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E-27

Special situations in emergency care

When can we start? – Evaluation of the effectiveness of a first aid education programme in kindergarten and primary school

Doctoral (Ph.D) thesis

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Introduction

In Europe and the USA occurs approximately 750.000 out-of-hospital cardiac arrests (OHCA) every year (Nichols et al, 2012). In Hungary there are approximately 20-25.000 OHCA annually (KSH). Bystander first aid can improve the chance of survival in the event of a sudden injury or illness. A victim with cardiac arrest is 2-4 times more likely to survive cardiac arrest with bystander CPR provision (Böttiger et al, 2001). The frequency and quality of first aid provision is different worldwide but usually are lower than expected (<20%) (Gräsner et al, 2013). With quick and correct bystander first aid 2-300.000 lives would be saved every year. In countries with high quality first aid education outcomes are better. The majority of Hungarian population attend a first aid training only when acquiring the driver's licence.

First aid education in early childhood can be one of the key initiatives to increase effective bystander numbers. "Kids save lives" project is endorsed by the World Health Organisation (WHO), the International Liaison Committee on Resuscitation (ILCOR), the European Resuscitation Council (ERC), the European Patient Safety Foundation (EuPSF) and the World Federation of Societies of Anaesthesiologists (WFSA) (Böttiger et al, 2015). Based on this project CPR education is recommended from the age of 12 (or younger) for every children worldwide. School resuscitation education is mandatory in several European countries, in many American states and in Canada. However, first aid training should be wider than resuscitation only. Hungarian national school curricula includes first aid and resuscitation education in primary- and secondary schools since 2012. Despite mandatory legislation school first aid training has not been successfully implemented.

First aid training in childhood can improve participants' knowledge, skills and willingness. However, there are a lack of evidences about starting age.

Objectives

The aim of the current study was to evaluate the effects of our first aid programme for kindergarten children (5-7 years old) and primary school children (7-14 years old). Our aim was to measure the children's first aid knowledge, skills and helping attitude before, immediately after, 4 and 15 months after the programme. Other aim was to measure the opinions of teachers and parents about our programme.

We hypothesized the followings:

- There is going to improve both of theoretical knowledge and practical skills in the topics which were assessed (calling the ambulance, adult basic life support (BLS) and automated external defibrillator (AED), handling an unconscious patient, managing bleeding) immediately after training compared to the pre-test (H1).
- Kindergarten children are going to know the correct ambulance number in a higher rate after 15 months than in the pre-test (H2).
- The childrens' age, body weight, body height and BMI are going to influence the effectiveness of chest compression depth and ventilation volume provided by the participating children (H3).
- The children can provide the recovery position on their classmates independently their sex immediately after training (H4).
- The childrens' helping attitude is going to increase (on their own admission) after the programme compared with the pre-test (H5).
- The age is going to influence the opinions about the appearance/role of first aid education in public education (higher age can cause more negative opinions) (H6).

Methods

This study was a longitudinal cohort study with both of quantitative and qualitative elements.

The children were required to participate in our first aid education programme which was held between January 2015 to June 2016. Participants in this study were from Inner-city kindergarten and Inner-city primary school (located in Pécs, Hungary). Children who had not attended all three lessons or did not pass any of the tests were excluded from the study.

Training consisted of three sessions (45 min each) on three consecutive weeks (one per week) with transfer of theoretical knowledge and practical skills about first aid. The most urgent situations were addressed in the study: BLS-AED, handling an unconscious patient, managing severe bleeding, and calling the ambulance. The education programme was adapted to the needs and abilities of all age groups. All of the instructors were paramedics and paramedic students. The training programme contained theoretical and 'hands-on training' components.

We administered a questionnaire to the students before, immediately after and 4 and 15 months after the training. The questionnaire used open-ended questions because we believe the answers of open questions better reveal actual knowledge than the results of multiple-choice tests. Children with lower levels of cognitive status could receive questions aurally and give answers orally. In addition, children were tested in first aid scenarios before and immediately after teaching, and then re-tested 4 and 15 months later. There were also measured the helping attitude in every steps of the study. First aid skills were scored by an instructor using checklists that were developed according to European Resuscitation Council (ERC) guidelines. We therefore measured theoretical knowledge, practical skills and attitude. Completion of the questionnaire and practical measurements were performed on the same days.

