Journal for Educators, Teachers and Trainers
The PROFESIOLab electronic, peer-reviewed, open-access Magazine

ISSN 1989–9572

DOI:10.47750/jett.2024.15.03.009

Impact of the Forgetting Curve on Cognitive Skills in Basic Life Support

Impacto de la Curva del Olvido en las Competencias Cognitivas en Soporte Vital

Raquel Catón-Cortés,
Francisco j.Gómez-Jiménez
Gerardo Gómez-Moreno
María A. Hernández-París
Francisco M. Parrilla-Ruiz
Antonio Cárdenas-Cruz.

Journal for Educators, Teachers and Trainers, Vol. 15 (3)

https://jett.labosfor.com/

Date of revision: 01 2024

Date of Published: 07 2024

Raquel Catón-Cortés, Francisco J. Gómez-Jiménez, Gerardo Gómez-Moreno, María A. Hernández-París[4], Francisco M. Parrilla-Ruiz, Antonio Cárdenas-Cruz (2024). Impact of the Forgetting Curve on Cognitive Skills in Basic Life Support Impacto de la Curva del Olvido en las Competencias Cognitivas en Soporte Vital. *Journal for Educators, Teachers and Trainers*, Vol. 15(3).99-111.

Impact of the Forgetting Curve on Cognitive Skills in Basic Life Support

Impacto de la Curva del Olvido en las Competencias Cognitivas en Soporte Vital

Raquel Catón-Cortés[1], Francisco J. Gómez-Jiménez[2], Gerardo Gómez-Moreno[3], María A. Hernández-París[4], Francisco M. Parrilla-Ruiz[5], Antonio Cárdenas-Cruz[6]

[1] Medical Doctor. Specialist in Family and Community Medicine, Emergency Department, Poniente University Hospital Almería (Spain). PhD candidate in the Clinical Medicine and Public Health Program at the University of Granada (Spain). Email:raquel.cc.huecija@hotmail.com

[2]Associate Professor, Department of Medicine, University of Granada (Spain). Email: fgomez@ugr.es

[3]Full Professor, Department of Stomatology, University of Granada (Spain). Medical Graduate. Email: ggomez@ugr.es

[4] Medical Doctor. Specialist in Family and Community Medicine, Emergency Department. Torrecárdenas University Hospital, Almería (Spain). Email: hernandezparis92@gmail.com

[5]Medical Doctor. Specialist in Family and Community Medicine, Emergency Department, San Cecilio Clinical University Hospital, Granada (Spain). Clinical Associate Professor, Department of Medicine, University of Granada (Spain). Email: parrilola@ugr.es

[6]Medical Doctor. Intensive Care Medicine Specialist, Virgen de las Nieves University Hospital, Granada (Spain). Clinical Associate Professor Department of Medicine, University of Granada (Spain). Director of the Research Group Criticallab CTS 609, Email: cardenascruz@ugr.es

ABSTRACT

In Spain, 24,000 cardiorespiratory arrests (CRA) occur annually, most of them occur in extra-hospital situations. Bystanders are present in some 70% of cases, but cardiopulmonary resuscitation is initiated in fewer than 30%. Objective: In the context of a basic life support (BLS) training program in secondary schools, to analyze cognitive skills acquisition and the shape of the forgetting curve according to age, gender, and school location. Materials and method: Six secondary educations schools in Granada (Spain) were selected randomly. Students took a multiple-choice test (including six key questions on the basic concepts of BLS) before, immediately after BLS training, and six months later. Results: Four hundred and twenty students out of an initial sample of 459 completed the program and follow-up. Cognitive skills acquisition was found to be good. Based on six key questions, the skills acquired after training improved by 26.8% compared with the baseline assessment, although an 18.1% decrease in cognitive skills was observed 6 months later. Conclusions: Conceptual training to boost the intellectual capital of students attending a BLS training program is essential to the subsequent acquisition of the other skills involved in BLS, the definition of key concepts being an adequate tool for skills learning.

Keywords: cardiopulmonary resuscitation; chest compressions; automated external defibrillation; students; secondary education center; teaching

RESUMEN
En España, se producen 24500 paradas cardiorrespiratorias anuales la mayoría extrahospitalarias. El 70 % son presenciadas, pero en menos del 30% se inician las maniobras de reanimación cardiopulmonar. Objetivo: Analizar la adquisición de competencias cognitivas y el desarrollo de la curva del olvido según edad, sexo y nivel socioeconómico dentro de un programa formativo en soporte vital básico (SVB). Materiales y método: Se seleccionaron aleatoriamente 6 centros de educación secundaria en Granada. Los alumnos realizaron un test de respuesta múltiple sobre conceptos umbrales de SVB antes del proceso formativo, al finalizar, y pasados 6 meses. El test se diseñó con el empleo de 6 preguntas clave vinculadas a los conceptos umbrales. Resultados: De 459 alumnos de la muestra, 420 finalizaron. Se obtuvo una adquisición significativamente positiva de competencias cognitivas. En base a las 6 preguntas "clave", el nivel de competencias adquiridas post-intervención aumentó un 26.8% de media respecto a la evaluación basal y transcurridos 6 meses se produjo un descenso del 18.1% respecto a lo aprendido. Conclusiones: La formación conceptual para incremental el capital intelectual de los estudiantes que forman parte de un programa formativo en soporte vital básico es esencial para la adquisición posterior del resto de las competencias, siendo una herramienta adecuada la definición de preguntas clave.

