ABSTRACT

Objective To compare the effectiveness of 4-month rolling-refreshers and annual retraining in basic life support (BLS) on a sample of schoolchildren.

Design Prospective longitudinal trial.

Setting and participants Four hundred and seventy-two schoolchildren (8–12 years old).

Interventions Schoolchildren were instructed in BLS and then split into the following three groups: control group (CG), standard group (SG) and rolling-refresher group (RRG). Their BLS skills were assessed within 1 week (T1) and 2 years later (T2). Moreover, CG did not receive any additional training; SG received one 50 min retraining session 1 year later; RRG participated in very brief (5 min) rolling-refreshers that were carried out every 4 months.

Primary and secondary outcomes Hands-on skills of BLS sequence and cardiopulmonary resuscitation.

Results BLS sequence performance was similar in all groups at T1, but SG and RRG followed the steps of the protocol in more proportion than CG at T2. When compared at T2, RRG showed higher proficiency than CG in checking safety, checking response, opening the airway and alerting emergency medical services. In addition, although the mean resuscitation quality was low in all groups, RRG participants reached a higher percentage of global quality cardiopulmonary resuscitation (CG: 16.4±24.1; SG: 25.3±28.8; RRG: 29.9%±29.4%), with a higher percentage of correct chest compressions by depth (CG: 3.9±11.8; SG: 10.8±22.7; RRG: 15.5±26.1 mm).

Conclusions In 8- to 12-year-old schoolchildren, although annual 50 min retraining sessions help to maintain BLS performance, 4-month very brief rolling-refreshers were shown to be even more effective. Thus, we recommend implementing baseline BLS training at schools, with subsequently brief rolling-refreshers.

INTRODUCTION

Basic life support (BLS) education of schoolchildren, combined with other community strategies, has been shown to be an effective measure to increase witness-assisted out-of-hospital cardiac arrest.1 This is the main reason why both first aid and BLS are promoted to be included in school curricula,2-4 which is the gold goal of the KIDS SAVE LIVES statement.

Previous studies have already shown the capacity of schoolchildren to learn BLS sequences,5-7 cardiopulmonary resuscitation (CPR)6-8 and automated external defibrillation use.7 9 Therefore, it is proven that they are able to learn. However, similar to adult laypeople, schoolchildren’s BLS education and knowledge retention cannot depend only on one-off trainings. In this sense, the inclusion of BLS in school curricula should imply that schoolchildren train periodically.3 4 10
The KIDS SAVE LIVES statement recommends 2 hours of CPR training up to the age of 12 years, although it could start earlier. An evidence-based educational pathway was also designed to help schoolteachers and academic institutions integrate BLS training into school curricula, and different education tools were designed and validated to educate and/or assess BLS schoolchildren's knowledge/skills. However, to the best of our knowledge, no longitudinal trials have been carried out to study different BLS training approaches in school environments in terms of methodology. We are aware of only one longitudinal (more than 1 year) study that compared groups of schoolchildren trained by schoolteachers or emergency physicians to determine whether teaching staff were as able as medical staff to teach BLS. Nonetheless, it was also shown to be effective in teaching and retaining other abilities as a BLS sequence. We hypothesised that the rolling-refreshers approach is more effective in maintaining schoolchildren's BLS skills over time than annual retraining. Therefore, the objective of the present study was to compare every 4-month 5 min rolling-refreshers with 50 min annual retraining in a sample of 8-to-12-year-old schoolchildren.

**METHODS**

**Participants**

A convenience sample of 658 schoolchildren was invited to participate. The participants were from three different city-based schools, which comprised the three cohorts of the study (see Design section). Schoolchildren were 8–12 years old, which corresponded with Spain’s third to sixth grades of elementary education.

The objectives and methods of the study were explained to parents/guardians, who authorised the participation of schoolchildren by signing an informed consent form. This also meant that they understood the voluntary character of the participation and that they could withdraw at any moment. In addition, verbal assent from each child was required. The Ethical Committee of the Faculty of Education and Sport Sciences—University of Vigo (Spain)—approved the study protocol. Participants with any physical or psychological impairment were excluded, as well as those whose parents or legal guards denied consent to participate. Schoolchildren who did not attend both BLS assessments were also excluded.

**Patient and public involvement**

This research was done without patient involvement.

**Design**

A 2-year prospective longitudinal design was followed in the present study. First, the heads of the schools were contacted by the research team, who explained the objectives and design of the study. In the next step, the physical education schoolteachers were contacted, since they would be in charge of educating schoolchildren after a previous BLS training.