The sex, age, body height, and weight of all children were recorded and their body mass index (BMI) calculated. Children used a 'code word' when they were measured, so we could follow them anonymously for the entire programme duration. Based on the questionnaire we documented whether participants had experienced previous first aid training.

In the topic calling the ambulance, we measured children's ability to recall the correct telephone number of the local ambulance service (104 or 112 in Hungary) and to giving necessary relevant information (location, nature of the emergency, number of victims, own telephone number). To test this as part of practical skills, we described emergency situations, and for each of these situations, the children had to decide whether it was necessary to call the ambulance service (e.g. mild nose bleeding vs. unconscious patient). To evaluate the CPR

performance, we used an AMBU® Man W model with AMBU® CPR Software (AMBU A/S, Baltorpbakken 13, DK 2750 Ballerup, Denmark). The program recorded the chest compression depth, frequency and rate, the hand position, the chest compression-ventilation rate, the ventilation volumes and frequency, compression-relaxation rate, and pause between each compression round during a continuous CPR scenario of 2-minutes duration. To teach and practice handling of the AED, we used a Lifepak® 1000 AED Trainer. 'Self-made wounds' were made to simulate severe bleeding. The victims were other children or adult imitators in the scenarios. Measurements were conducted in a private classroom. Other participants waited in another room.

Parents' and teachers' opinions were collected by a questionnaire what used open-ended questions. Participants filled in the questionnaire immediately after our programme.

Statistical analysis was conducted using SPSS 22.0 (Statistics Package for Social Sciences, Chicago, IL, USA) statistical software. Descriptive statistics were performed (percentages, mean, SD). Categorical variables were presented as number (%) and were compared using Chi-square-test, or Fisher's exact test as appropriate (knowledge, skills, attitude, opinions). One-way ANOVA and t-test was applied to test the association between knowledge, skills (pre-, post-, and after 4 and 15 months) and demographic characteristics (age, body weight and height, BMI, previous first aid experience). Pearson correlation analysis was applied to test resuscitation (CPR) quality (chest compression depth and ventilation volume vs. age, BMI, body weight and height). Opinions were cathegorized (positive vs. negative) or were left in their original form. A $p<0.05$ was considered to be statistically significant.

Results

Results of the kindergarten children

One hundred and twenty-three kindergarten children were recruited into our study. Of these, five were excluded from the study because did not pass at least one of these tests. There were therefore 118 study participants (5-7 years old), comprising 71 girls (60.2%) and 47 boys (39.8%).

The majority of children had not knowledge in the measured topics before the programme. In all of the children the theoretical knowledge immediately after the programme, and at 4 and 15 months was significantly higher than in baseline ($p<0.01$). Based on these results, our first hypothesis (H1) was proven correct in kindergarten children's theoretical

knowledge. Theoretical knowledge were independent of children's age, sex and physical factors (body weight, body height and BMI).

Kindergarten children knew the correct emergency phone number in higher rate after 15 months than in the pre-test. Based on these results our second hypothesis (H2) was proven correct.

In all of the practical skills the ability immediately after training and at 4 and 15 months was significantly higher than before the programme ($p<0.01$). Based on these results, our first hypothesis (H1) was proven correct also in kindergarten children's practical skills.

In the facilitated situation game, the number of participants who could decide whether it was necessary to call the ambulance before training, immediately after training, 4 and 15 months after training were 62 (53%), 78 (66%), 106 (90%) and 67 (57%), respectively.

The effectiveness of resuscitation (CPR, chest compression and ventilation) with AMBU® CPR Software was only detected once, immediately after training. None of the participants were able to establish effective chest compression depth and ventilate the patient. There was no significant correlation between chest compression depth and children's age ($r=0.123$; $p=0.50$), body weight ($r=-0.206$; $p=0.25$), body height ($r=-0.257$; $p=0.15$), and BMI ($r=-0.124$; $p=0.50$). Based on these results our third hypothesis (H3) was proven incorrect in kindergarten children. There was also no significant correlation between chest compression depth and children's sex ($p=0.06$). Correct hand position was not dependent on sex ($p=0.62$) and BMI ($p=0.36$) as well as knowledge of correct compression-ventilation ratio ($p=0.49$; $p=0.33$). Chest compression frequency was independent of age ($r=0.098$; $p=0.59$), sex ($p=0.42$), body weight ($r=-0.042$; $p=0.82$), body height ($r=0.090$; $p=0.62$) and BMI ($r=-0.087$; $p=0.63$).