Palabras clave: reanimación cardiopulmonar, compresiones torácicas, desfibrilación externa automatizada, estudiantes, centro de educación secundaria, enseñanza

1. INTRODUCTION

Cardiorespiratory arrest (CRA) is defined as the potentially reversible loss of cardiorespiratory functions. The potential resuscitation of the victim is time-dependent (Ballesteros, Pérez, Ríos, & Lozano, 2020; Cárdenas Cruz et al., 2019a, 2019b; Pérez-Bailón, Parrilla-Ruiz, Gómez-Moreno, Herrera-Mingorance, & Cárdenas-Cruz, 2023). The World Health Organization views CRA as a major public health problem due to its high rates of morbidity/mortality (Muñoz Bonet, Cárdenas Cruz, Parrilla Ruiz, & Gómez Jiménez, 2016; Pivač, Gradišek, & Skela-Savič, 2020; Pivač, Skela-Savič, & Gradišek, 2021), making CRA the main cause of death in the industrialized world (Villanueva Ordóñez, Rey Galán, Crespo Ruiz, Díaz González, & Martínez Bastida, 2019). Here in Spain, it is estimated that 24,500 CRAs occur annually (Ballesteros et al., 2020), most of them (around 80%) in extra-hospital situations (Muñoz Bonet et al., 2016; Villanueva Ordóñez et al., 2019). It is calculated that over 70% of cases of CRA take place in the presence of one or more people (Ballesteros-Peña, Abecia-Inchaurregui, & Echevarría-Orella, 2013; Ballesteros et al., 2020; Böttiger et al., 2020; Martínez-Isasi et al., 2020), but in only 30% of such cases (López et al., 2018; Martínez-Isasi et al., 2020; Muñoz Bonet et al., 2016; Plant & Taylor, 2013; Villanueva Ordóñez et al., 2019) do bystanders initiate cardiopulmonary resuscitation maneuvers before the arrival of emergency services (ES). The reason for this is the fact that bystanders are likely to have no knowledge of CPR, not know how to carry out CPR, are frightened of catching some infection, or are frightened of causing injury or making a mistake with serious consequences (Pivač et al., 2021). These figures have remained unchanged for many years and the overall survival rates for CRA have not varied much during the last two decades, being around 10% in both the USA and Europe (Pivač et al., 2020; Plant & Taylor, 2013; Villanueva Ordóñez et al., 2019). However, it is a well-known fact that that prompt initiation of revival maneuvers by bystanders can double or even triple the chances of survival (Ballesteros et al., 2020; López et al., 2018; Villanueva Ordóñez et al., 2019).

Cardiopulmonary resuscitation (CPR) consists of a set of actions carried out in sequence, aimed at substituting the cardiopulmonary functions that the victim has lost (Ballesteros et al., 2020; Cárdenas Cruz et al., 2019a). Basic life support (BLS) is a broader concept that includes CRA prevention, CRA detection if and when it occurs, immediate ES call-out, initiation of basic CPR measures and the use of an automated external defibrillator (AED) (Ballesteros et al., 2020; Cárdenas Cruz et al., 2019a; Pérez-Bailón et al., 2023).

The BLS chain of survival is the set of actions carried out in the right order, each at the right moment, which have been found to reduce the mortality of those suffering CRA significantly (Cárdenas Cruz et al., 2019a). A range of studies of the general public point to scant knowledge of the two first moves (1. early recognition + ES call-out; 2. prompt initiation of CPR) and the need to improve peoples' attitude to CPR as well as cognitive and procedural BLS skills. This would be the best way to improve the survival of victims of CRA in extra-hospital settings (Castellanos, Carmona, REDONDO, Cruz, & Redondo, 2014; Pérez-Bailón et al., 2023; Villanueva Ordóñez et al., 2019).

It is estimated that at least 15% of the population should receive training in BLS if we are to achieve any significant improvement in CRA survival. Training undergone voluntarily (as at present) is not enough to reach this objective (Pivač et al., 2020; Pivač et al., 2021). Both the American Heart Association (AHA) and the European Resuscitation Council (ERC) advocate introducing BLS training in schools, as school students are an easily accessible group – primary and secondary education being compulsory – children are willing, able and interested in carrying out CPR maneuvers, the youngsters learn fast and are able to retain what

that they have learnt, and such training initiatives are well received by schools and their communities (Alvarez-Cebreiro, Abelairas-Gómez, García-Crespo, Varela-Casal, & Rodriguez-Nuñez, 2020; Ò Miró, Díaz, Escalada, Pérez Pueyo, & Sánchez, 2012; Pivač et al., 2020; Pivač et al., 2021; Villanueva Ordóñez et al., 2019).

Opinions vary as to the right age to impart BLS training, as do the length of training, the method, and who should supply training (healthcare personnel or schoolteachers) (Cerdà, Chanovas Borras, Escalada Roig, & Espuny Vidal, 2012; Díaz-Castellanos et al., 2014; López et al., 2018; Martínez-Isasi et al., 2020; Pivač et al., 2020; Villanueva Ordóñez et al., 2019). The ERC, backed by the WHO, have published a statement titled "Kids Save Lives," which recommends BLS training from the age of twelve for two hours per year (Ballesteros et al., 2020; Böttiger et al., 2020; López Messa, 2016; Martínez-Isasi et al., 2020; Pivač et al., 2020; Pivač et al., 2021). But other research recommends training in basic concepts of BLS and first aid at younger ages, extending this progressively over time (Cerdà et al., 2012; Martínez-Isasi et al., 2020).

In Spain, various institutional projects and initiatives have been realized in school settings (Martínez-Isasi et al., 2020) including the *Modelo Cervantes* (Cervantes Model) in Granada, the *Programa Alertante* (Alert Program) in Madrid, *El ABC que salva vidas* (The ABC of life-saving) by the local government in Navarra, *Urgencias sanitarias en escuela para centros docentes* (Health Emergencies for Schools) by the Basque local government, a *Plan piloto* (Pilot Plan) from the Catalonian Resuscitation Council and the Council for Education and Health with a spiral training model, *RCP na aula* (CPR in the classroom) in Lugo, *PROCES* (Cardiopulmonary Resuscitation Program for Secondary Education Centers) in Barcelona, etc. (Ballesteros et al., 2020; Ò Miró et al., 2012; Pérez-Bailón et al., 2023).