Each school was randomly assigned to a group (figure 1), the control group (CG) or one of the two experimental groups. Initially, anthropometric data (weight and height) were registered, and the three groups were trained in BLS with the same methodology. Afterwards, the following two BLS assessments were carried out: a short-term evaluation within 1 week after the training (T1) and a long-term follow-up 2 years later (T2). Moreover, participants in the CG did not receive any additional intervention. One of the experimental groups, the standard group (SG), received one annual 50 min BLS retraining. The rolling-refresher group (RRG) received BLS rolling-refreshers every 4 months from T1 to T2 (adding up five sessions). Schools which did not attend all the trainings/rolling-refreshers or both assessments were excluded.

**Previous schoolteachers training**

Training was offered to all the teachers of the schools participating in the study; although, only physical education teachers participated in the training of the schoolchildren. The methodology and results regarding the training have already been discussed. Briefly, all the schoolteachers received the same instruction, as follows: 2 hours on BLS (out-of-hospital cardiac arrest (OOHCA), BLS sequence and compression-only CPR (CO-CPR), 40 min of theoretical contents and 80 min of practical skills (BLS sequence and CO-CPR). The initial training lasted 100 min. The first lecture...
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While CG only received the initial training, SG was retrained 1 year later, and RRG was involved in rolling-refreshers every 4 months. The retraining of SG was similar to the second lesson of the initial training. It was mainly practical, with a 50 min split in 5 min of theoretical overview of the BLS sequence and 45 min of practical skills retraining with the same rotational system as the first training.

According to the ‘just-in-case’ and ‘just-in-place’ education approaches,15 5-min rolling-refreshers were implemented in the RRG. These very brief refreshers were carried out at physical education lessons. In groups of five schoolchildren, physical education schoolteachers refreshed children’s memory in terms of BLS sequence. Afterwards, schoolchildren had to perform 2 min of CPR in groups of three children with one manikin for each one.

Statistical analysis
Variables are expressed as the mean (SD) or absolute frequencies (relative frequencies) as appropriate. Inter-group and intragroup analyses were carried out with BLS and CPR variables. All the BLS sequence variables were dichotomous. The χ² test was used in the intergroup analysis to compare the three groups. To analyse differences between tests (intragroup: T1 vs T2), the McNemar test was used. Measured repeated ANOVA (MANOVA) was used to analyse CPR variables with the following two factors included in the model: intergroup (CG vs SG vs RRG) and intragroup (T1 vs T2) factors. Previously, ANCOVA was carried out for each CPR variable to determine and control possible covariate effects. In this sense, anthropometric variables were included as covariates in the model, since previous studies have shown correlations between anthropometry and CPR quality.8 In the MANOVA model, anthropometric variables with p<0.05 reached in the ANCOVA analysis were included as covariates. The Pearson coefficient was used to analyse the linear correlation between anthropometric and CPR variables.

All the registered data were transferred to SPSS software (IBM Corp, V.23.0.0.0) for analysis. A significance level of p<0.05 was considered in all analyses.

RESULTS
The final sample comprised 472 schoolchildren, since 186 were excluded due to not attending both training and/or evaluations and not signing informed consent or because of logistical problems in data collection. The distribution of participants was as follows: CG, n=146; SG, n=124; RRG, n=202.

Anthropometric variables were registered (weight, height and body mass index (BMI)) in both tests. No differences in any variable were found between groups at any time. However, as expected, due to the normal children growing pattern, significant changes were observed comparing T1 with T2 for the three variables in the three groups (p<0.001 in all cases).

Figure 2 shows the proportion of participants performing each step of the BLS sequence in the intra-group analysis. At T2, there was a drastic decrease in CG participants in all steps of the BLS sequence except to start CPR (p<0.05). Regarding SG, significantly fewer
participants were able to check safety, check response, open airway and breathing when T1 was compared with T2 (p<0.05). Finally, the proportion of RRG participants able to perform any step of the sequence was similar at T1 and T2.

On the other hand, in the T2 intergroup analysis, except for the step ‘starting CPR’, the percentage of CG children who were able to perform any of the other BLS steps was significantly lower than that of SG and RRG children (p<0.05). When compared with SG children, RRG children reached a significantly higher proficiency in checking safety, checking response, opening airway and alerting EMS (figure 3). The only group in which each step of the BLS sequence was performed by at least 70% of participants was RRG.

In a more stringent analysis of the BLS sequence, participants who correctly performed all the steps of the protocol were registered. Nobody in CG completed the entire BLS sequence in T2. In contrast, 28 (22.6%) participants in the SG and 88 (43.6%) in the RRG received it (p<0.001 for all comparisons). These differences were significant between the CG and both experimental groups, as well as between the SG and RRG (p<0.001 in all cases).

Table 1 shows the data related to the quality of chest compressions (Q-CC), with intergroup and intragroup analysis adjusted by weight, height and BMI. In T2, the RRG reached higher figures for mean depth, correct CC by depth and Q-CC than the CG and SG (p<0.001). SG and RRG also obtained higher percentages of correct hand positions than CG (p<0.001).

