1016/j.resuscitation.2007.08.019

29. Beckers SK, Fries M, Bickenbach J, Skorning MH, Derwall M, Kuhlen R, *et al*. Retention of skills in medical students following minimaltheoretical instructions on semi and fully automated external defibrillators. Resuscitation. 2007;72(3):444-50. https://doi.org/10.1016/j.resuscitation.2006.08.001

30. Resuscitation Council UK. Resuscitation Council UK's interactive training tool Lifesaver is a cutting-edge way to learn lifesaving skills anytime, anywhere. Available from: https://www.resus.org.uk/public-resource/how-we-save-lives/lifesaver-learning

31. Hansen CM, Zinckernagel L, Ersbøll AK, Tjørnhøj-Thomsen T, Wissenberg M, Lippert FK, *et al*. Cardiopulmonary Resuscitation Training in Schools Following 8 Years of Mandating Legislation in Denmark: A Nationwide Survey. J Am Heart Assoc. 2017;6(3):e004128. https://doi.org/10.1161/JAHA.116.004128

32. Sena DP, Fabrício DD, Silva VD, Bodanese LC, Franco AR. Comparative evaluation of video-based on-line course versus serious game for training medical students in cardiopulmonary resuscitation: a randomised trial. PLoS One. 2019;14(4):e0214722. https://doi.org/10.1371/journal.pone.0214722

33. Drummond D, Delval P, Abdenouri S, Truchot J, Ceccaldi PF, Plaisance P, *et al*. Serious game versus online course for pretraining medical students before a simulation-based mastery learning course on cardiopulmonary resuscitation: A randomised controlled study. Eur J Anaesthesiol. 2017;34(12):836-44. https://doi.org/10.1097/EJA.0000000000000675

34. Lockey AS, Barton K, Yoxall H. Opportunities and barriers to cardiopulmonary resuscitation training in English secondary schools. Eur J Emerg Med. 2016;23(5):381-5. https://doi.org/10.1097/MEJ.0000000000000307

35. Bonizzio CR, Nagao CK, Polho GB, Paes VR. Basic Life Support: an accessible tool in layperson training. Rev Assoc Med Bras. 2019;65(10):1300-7. https://doi.org/10.1590/1806-9282.65.10.1300

36. Riggs M, Franklin R, Saylany L. Associations between cardiopulmonary resuscitation (CPR) knowledge, self-efficacy, training history and willingness to perform CPR and CPR psychomotor skills: a systematic review. Resuscitation. 2019;138:259-72. https://doi.org/10.1016/j.resuscitation.2019.03.019

37. Hawkes CA, Brown TP, Booth S, Fothergill RT, Siriwardena N, Zakaria S, *et al*. Attitudes to Cardiopulmonary Resuscitation and Defibrillator Use: A Survey of UK Adults in 2017. J Am Heart Assoc. 2019;8(7):e008267. https://doi.org/10.1161/JAHA.117.008267

38. Van Kerschaver E, Delooz HH, Moens GF. The effectiveness of repeated cardiopulmonary resuscitation training in a school population. Resuscitation. 1989;17(3):211-22. https://doi.org/10.1016/0300-9572(89)90037-3

39. Jones I, Whitfield R, Colquhoun M, Chamberlain D, Vetter N, Newcombe R. At what age can schoolchildren provide effective chest compressions? An observational study from the Heartstart UK schools training programme. BMJ. 2007;334(7605):1201. https://doi.org/10.1136/bmj.39167.459028.DE

40. Bollig G, Wahl HA, Svendsen MV. Primary school children are able to perform basic life-saving first aid measures. Resuscitation. 2009;80(6):689-92. https://doi.org/10.1016/j.resuscitation.2009.03.012