The aim of this study was to determine the level of cognitive skills acquisition achieved by this type of training initiative, to assess if training should take place from the age of twelve as recommended by the ERC in 2015 (Monsieurs et al., 2015), as well as to consider the correct periodicity for this type of training activity in terms of immediate knowledge acquisition and the forgetting curve.

2. MATERIALS AND METHOD

2.1. Study Type

Prospective, analytical, observational.

2.2. Sample

Six secondary education centers were selected, three of them in Granada (Spain), the other three in the Granada metropolitan area, including a total of 459 students aged between 12 and 15 years.

The selection of schools was made randomly from among those secondary schools with a capacity to accommodate this type of training. Regarding their location, the sample was selected from all the centers located in the city of Granada and in the Granada metropolitan area. Three centers in each group were chosen at random: *El Carmelo IES* (Institute of Secondary Education), *IES* Ganivet, and *IES* Padre Manjón in Granada; *IES* Alfacar, *IES* Atarfe, and *IES* Pulianas in the metropolitan area.

An introductory letter giving details of the activities included in the training program was sent to each center for acceptance by headteachers and Parents' Associations.

As this was a descriptive study without patient participation, according to Spanish and European legislation, approval by the Clinical Research Ethics Board was not necessary. Nevertheless, the study design was developed following guidelines laid down in the Helsinki Declaration and all persons with any legal responsibility gave their informed consent to contribute.

2.3. Instruments

A multiple-choice test (Table 1) was created, consisting of 20 questions about BLS concepts with five answers, one of them correct. The test included six key questions considered essential for adequate subsequent BLS learning. These questions were devised on the basis of their importance: two about the basic order in which maneuvers should be carried out, two about practical actions to be taken in real life situations, and two about the importance of timing and chest compressions.

Table 1. Multiple-choice test to assess theoretical knowledge and understanding based on specific key concepts of BLS and CPR.

Questions and answers
1) If you find yourself alone with a person who has collapsed, what is the first thing you should do before starting CPR (cardiopulmonary resuscitation) maneuvers?* a) Position the person with their feet up b) Search the person for their family's telephone number. c) Throw cold water on their face and see if they react.

d) Place in the recovery position. e) Make sure both the victim and the rescuer are safe and then immediately afterwards place them in the recovery position (supine – flat on the back – arms by their side) and check their state of consciousness by shouting and gently shaking.
2) Indicate which statement is false: a) Most CRAs occur in hospital. b) Most CRAs occur outside hospitals/healthcare settings. c) Most CRAs occur away from healthcare settings, with another person or people present. d) Most CRAs occur away from healthcare settings, with another person or people present, in the victim's home. e) The percentage of people trained in life support is very low in this country.
3) Chest compressions are applied to the center of the person's chest, stretching your arm and placing the heel of your hand on: * a) The left breast. b) The center of the chest, over the sternum, and between the nipples. c) The chest, it doesn't matter where. d) The upper third of the sternum, at mid-line e) The left side of the ribcage.
4) In basic life support, which of the following may be used: a) Mouth-to-mouth barrier devices b) A Guedel airway c) Self-inflating bag and facemask. d) Laryngoscope e) In basic BLS, no devices should be used, only hands and mouth.
5) CPR maneuvers must not be interrupted in the following circumstances: a) The patient shows signs of life. b) When we know for certain that it will be impossible to obtain the help of emergency services within 10 minutes after starting CPR. c) If the first 5 minutes of basic CPR obtains no response. d) If the patient shows clear signs of life after applying the first discharge with a semi-automated external defibrillator. e) When basic CPR seems to have been exhausted.
6) When a person collapses in front of you, you approach but they do not respond to "shout and shake," what is the next thing you should do?: a) Call emergency services immediately, as the patient may have suffered a CRA. b) Place the patient in the lateral recovery position. c) Open the airway using the jaw-chin maneuver and then check if they are breathing or not using the look, listen and feel approach. d) Leave them be, perhaps they're just tired. e) Start CPR immediately, with cardiac massage and mouth-to-mouth resuscitation.
7) Regarding the use of a semi-automated external defibrillator (SAED) in CPR it would be false to say that: a) The use of the SAED can restore circulation spontaneously through defribillable rhythms b) Only doctors and nurses should use this device. c) It is a device that anyone can use providing they have received adequate training d) The device has a positive impact on the survival of patients needing CPR e) They should be installed in any public place where more than 5,000 people per year pass by
8) Define the correct sequence of actions to perform if a man aged about 50 collapses in front of you: * a) The first thing to do is give him a precordial thump (thump the chest as hard as you can) as this is the best way to reverse CRA in places other than the hospital b) Call emergency services, place the patient in the lateral recovery position, and wait c) Check to see if he is breathing, and if not, seek help and call the emergency services, check to see if there is a SAED in the vicinity, then initiate basic CPR with 30:2 cycles while waiting for help to arrive d) Check consciousness and if the patient is unconscious carry out CRA diagnosis and initiate life support measures e) The best thing to do is cross the street and stay out of trouble
9) As soon as we have found that a patient is unconscious with the shout and shake method, have opened the airway with the jaw-chin maneuver, and then checked to see if they are breathing using the look, listen feel method, and found that they are not breathing, what is the next step?:

a) Start cardiac massage and mouth-to-mouth resuscitation in cycles of 30:2
b) Start cardiac massage and mouth-to-mouth resuscitation in cycles of 5:1
c) Start cardiac massage alone
d) Seek help, call the emergency services, request a SAED if available, and initiate CPR.
e) Place the patient in the lateral recovery position

