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Schoolchildren as life savers: At what age do they become strong enough?☆

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ABSTRACT

Objective: It is not clear when schoolchildren become enough strong to perform good quality chest compressions (CC). Our purpose was to assess CC quality in schoolchildren.
Methods: 721 children, 10–15 years old (YO) participated in 1 h hands-on training session. Subjects were tested during performing 2 min of continuous CC by means of Laerdal Resusci Anne® with Skillreporter®, without feedback.
Results: Mean compression depth (MCD) increased with age, from 30.7 mm in 10YO to 42.9 mm in 15YO ($p < 0.05$) and was related to height, weight, and BMI. Boys delivered significantly deeper CC than girls in the 10, 13, 14 and 15YO groups ($p < 0.001$). The percentage of children who achieved the MCD goal (50–60 mm), increased with age, from 0.0% at 10 years to 26.5% at 15 years ($p < 0.001$). Mean compression rate (MCR) ranged from 121 min^{-1} in 15YO to 134 min^{-1} in 12YO. The percentage of children who achieved a CC rate inside the goal (100–120 min^{-1}), ranged from 20.3% in 11YO to 31.0% in 15YO. Correct CC fraction was low and ranged from 2% in the 10YO to 22% in the 15YO ($p < 0.05$). Children older than 13YO obtained better results than younger ones for all analyzed variables ($p < 0.001$). Performance decreased with time: 12% of children achieved >50% of correct CC fraction in first minute, while only 5% did it in second minute ($p < 0.001$).
Conclusions: In schoolchildren, age, sex and anthropometry are significant CPR quality factors. Although quality increases with age, their global performance is poor. Thirteen years is the minimum age to be able to achieve a minimum CPR quality similar to the one adult possess. CPR performance in schoolchildren significantly deteriorates within 60 s.

1. Introduction

Since at least two decades ago, teaching and training CPR at schools have been proposed as a way to disseminate skills and increase the rate of bystander resuscitation.[1,2] As a consequence, a variety of programs to teach CPR in school has been developed in European countries.[3–9] Also, in 2011 the American Heart Association (AHA) recommended that CPR training for schoolchildren (including high-quality chest compressions (CC) with minimum interruptions) should be mandatory.[10]

While there is general agreement on the usefulness of training interventions in order to increase knowledge and skills of school children,[3,10,11] a debate remains about the methods, the optimal age to start and the age at what they become enough strong to perform high-quality CPR.[12,13]

Two studies that evaluated children's performance based on 2005 international guidelines, indicated that schoolchildren aged less than 13 years old (YO)[12,13] did not achieve the standards for compression depth.

ERC and AHA 2010 guidelines have increased the recommended CC depth from 39–51 mm to 50–60 mm, and the CC rate from 90–100 per min, to 100–120 per min.[14–16] As we are not aware

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of studies that tested children's ability to fill current CPR guidelines, our purpose was to investigate this point and to correlate CC quality with children's age, sex and anthropometry.

2. Methods

2.1. Participants

Children 10–15 years old from 7 public schools in Pontevedra, A Coruña and Madrid (Spain) were candidates to participate in the study. Children with physical handicaps or underlying diseases that significantly limit physical performance, and those whose parents did not consented were excluded. A total of 721 children (361 boys/360 girls) were finally included.

2.2. Ethics

The study protocol was approved by the ethics committee of the Faculty of Education and Sport Science of the University of Vigo (Spain).

2.3. Study design and implementation

The purpose and methods were explained to the staff of the school, children and parents, who respectively gave verbal and written consent to participate in the study and to use data in the analysis phase. Children's date of birth was registered, their weight and height were measured and their body mass index (BMI) was calculated.

2.4. CPR training

Groups of 5 participants were made. Each group was trained during 1 h by an instructor. The session included brief explanations about the importance of immediate life support by laypersons in case of cardiac arrest, the clues to recognize it and the basic life support maneuvers with emphasis on the high-quality uninterrupted CC (according to ERC 2010 guidelines).[14] Short videos were used as teaching support. Repetitive hands-on training was done on Resuci Anne® (Laerdal, Norway) manikins (one manikin per student). Students received on-the-fly verbal feedback from instructors.