None of the participants knew the function of an AED before training. However, approximately 11-17% of the children knew the correct electrode position, followed the instructions correctly and could deliver a safety shock before our programme. AED ability rose from 11-17% pre-test to >50% for the tested aspects after the programme and remained significantly higher than in baseline at 4 and 15 months ($p<0.01$).

Before the programme only 28% of participants could identify if a patient was breathing correctly. Immediately after training 64%, at 4 and 15 months 66% and 43%, respectively, of the children could determine whether the patient did or did not have normal breathing. More than three-quarters of the children were able to establish the correct recovery position immediately after training. Providing recovery position was independent of children's sex, so our fourth hypothesis (H4) was proven correct. At 4 and 15 months results decreased substantially, ratio of participants who were able to establish the correct recovery position were

20% and 12%, respectively. Only a low number of children could place the adult patient in the recovery position alone because of their physical abilities. Other children solved the problem by working in groups.

Management of bleeding also significantly improved after training and remained significantly higher than in baseline level at 4 and 15 months ($p<0.01$).

Practical skills were independent of children's age, sex and physical factors.

Attitude towards first aid improved significantly after training ($p<0.01$). Based on these results, our fifth hypothesis (H5) was proven correct in kindergarten children's helping attitude. At 4 and 15 months willingness and attitude decreased but remained significantly higher than in baseline ($p<0.01$). Attitude was independent of children's age, sex and physical factors.

Results of the primary school children

We recruited 607 children. Of these, 25 were excluded from the study because they did not attended all three lessons (13 children) or children did not pass at least one of the tests (12 children). There were therefore 582 study participants, between 7 and 14 years old, comprising 317 girls (54.5%) and 265 boys (45.5%). Seventy-five (12.9%) of these students had previously attended first aid training.

Our results showed that some children without previous first aid training had preliminary first aid knowledge from different sources (e.g. media, parents). In almost all of the children the theoretical knowledge immediately after the programme, and at 4 and 15 months was significantly higher than in baseline ($p<0.01$). Based on these results, our first hypothesis (H1) was proven correct in primary school children's theoretical knowledge.

The majority of children were able to give the correct ambulance phone number and location and type of emergency prior training; the proportion improved immediately after the course and remained high at 4 and 15 months. Knowledge of the correct telephone number was associated with previous first aid training ($p=0.015$) and age (7-8 years old children vs. older children; $p<0.001$) in the pre-test, but these factors were not associated post-test and 4 and 15 months later.

Ability to perform the steps of BLS was very low (<20%) prior to the course, and improved significantly after the course ($p<0.01$). Four and 15 months after, this knowledge declined somewhat but remained significantly higher than the pre-test ($p<0.01$). Sex, age, previous first aid training, were not associated with breathing assessment on the pre-test. However, children with prior first aid training had better knowledge of chest compression frequency ($p<0.001$), depth ($p=0.01$), rate ($p=0.02$), and ventilation rate ($p=0.02$) on the pre-

test. Significant differences were not detected for any of these items immediately after and at 4 and 15 months.

Theoretical knowledge about AED was low overall (14%) but improved post-test and remained significantly better at 4 and 15 months compared with pre-test ($p<0.01$). Age was associated with this knowledge of the AED 4 and 15 months after training (12-14 years old vs. younger children; $p<0.001$).

The proportion of children who knew how to approach an unconscious patient was 12% and rose after training (77%) and remained significantly higher at 4 and 15 months. Age, sex and prior first aid training were not associated with this knowledge.

Management of bleeding also rose significantly after training and some aspects improved further at 4 and 15 months. In the pre-test 11-14 years old children had significantly better knowledge of the management of severe bleeding, than 7-8 years old children ($p<0.001$).