10) Which of the following factors related to circulatory support by means of cardiac massage will have the most impact on the patient's survival?:
a) Combining cardiac massage with mouth-to-mouth resuscitation
b) Depressing the sternum exactly 8 cm
c) Depressing the sternum exactly 10 cm
d) Applying compressions at a rate of 80 compressions per minute
e) Carrying out cardiac massage correctly and continuously

11) At what point during basic life support should you request a SAED?
a) The SAED is a medical device and so plays no part in BLS
b) As soon as you have established that the patient is unconscious, not breathing, and the emergency services have been alerted
c) When you have been applying basic CPR with cardiac massage and mouth-to-mouth for at least 10 minutes
d) When the medical emergency services have arrived
e) The SAED can only be used by emergency healthcare personnel

12) What is the name of the technique used in BLS to open the airway?:
a) Jaw-thrust maneuver
b) Locked finger maneuver
c) Triple airway maneuver
d) Kotcher maneuver
e) Jaw-chin maneuver

13) What is the maximum, time we can take to determine whether the patient is breathing or not, using the look, listen, feel method?:*
a) 10 minutes
b) 10 seconds
c) 1 hour
d) 15 seconds
e) 15 minutes

14) When two persons trained in BLS are present, how should they each act together to carry out CPR?:
a) They should apply basic CPR maneuvers (cardiac massage and mouth-to-mouth resuscitation) taking turns lasting 2 minutes.
b) One should perform cardiac massage and the other carry out mouth-to-mouth, taking turns as each one tires
c) Two persons performing CPR is not recommended.
d) The first applies basic CPR techniques (cardiac massage and mouth-to-mouth) until he/she tires and the second takes over until he/she tires, and so on, taking turns.
e) One applies cardiac massage and mouth-to-mouth, while the other alerts the emergency services and looks for a SAED (and that's all the second rescuer does)

15) Out of all the techniques included in BLS, which of the below has the most impact on CPR patient survival?: *
a) Seeking help
b) Mouth-to-mouth resuscitation
c) Jaw-chin maneuver
d) Continuous and correct cardiac massage
e) Look, listen, feel method

16) ¿When should the emergency services be alerted in the case of a child needing CPR when there is only one rescuer present?
a) After opening the airway
b) After checking that the patient is not breathing and giving five mouth-to-mouth ventilations
c) After establishing the loss of signs of circulation, including the loss of pulse
d) After 1 minute of chest compressions and mouth-to-mouth ventilations
e) After 5 minutes of CPR maneuvers

17) In a case of partial choking when the victim can cough and speak, what should we do?
a) Give them five thumps on the back
b) Apply the Heimlich maneuver (five abdominal compressions)
c) Apply five chest compressions

d) Give them five thumps on the back followed by five chest compressions e) Encourage them to cough
18) When an adult has suffered an airway obstruction by a foreign body and has fallen to the ground unconscious, where must we apply our hands to carry out abdominal compressions (known as Heimlich compressions)?: a) To the chest, in the third below the sternum b) To the abdomen, below the navel. c) To the abdomen, between the navel and the xiphoid process (the pit of the stomach) d) To the lower abdomen e) Abdominal compressions should not be applied, rather CPR should be initiated with chest compressions and mouth-to-mouth resuscitation
19) ¿When must abdominal compressions (Heimlich maneuvers) be used? * a) When the victim has lost consciousness b) When the victim is a child c) When the victim coughs d) When the victim vomits e) When the victim is choking, cannot speak or cough, and obstruction persists after giving them five thumps on the back
20) In CPR of an infant (up to one year old): a) Before starting chest compressions, five mouth-to-mouth rescue ventilations should be given b) When only one helper is present, the first thing they should do is call the emergency services c) Compressions should be administered, placing both hands at the center of the chest d) Determining whether the victim is breathing or not should not take more than 5 seconds e) Half the width of the chest must be depressed with chest depressions

NB: Key questions are marked with an asterisk (*)

2.4. Procedure

The training program was supplied to first and fourth-year secondary school students and consisted of two training processes separated by a period of six months. In the first, students completed the multiple-choice test to assess their baseline knowledge of BLS/CPR. Then a 30-minute lesson about theoretical content was imparted, supported by video, following recommendations of the ERC (2015). This lesson covered all the basic concepts of BLS and CPR. This was followed by a 90-minute practical workshop using approved simulators, aimed at imparting procedural and attitude skills in BLS. In order to maximize learning, the ratio of teachers to students was high: 1:8. Much importance was given to the threshold concepts as the essential basis for imparting the cognitive aspects that every student must know and understand when it comes to dealing with a CPR situation. Once these had been defined, the remaining stages of the training program focused on consolidating students' understanding of these concepts as the basis of essential cognitive skills, using various methodologies, materials, and strategies.

To complete this stage in training, the multiple-choice test was repeated, comparing the difference in results with the baseline test.

The second session took place six months later, when students took the multiple-choice test for the third time, comparing the results with the previous tests. The time lapse between the second and third tests was chosen according to recommendations and findings published in the literature, whereby cognitive skills begin to diminish after 6 or 7 months after acquisition (the forgetting curve).

2.5. Statistical Analysis

All data were collated and assessed anonymously, so that no data could be linked to individual students.

For statistical analysis, a database was created using statistical analysis software SPSS 20.0. The variables analyzed were: age, gender, school location (these three were characterized as nominal dichotomous quantitative variables), marks obtained in each of the three tests (compiled as discrete quantitative variables), marks for each question (nominal dichotomous variable).

The evolution of marks obtained in tests was analyzed with a non-parametric Friedman test, with a 95% confidence interval and Bonferroni correction for multiple comparisons. For analysis of the variables age, gender, location, a general linear model for repeated measures was used, taking age as intersubject factor, and test marks as intrasubject factor.