2.5. CPR quality testing

One hour after training, children were asked to perform 2 min of continuous CC on the same manikin, then with the Wireless Skillreporter® software version 1.1 (Laerdal, Norway) enabled. This system is able to detect and record CC characteristics in real time (rate, depth, leaning and hands position). To be considered as "correct" a CC must be performed without any error. The system was configured according to the ERC 2010 guidelines: correct depth 50–60 mm and correct rate 100–120 CC per min.[14] The record of one of participants can be found in the supplementary file. The evaluations were conducted in a private room in order to avoid any influence on other waiting children. No feedback (visual or acoustic) was permitted during the test.

2.6. Data analysis

The independent variables that were analyzed were weight, height, sex, age, and BMI. Dependent variables were CC depth (in mm), CC rate (in CC per min), percent of correct CC and different types of errors (by insufficient depth, by leaning, or by hand position). An arbitrary cardiac output simulated equivalent index (ACOEI) was calculated (ACOEI = CC depth × CC rate). Descriptive statistics included mean, standard deviation and 95% confidence interval. Levene test was used to assess the homogeneity of variances between groups, one-way ANOVA to investigate differences between means and Bonferroni (equal variances assumed) or Games-Howell (equal variances not assumed) to check the statistical significance of results between different age groups. Independent-samples *t*-test (girls vs. boys) and paired-samples *t*-test (minute 1 vs. minute 2) were used to analyze differences between means. A lineal regression analysis was done to investigate the potential association between independent and dependent variables.

3. Results

All participants ($n = 721$) were able to perform the CPR quality test and all data were available for analysis.

Anthropometry (Table 1 and tables in supplementary files).

Height, weight and BMI of the whole sample are shown in Table 1. Ten YO children's mean weight was significantly lower than the weight of the other groups ($p < 0.05$), as well as 11–12 YO children when compared with older ones ($p < 0.05$). No statistically significant differences were observed in weight of children who were 13–15 YO. The same results were observed when boys and girls were analyzed.

Mean height was statistically different by age group, except when 13 and 14 YO, and 14 and 15 YO groups were compared.

When ages by sex were compared, mean weight and height were statistically different only in the 14 and 15 YO groups ($p < 0.001$).

Regarding BMI, no statistically significant differences were observed as far as age or sex were concerned.

CPR quality (Table 1 and tables in supplementary files).

3.1. CC depth

Mean compression depth (MCD) increased with age (from 30.7 mm in 10 years old to 42.9 mm in 15 YO) ($p < 0.05$) and had statistical relation to height ($b = 0.21\ \text{cm}^{-1}$, $p < 0.001$), weight ($b = 0.32\ \text{kg}^{-1}$, $p < 0.001$) and BMI ($b = 1.18$ per kg m^{-2}, $p < 0.001$).

Sex was a significant factor of CC depth in the 10 YO group (boys: 33 ± 7.5 mm; girls: 29 ± 6.6 mm), 13 YO (boys: 40 ± 7.5 mm; girls: 36 ± 7.4 mm), 14 years old (boys: 45 ± 7.5 mm; girls: 41 ± 6.4 mm) and 15 YO (boys: 47 ± 6.9 mm; girls: 40 ± 7.8 mm) ($p < 0.001$ in all cases).

A significant correlation between CC depth and weight ($r = 0.63$), height ($r = 0.59$) and BMI ($r = 0.46$) ($p < 0.001$ in all cases) was observed in both sexes.

The percentage of children who achieved a mean MCD in the goal range of 50–60 mm, increased with age, ranging from 0.0% at 10 years to 26.5% at 15 years in the whole group ($p < 0.001$); from 0.0% to 46.0% in boys ($p < 0.001$) and from 0.0% to 42.9% in girls ($p < 0.001$) (Fig. 1).

3.2. CC rate

Two minutes total number of CC and CC per minute was related to age ($p < 0.001$) in the whole group as well as in boys and girls (Table 1). Younger children delivered more CC per minute (outside the recommended range) than older children (that performed in the high limit of the recommended range). Mean compression rate (MCR) ranged from 134.7 min^{-1} in 12 YO to 121.5 min^{-1} in 15 YO in the whole group, with similar values for boys and girls.

The percentage of children who achieved a CC rate inside the goal of 100–120 min^{-1}, ranged from 20.3% in 11 YO to 31.0% in 15 YO in the whole group, with similar values in boys and girls (Fig. 2).