Pearson correlation coefficients calculated between anthropometric variables and mean depth in T2 obtained a significant linear correlation independent of the group (p<0.001 in all cases). However, Pearson coefficients were higher in CG than in SG and RRG and lower in the RRG than in the SG (figure 4). In this sense, a greater proportion of RRG participants (12.4%) were able to reach at least a mean chest compression depth of 50 mm (CG: 6.2%; SG: 8.1%) (figure 4).

**DISCUSSION**

The present 2-year prospective longitudinal study aimed to compare the effect of annual retraining with very brief 4-month rolling-refreshers on the BLS skills of previously trained schoolchildren. We observed that schoolchildren involved in rolling-refreshers achieved better proficiency in both assessed skills, BLS sequence and Q-CC, than those not retrained at all or annually retrained peers. In terms of BLS sequence, higher proportions of RRG children were able to correctly perform the protocol steps. On the other hand, they also reached higher-quality CPR, especially in variables related to depth, although the absolute Q-CC was suboptimal.

The learning capacity of schoolchildren to perform BLS in simulated5–9 12 14 and real conditions20 has already
been demonstrated. In fact, some authors suggested that schoolchildren might learn BLS better and maintain knowledge over more time than adults.21 These are some of the reasons that BLS is strongly recommended to be taught in schools.2–4 10 11 14 In this sense, different investigations to develop evidence base around how BLS should be best taught in schools are needed.2

However, little is known about how often schoolchildren should train to maintain BLS knowledge/skills, and currently, 2 hours of training annually from the age of 12 years is recommended.11 As the year period may be too long for skills retention and perhaps it could not be easy to integrate 2-hour sessions into current school curricula, we tested two relatively innovative, feasible and practice-oriented strategies: brief annual retraining and very brief every 4 months of rolling-refreshers.

Regarding BLS sequence, a greater proportion of children in both experimental groups were able to perform the steps than CG 2 years after the first training, and at least 70% of the participants of RRG were able to perform each step correctly, reaching better proficiency than those schoolchildren of SG. Thus, 5 min rolling-refreshers were more effective than annual 50 min retraining in retaining how to correctly perform the BLS sequence. It must be considered that the BLS sequence requires acquiring much theoretical knowledge (to remember all the steps) and skills (to perform the steps correctly), which might be a reason why shorter refreshers shorter refreshers run

| Table 1 Intragroup and intergroup analysis of CPR variables |
|-----------------|----------------|----------------|-------------------------------|----------------|----------------|----------------|
|                 | CG             | SG             | RRG                         | CG vs SG       | CG vs RRG      | SG vs RRG      |
| Global quality of CPR (%) |             |                |                             |                |                |                |
| T1              | 12.8 (22.3)    | 26.8 (29.2)    | 10.8 (18.6)                 | <0.001         | –              | <0.001         |
| T2              | 16.4 (24.1)    | 25.3 (28.8)    | 29.9 (29.4)                 | –              | <0.001         | 0.025          |
| p*              | –              | –              | <0.001                      |                |                |                |
| Mean rate       |                |                |                             |                |                |                |
| T1              | 114.9 (21.6)   | 113.6 (17.5)   | 107.5 (22.4)                | –              | 0.040          | 0.001          |
| T2              | 123.0 (23.4)   | 115.7 (18.9)   | 105.9 (20.2)                | 0.041          | <0.001         | <0.001         |
| % CC by depth   |                |                |                             | <0.001         | <0.001         | <0.001         |
| T1              | 26.4 (10.1)    | 30.6 (12.1)    | 26.3 (9.1)                  | 0.020          | –              | –              |
| T2              | 31.3 (10.9)    | 33.5 (10.8)    | 36.7 (11.5)                 | –              | <0.001         | <0.001         |
| p*              | <0.001         | 0.001          | <0.001                      |                |                |                |
| Mean depth      |                |                |                             |                |                |                |
| T1              | 3.9 (11.8)     | 4.3 (13.3)     | 2.3 (7.3)                   | –              | –              | –              |
| T2              | 7.2 (16.7)     | 10.8 (22.7)    | 15.5 (26.1)                 | –              | <0.001         | 0.010          |
| p*              | 0.030          | 0.002          | <0.001                      |                |                |                |
| % CC by rate    |                |                |                             |                |                |                |
| T1              | 36.4 (33.4)    | 40.6 (33.1)    | 32.7 (30.6)                 | –              | –              | –              |
| T2              | 34.9 (34.9)    | 39.8 (36.8)    | 38.8 (35.8)                 | –              | –              | –              |
| p*              | –              | –              | –                           |                |                |                |
| % CC with complete recoil |            |                |                             |                |                |                |
| T1              | 89.0 (19.1)    | 89.8 (21.3)    | 89.2 (16.4)                 | –              | –              | –              |
| T2              | 89.4 (18.8)    | 86.2 (24.7)    | 84.8 (26.2)                 | –              | –              | –              |
| p*              | –              | –              | –                           |                |                |                |
| % CC with correct hands position |          |                |                             |                |                |                |
| T1              | 97.0 (14.4)    | 96.1 (21.7)    | 98.2 (10.8)                 | –              | –              | –              |
| T2              | 76.4 (35.1)    | 92.5 (19.7)    | 95.0 (17.2)                 | <0.001         | <0.001         | –              |
| p*              | <0.001         | –              | –                           |                |                |                |