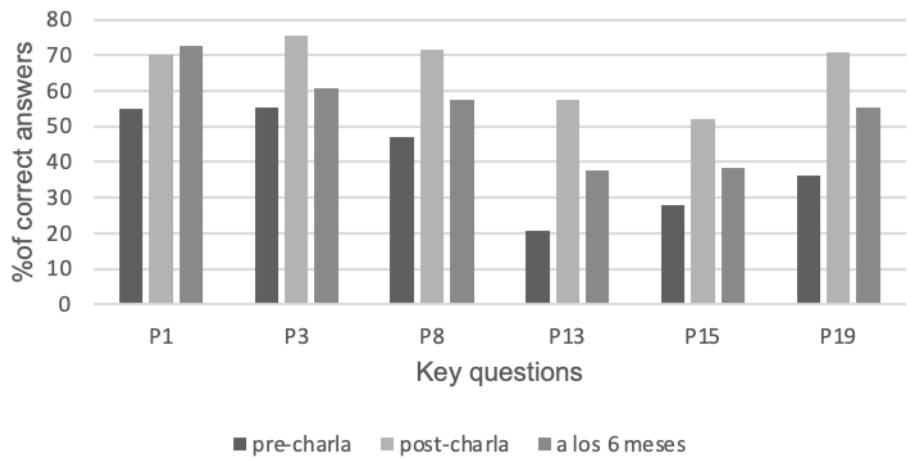
3. RESULTS AND ANALYSIS

Demographic characteristics are shown in Table 2, whereby the 420 students who completed the training program are classified in relation to three variables: secondary school year, gender, secondary school location.

Table 2. Distribution of variables across the sample	
Secondary School Year	**N (%)**
4th	192 (45.7)
1st	228 (54.3)
Gender	
Female	208 (49.5)
Male	212 (50.5)
Secondary School Location	
Granada	220 (52.4)
Granada metropolitan area	200 (47.6)

Figure 1 shows the percentage of students who answered each key question successfully in the three tests; it can be seen that the mean percentage increased between the baseline test (40.51%; $p < 0.001$) and the second (67.3%; $p < 0.001$). Six months later when the test was taken for the third time, the mean decreased by some 10% from the mean obtained after training to 57.25% ($p < 0.001$). Making a more detailed analysis of the key questions, it can be seen that this pattern was roughly the same in all cases with the exception of the first key question about the first step in the BLS algorithm, in which the percentage of correct answers increased with each test (54.9%, 70.2% and 72.5%).

Figure 1. Percentage of correct answers for the six key questions in the three tests



Considering demographic variables in relation to baseline knowledge/understanding, the only statistically significant difference was found between secondary school years (first and fourth), with more correct answers given by the older students in their fourth year of secondary education (Table 3, first column).
Knowledge acquired was significantly related to age, secondary school year, and gender. In the test taken after theoretical and practical training, female students, fourth-year students and schools located in the city of Granada acquired greater knowledge although with less statistical significance (Table 3, second column).
Lastly, the retention of knowledge after six months, as expressed in the third column, was greater at the schools located in Granda city, among fourth-year students and among female students.

Table 3. Differences in test results at baseline, after training, and six months after training in relation to variables: location, age, sex									
Variable	**Baseline Test**			**Post-training Test**			**Test taken 6 months after training**		
	Differenc			Difference			Differenc		

	e in correct answers	P	CI 95%	in correct answers	P	IC 95%	e in correct answers	P	IC 95%
Metropolitan area Granada city	0.377	0.102	0.830-0.076	0.585	0.061	1.196-0.027	2.523	0.000	3.067-1.978
4th year 1st year	0.838	0.000	1.286-0.390	1.483	0.000	2.082-0.884	2.284	0.000	2.840-1.729
Female Male	0.207	0.371	0.660-0.247	1.483	0.000	1.988-0.818	0.702	0.013	1.253-0.150

4. DISCUSSION AND CONCLUSIONS

Although the WHO considers CPR a major challenge facing public health due to the morbidity and mortality rates of CRA victims (Muñoz Bonet et al., 2016; Pivač et al., 2020; Pivač et al., 2021), only 15-30% of bystanders witnessing a CRA initiate CPR (Martínez-Isasi et al., 2020; Muñoz Bonet et al., 2016; Plant & Taylor, 2013; Villanueva Ordóñez et al., 2019). This could be partly due to the weak or missing link in the chain of survival (Cárdenas Cruz et al., 2019a) resulting from the scant training in BLS/CPR among the general population (Alvarez-Cebreiro et al., 2020; Díaz-Castellanos et al., 2014). This points to the importance of imparting knowledge and understanding of BLS to the public at large. Countries such as Japan and Sweden, where BLS skills are widely disseminated, have seen significant increases in rates of resuscitation achieved by bystanders and passers-by (Díaz-Castellanos et al., 2014; Pérez-Bailón et al., 2023).

Various organizations such as the AHA, ERC, and WHO recommend the compulsory implementation of BLS training in schools (Alvarez-Cebreiro et al., 2020; Díaz-Castellanos et al., 2014; Martínez-Isasi et al., 2020; Pivač et al., 2020; Villanueva Ordóñez et al., 2019), considering children and teenagers a target group for BLS training. In response, diverse national and international projects have been developed aimed at these younger age-groups (Ò Miró et al., 2012; Muñoz Bonet et al., 2016).

The ages of the secondary school students who took part in the present project were aged between 12 and 15 years. Looking at the results obtained, the students generally exhibited a notable lack of knowledge of CPR maneuvers in the baseline test before training (baseline mean percentage of correct answers of around 40%). After the training program, in which the importance of CPR was explained and the importance of prompt intervention when a CRA occurs and of implementing CPR procedures immediately, the percentage of correct test answers rose to 67.38%. This result concurs with results obtained in other studies of school-age youngsters (Òscar Miró et al., 2005; Pérez-Bailón et al., 2023; Pivač et al., 2020; Pivač et al., 2021; Plant & Taylor, 2013).

Analyzing differences observed in the present results in relation to age, an improvement in the percentages of correct answers was found for all students after training. Other studies have published similar findings, a fact that backs the teaching of theoretical and practical knowledge to this population. However, in the present work, significant differences were found in knowledge acquisition between fourth-year students and first-year students, which cannot be compared with other studies, due to differences in the target age-groups investigated. One study in Germany, compared outcomes for ten-year-olds and thirteen-year-olds, while another in Slovenia compared students in the seventh and ninth years, and the *Modelo Cervantes* (Cervantes Model) in Granada included secondary students, baccalaureate students and students in vocational training (Pérez-Bailón et al., 2023; Pivač et al., 2020; Pivač et al., 2021).

Regarding the age at which BLS training can be given, the AHA recommends that compulsory training should commence after the age of nine, while the ERC recommends training from the age of twelve (Pivač et al., 2021). Nevertheless, a range of studies argue that training can start at younger ages (even at infant school age) (Ballesteros et al., 2020; Cerdà et al., 2012), introducing skills and concepts gradually, as this

has been shown to reduce worries about making mistakes, boosts empathy with the victim, and increases willingness to help others. As these children get older, gain maturity, and sufficient physical stature to perform chest compressions well, they will have retained knowledge and skills acquired at earlier stages more successfully than students who commence training at older ages (Pivač et al., 2020; Pivač et al., 2021; Plant & Taylor, 2013). All this can contribute to an ongoing 'culture of CPR' as a basic concept touching all of society.

In relation to gender, the present study found better performances among females than males, a finding that coincides with other research (Ò Miró et al., 2012; Pérez-Bailón et al., 2023; Pivač et al., 2020). In a systematic review of school students, girls obtained better results in theoretical skills acquisition, in motivation to put them into practice, and in a higher multiplying effect whereby they spread their knowledge to others in their families and social circles (Finke et al., 2018). But other similar studies have not revealed differences for the gender variable (Castellanos et al., 2014).

The present work investigated possible differences between student groups according to secondary school location (Granada city compared with the Granada metropolitan area). There was a special reason for this. The University of Granada has already implemented various BLS training initiatives at schools within the city. However, the only significant difference in results was found at the third evaluation, whereby the schools located in the city of Granada obtained better marks. Comparisons of this finding with other published studies proved impossible as the literature does not include any similar cases, which points to a direction for further research in order to establish an explanation for this result.

In Spain, Royal Decrees 126/2014 (*REAL DECRETO* 126/2014, of 28th February: the Primary Education Curriculum) and 1105/2014 (*REAL DECRETO* 1105/2014, of 26th December 2014: the Secondary Education and Baccalaureate Curricula) together define the educational paths that school students must follow through primary and secondary education. The curricula include first aid training but do not list the exact content that must be imparted, so that BLS and CPR do not enter compulsorily into Spanish school education. One simple and practical way of making BLS and CPR training a reality would be to introduce these topics into the curricula, and then train and help teachers to impart them. Given that teachers already possess the pedagogical tools to teach children effectively, various studies have shown that school teachers impart BLS knowledge and skills well once they have received appropriate training (López et al., 2018; Pérez-Bailón et al., 2023). In this way, teaching BLS in schools would be cost effective, as all that would be needed would be to supply some materials and train the teachers (such training could be introduced into standard teacher training at University).

In the present study, a drop in the knowledge acquired was observed six months after training, whereby students had forgotten about half of the key concepts. This concurs with the results obtained in similar studies (Díaz-Castellanos et al., 2014), the forgetting curve being the reason why the ERC and the AHA recommend that training should take place annually (Arriola Infante, Cárdenas Cruz, Gómez Jiménez, Cárdenas Cruz, & Parrilla Ruiz, 2017; Averell & Heathcote, 2011; Cárdenas Cruz et al., 2017; Cruz et al., 2014; Monsieurs et al., 2015; Pivač et al., 2020; Pivač et al., 2021; Villanueva Ordóñez et al., 2019). In light of this finding, we propose to implement further research into whether or not increasing the frequency of training is recommendable.

Different studies have analyzed training strategies comparing theoretical and practical training with theoretical training alone, finding better outcomes with the former (Ballesteros et al., 2020). For this reason, we recommend both theoretical and practical training whenever possible, as acquisition of the basic concepts underpinning procedural and attitude skills are essential when it comes to the practical application of the correct maneuvers involved in BLS.

Regarding the knowledge, skills and aptitudes that school students should acquire from a course in BLS, most of the available research focuses on evaluating practical skills rather than theoretical content as the basis for cognitive skills that must then be reinforced by means of series of methodological strategies during the learning process. In this sense, the bibliography makes the case for including knowledge and understanding of the chain of survival as a key part of theoretical learning (emphasizing the first two steps: prompt recognition of a CRA situation and emergency medical services activation, as well as prompt initiation of basic CPR) (Calvo Bota, 2022; Villanueva Ordóñez et al., 2019). This includes knowing the correct sequence of BLS actions, in particular knowing how to identify the victim of CRA (a person who is unresponsive and not breathing normally), knowing the right emergency number to call, as well as how to apply chest compressions correctly (Calvo Bota, 2022; De Buck et al., 2015). In addition, after completing training in BLS, the students must know which patients to place in the lateral recovery position, as well as the correct sequence of actions for opening the airway if obstructed by a foreign body, the ability to differentiate between partial obstruction (the sufferer is able to speak and cough) and complete obstruction (the sufferer is unable to speak or cough), and how to manage either case (Calvo Bota, 2022; De Buck et al., 2015).