Continuous variables expressed as mean (SD).
*Intragroup analysis.
†Intergroup analysis.
CC, chest compression; CG, control group; CPR, cardiopulmonary resuscitation; RRG, rolling-refresher group; SG, standard group with retraining.
revealing that RRG compressed deeper than the other two groups, analysis by weight, height and BMI, our results showed as an option easily embeddable into schools’ schedule teachers, and we proposed every 4 months of retraining very frequent sessions might not be acceptable by school- the student. In the case of schoolchildren, we considered the specific content (theoretical/practice) and the age of Nevertheless, the retention of BLS skills might depend on the student in a growing stage of development, and their weight and height increased between both tests. Positive associations between anthropometric variables and the capacity to compress deeper were also shown not only in school- tions between anthropometric variables and the capacity to compress deeper were also shown not only in school-

clear that the participants were schoolchildren who were in a growing stage of development, and their weight and height increased between both tests. Positive associations between anthropometric variables and the capacity to compress deeper were also shown not only in school- children but also in adults. However, after adjusting the analysis by weight, height and BMI, our results showed that RRG compressed deeper than the other two groups, revealing that 4-month rolling-refresher sessions had a relevant impact in this sense. In any case, none of the three groups were able to reach the minimum chest compression depth (50 mm).

Skills retention is a main problem of life support training for both laypeople and healthcare professionals; thus, the frequency of rolling-refresher is also a debated topic. Monthly refreshers were shown to be more effective than other training frequencies, such as every 3, 6 and 12 months in healthcare samples. Nevertheless, the retention of BLS skills might depend on the specific content (theoretical/practice) and the age of the student. In the case of schoolchildren, we considered that in the current stage of BLS training at schools, such very frequent sessions might not be acceptable by school- teachers, and we proposed every 4 months of retraining as an option easily embeddable into schools’ schedule (one refresher taught in each of the three trimesters of academic year).

However, how can rolling-refresher be implemented in school curricula schedules? Time devoted and logistics matter. In our study, although each schoolchild received hands-on 5 min training at each refresher session, schoolchildren had to spend a 50 min lesson, since they only had three manikins. Therefore, it might not be considered efficient in terms of time use to spend a whole lesson for only 5 min of training. In this regard, a recent publication suggested that low-cost handmade manikins might be adequate to teach and learn BLS skills at school. This option might be a cheap and feasible choice at any place that would also be advantageous in terms of time utilisation, since each child might have their own manikin. This would allow us to answer one question that emerged from our results regarding whether an increase in time of practice to 10 or 15 min would have a relevant impact on performance. Finally, another barrier to implementing BLS training at schools (at baseline, retraining and/or rolling-refresher) is the training and engagement of schoolteachers. To solve this potential problem, in the present study, schoolteachers were previously taught in BLS; if BLS training was mandatory in universities, it would be easier to teach this content to schoolchildren.

CONCLUSIONS

In 8-to-12-year-old schoolchildren, although annual 50 min retraining sessions help to maintain BLS performance, 4-month very brief rolling-refresher were shown to be even more effective. Thus, we recommend implementing baseline BLS training at schools, with subsequently brief rolling-refresher.

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Acknowledgements We would like to thank everyone who made possible this research, especially schoolteachers and schoolchildren.

Contributors CA-G, SM-I, RB-F and AR-N conceived the study. CA-G, SM-I, RB-F, CV-C, LSS and AR-N designed the study protocol, with input from the rest of the
authors. The data were collected by AC-F, MP-L, FFM and MO-A. CA-G, SM-I and AC-F analysed the data. CA-G and AR-N drafted the manuscript and made revisions following critical review by all authors. SM-I is responsible for the overall content as guarantor. All authors approved the final version of the manuscript.

**Funding** Research funded by Instituto de Salud Carlos III - ISCIII - P20/01355 - Cofunded FEDER, AC-F (FPI19/02017) is recipient of a predoctoral fellowship by the Spanish Ministry of Science, Innovation and Universities.

**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

**Patient consent for publication** Consent obtained from parent(s)/guardian(s).

**Ethics approval** The study protocol has been approved by the Ethical Committee of the Faculty of Education and Sport Sciences – University of Vigo (Spain).

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available upon reasonable request. Data available upon request to the author, smztisisasi@gmail.com.

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