On the basis of the present findings, the introduction of BLS training into the school curriculum is to be recommended. This should consist of structured content, whereby knowledge, skills and attitudes are imparted progressively according to student age, starting the learning process in primary education and

continuing through the years of compulsory state education. This would require appropriate teacher training. In this way, BLS training could be ongoing and continuous, allowing the consolidation of cognitive, procedural and attitude skills by means of at least annual training sessions. If and when such a plan becomes a reality, it would be important to analyze its impact on the rate of survival of CRA victims in extra-hospital situations.

In conclusion, conceptual learning is an essential part of BLS leaning, increases students' intellectual capital and is essential to the subsequent acquisition of the other skills required. The definition of key items of knowledge is an adequate tool for imparting and consolidating the essential concepts of BLS and CPR.

CONFLICT DE INTERESTS

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

The authors thank the management team, together with teaching staff and students at the secondary schools that took part in this study (IES El Carmelo, IES Ganivet, IES Padre Manjón, IES Alfacar, IES Iliberis e IES Bulyana), as well as Dr. María Teresa Miranda of the Department for Statistics, University of Granada (Spain).

REFERENCES

1. Alvarez-Cebreiro, N., Abelairas-Gómez, C., García-Crespo, O., Varela-Casal, C., & Rodriguez-Nuñez, A. (2020). Efecto de la formación en soporte vital básico a través de un video difundido en redes sociales. *Educación Médica, 21*(2), 92-99. https://doi.org/10.1016/j.edumed.2018.05.012
2. Arriola Infante, J. E., Cárdenas Cruz, A., Gómez Jiménez, F. J., Cárdenas Cruz, D. P., & Parrilla Ruiz, F. M. (2017). Análisis de la Curva del Olvido para las principales actuaciones del Soporte Vital Avanzado en la formación de alumnos de Sexto Curso de Medicina. *Actualidad Médica, 102*(801), 80-85. https://doi.org/10.15568/am.2017.801.or04
3. Averell, L., & Heathcote, A. (2011). The form of the forgetting curve and the fate of memories. *Journal of mathematical psychology, 55*(1), 25-35. https://doi.org/10.1016/j.jmp.2010.08.009
4. Ballesteros-Peña, S., Abecia-Inchaurregui, L. C., & Echevarría-Orella, E. (2013). Factores asociados a la mortalidad extrahospitalaria de las paradas cardiorrespiratorias atendidas por unidades de soporte vital básico en el País Vasco. *Revista Española de Cardiología, 66*(4), 269-274. https://doi.org/10.1016/j.recesp.2012.09.016
5. Ballesteros, B. J. L., Pérez, J. R., Ríos, S. S., & Lozano, J. M. F. (2020). Eficacia de la enseñanza teórico-práctica en institutos de reanimación cardiopulmonar. *Revista Española de Salud Pública* (94), 109.
6. Böttiger, B., Lockey, A., Georgiou, M., Greif, R., Monsieurs, K., Mpotos, N., . . . Semeraro, F. (2020). KIDS SAVE LIVES: ERC Position statement on schoolteachers' education and qualification in resuscitation. *Resuscitation, 151*, 87-90. DOI: 10.1016/j.resuscitation.2020.04.021
7. Calvo Bota, A. M. (2022). Beneficios de la formación en soporte vital básico en la población escolar (1st ed.). Illes Balears: Universitat de les Illes Balears. http://hdl.handle.net/11201/157783
8. Cárdenas Cruz, A., Santiago Suárez, I. M., Navarro Guillamón, L., Cárdenas Cruz, D. P., Parrilla Ruiz, F. M., & Gómez Jiménez, F. J. (2017). Análisis del desarrollo de la curva del olvido dentro de un programa de formación en Soporte Vital Básico para alumnos del Grado de Medicina de la Universidad de Granada. Estudio piloto. *Actualidad Médica, 102*(802), 140-144. DOI: 10.15568/am.2017.802.or02
9. Cárdenas Cruz, A., Vasserot Vargas, J., Navarro Guillamón, L., Cáliz Ortiz, C., Cárdenas Cruz, D. P., & Tejero Aranguren, J. (2019a). Análisis del grado de adquisición de competencias en Soporte Vital Básico (SVB) por parte de cooperantes. *Actualidad Médica*. DOI: 10.15568/am.2019.808.or04

10. Cárdenas Cruz, A., Vasserot Vargas, J., Navarro Guillamón, L., Cáliz Ortiz, C., Cárdenas Cruz, D. P., & Tejero Aranguren, J. (2019b). Análisis del grado de adquisición de competencias en Soporte Vital Básico (SVB) por parte de cooperantes. *Actualidad Médica, 104*(808), 170-174. DOI: 10.15568/am.2019.808.or04
11. Castellanos, M. Á. D., Carmona, A. F., REDONDO, A. D., Cruz, A. C., & Redondo, T. D. (2014). Influencia de los factores sociodemográficos en la adquisición de habilidades en soporte vital básico. *Emergencias, 26*(3), 202-205.
12. Cerdà, M., Chanovas Borras, M., Escalada Roig, X., & Espuny Vidal, C. (2012). Plan piloto de formación en soporte vital y RCP en las escuelas. *Medicina Intensiva, 36*(2), 158-159. DOI: 10.1016/j.medin.2011.03.008
13. Cruz, A. C., Parrilla, F., Cruz, D. C., Jiménez, F. J. G., Hernández, J. L., Palacios, P. R., & García, I. S.-M. (2014). Implementación de un Programa Reglado de Formación en Soporte Vital Avanzado dentro del mapa competencial de los futuros alumnos del Grado Superior de Medicina de la Universidad de Granada. *Actualidad Médica, 99*(791), 27-30. DOI: 10.15568/am.2014.791.do01
14. De Buck, E., Van Remoortel, H., Dieltjens, T., Verstraeten, H., Clarysse, M., Moens, O., & Vandekerckhove, P. (2015). Evidence-based educational pathway for the integration of first aid training in school curricula. *Resuscitation, 94*, 8-22. DOI: 10.1016/j.resuscitation.2015.06.008
15. Díaz-Castellanos, M., Fernández-Carmona, A., Díaz-Redondo, A., Cárdenas-Cruz, A., García-del Moral, R., Martín-Lopez, J., & Díaz-Redondo, T. (2014). Enseñando soporte vital básico a la población general. Análisis de las intervenciones de los alumnos. *Medicina Intensiva, 38*(9), 550-557. DOI: 10.1016/j.medin.2013.10.010
16. Finke, S.-R., Schroeder, D. C., Ecker, H., Wingen, S., Hinkelbein, J., Wetsch, W. A., . . . Böttiger, B. W. (2018). Gender aspects in cardiopulmonary resuscitation by schoolchildren: A systematic review. *Resuscitation, 125*, 70-78. DOI: 10.1016/j.resuscitation.2018.01.025
17. López Messa, J. B. (2016). ¿Está la población española sensibilizada y capacitada para actuar ante la parada cardiaca? *Medicina Intensiva, 40*(2), 73-74. DOI: 10.1016/j.medin.2016.01.001
18. López, M. P., Martínez-Isasi, S., Barcala-Furelos, R., Fernández-Méndez, F., Santamarina, D. V., Sánchez-Santos, L., & Rodríguez-Nuñez, A. (2018). *Un primer paso en la enseñanza del soporte vital básico en las escuelas: la formación de los profesores.* Paper presented at the Anales de pediatría. DOI: 10.1016/j.anpedi.2017.11.002
19. Martínez-Isasi, S., Abelairas-Gómez, C., Pichel-López, M., Barcala-Furelos, R., Varela-Casal, C., Vázquez-Santamariña, D., . . . Rodríguez-Núñez, A. (2020). *Aprendiendo a reanimar en la escuela. Estudio en escolares de 8-12 años.* Paper presented at the Anales de Pediatría. DOI: 10.1016/j.anpedi.2020.09.018
20. Miró, Ò., Díaz, N., Escalada, X., Pérez Pueyo, F., & Sánchez, M. (2012). *Revisión de las iniciativas llevadas a cabo en España para implementar la enseñanza de la reanimación cardiopulmonar básica en las escuelas.* Paper presented at the Anales del Sistema Sanitario de Navarra. DOI:10.4321/S1137-66272012000300014
21. Miró, Ò., Jiménez-Fábrega, X., Díaz, N., Coll-Vinent, B., Bragulat, E., Jiménez, S., . . . Álvarez, M. T. (2005). Programa de Reanimación cardiopulmonar Orientado a Centros de Enseñanza Secundaria (PROCES): análisis de los resultados del estudio piloto. *Medicina Clínica, 124*(1), 4-9.

22. Monsieurs, K., Nolan, J., Bossaert, L., Greif, R., Maconochie, I., Nikolaou, N., . . . Wyllie, J. (2015). Recomendaciones para la Resucitación 2015 del Consejo Europeo de Resucitación (ERC). *Resumen ejecutivo. Eur Resucitation Counc, 1*, 6-70. https://doi.org/10.1016/j.resuscitation.2015.07.038
23. Muñoz Bonet, O., Cárdenas Cruz, A., Parrilla Ruiz, F. M., & Gómez Jiménez, F. J. (2016). Impacto social del entrenamiento en Soporte Vital Básico para estudiantes de la Universidad de Granada. *Actualidad Médica*. DOI: 10.15568/am.2016.799.or02
24. Pérez-Bailón, A. M., Parrilla-Ruiz, F. M., Gómez-Moreno, G., Herrera-Mingorance, J. D., & Cárdenas-Cruz, A. (2023). Estudio comparativo sobre la función del profesor de educación secundaria como base para la enseñanza del soporte vital: Modelo Cervantes. *Educación Médica, 24*(1), 100789. DOI: 10.1016/j.edumed.2022.100789
25. Pivač, S., Gradišek, P., & Skela-Savič, B. (2020). The impact of cardiopulmonary resuscitation (CPR) training on schoolchildren and their CPR knowledge, attitudes toward CPR, and willingness to help others and to perform CPR: mixed methods research design. *BMC Public Health, 20*(1), 1-11. DOI: 10.1186/s12889-020-09072-y
26. Pivač, S., Skela-Savič, B., & Gradišek, P. (2021). Effects of cardiopulmonary resuscitation with automated external defibrillator training among schoolchildren in Slovenia: a pre-and post-test cohort study. *Slovenian Journal of Public Health, 60*(2), 131-137. DOI:10.2478/sjph-2021-0019
27. Plant, N., & Taylor, K. (2013). How best to teach CPR to schoolchildren: a systematic review. *Resuscitation, 84*(4), 415-421. DOI: 10.1016/j.resuscitation.2012.12.008
28. REAL DECRETO 126/2014, de 28 de febrero, por el que se establece el currículo básico de la Educación Primaria. (2014). *BOE núm. 54*(1 de marzo de 2014), 19349-19420.
29. REAL DECRETO 1105/2014, de 26 de diciembre, por el que se establece el currículo básico de la Educación Secundaria Obligatoria y del Bachillerato. (2015). *BOE, núm. 3*(3 de Enero de 2015), 169-546.
30. Villanueva Ordóñez, M. J., Rey Galán, C., Crespo Ruiz, F., Díaz González, L., & Martínez Bastida, G. (2019). Análisis de una experiencia perdurable de un proyecto educativo de reanimación cardiopulmonar en un centro escolar. *Emergencias (Sant Vicenç dels Horts)*, 189-194. https://dialnet.unirioja.es/servlet/articulo?codigo=6921661