In almost all of the practical skills, ability after training and at 4 and 15 months were significantly higher than pre-test ($p<0.01$). Based on these results, our first hypothesis (H1) was proven correct in primary school children's practical skills.

In the facilitated situation game, the number of participants who could decide whether it was necessary to call the ambulance before training, immediately after training, 4 and 15 months after training were 285 (48.9%), 530 (91.1%), 512 (88%) and 314 (54%), respectively.

In relation the effectiveness of CPR (chest compression and ventilation) there was a significant correlation between chest compression depth and children's age ($r=0.604$; $p<0.001$), body weight ($r=0.645$; $p<0.001$), body height ($r=0.605$; $p<0.001$), and BMI ($r=0.373$; $p<0.001$). Children in the 12–14-year-old age group performed significantly better chest compressions than younger children ($p<0.001$). Ventilation volume correlated significantly with children's age ($r=0.395$; $p<0.001$), body weight ($r=0.374$; $p<0.001$), body height ($r=0.372$; $p<0.001$), and BMI ($r=0.18$; $p=0.002$). Based on these results, our third hypothesis (H3) was proven correct in primary school children.There was no significant correlation between chest compression depth ($p=0.1$), ventilation volume ($p=0.618$), and children's sex. Correct hand position was not dependent on BMI ($p=0.368$), age ($p=0.213$), and sex ($p=0.17$). Compression-ventilation ratio was not dependent on BMI ($p=0.923$), age ($p=0.06$), and sex ($p=0.584$). Children who previously learned first aid compressed the chest significantly deeper ($p=0.018$), but ventilated the manikin to a similar volume as the group without previous first aid training ($p=0.308$). Applied compression-ventilation ratio was independent from previous first aid course ($p=0.619$).

Correct use of an AED was not difficult for a majority of the children. Only a little more than 10% of the participants knew the function of an AED before training. However, approximately one-third of the participants knew the correct electrode position, followed the instructions correctly, and could deliver a safety shock before training. AED ability rose from 35% in the pre-test to >90% for the tested aspects post-instruction, and remained significantly higher than pre-test at 4 and 15 months. Using an AED were dependent on children's age in the pre-test, post-test and four months later (7-8 years vs. older children; $p<0.001$). Sex and previous first aid experience did not influence correct practical use of the AED.

Management of the unconscious patient rose substantially after our programme. Prior to training only 2% of participants could identify if a patient was breathing correctly; after training, at 4 and 15 months 83%, 74% and 57% of the children could determine whether the patient did or did not have normal breathing. Only children >10 years of age could place the adult patient in recovery position alone in the pre-test, post-test and 4 and 15 months later (because of their better physical abilities). Other children solved the problem by working in groups. Providing correct recovery position was independent of children's sex, so our fourth hypothesis (H4) was proven correct. Children assessed the breathing of an unconscious patient more often than they did in the BLS scenario immediately after training.

Management of bleeding also significantly improved after training ($p<0.01$). Previous training was associated with the performance of raising the injured extremity ($p=0.017$) and apply direct pressure to the wound ($p=0.041$) in the pre-test. Children $\geq$ 10 years of age managed bleeding significantly higher than younger children in the pre-test: lay the patient ($p=0.01$), raise the injured extremity ($p<0.001$), apply direct pressure to the wound ($p=0.001$), and call the ambulance service ($p=0.001$). Immediately after training, 4 and 15 months later there were not differences between age groups.

Attitude towards first aid improved significantly after training ($p<0.01$). Based on these results, our fifth hypothesis (H5) was proven correct in primary school children's helping attitude. At 4 and 15 months willingness and attitude decreased but remained significantly higher than in baseline ($p<0.01$). Attitude was independent of children's age, sex and physical factors.

Opinions about first aid education programme

Immediately after the programme 93% of kindergarten children and 87% of primary school children considered the program positive.

Immediately after the programme 9 kindergarten teachers were asked about the programme. All of their opinions were positive. We asked 20 teachers after our programme. They had also positive opinions about our first aid education programme. It is interesting to note that the general opinions of teachers about first aid education in childhood were more negative than the opinions about our programme. Based on this results our sixth hypothesis (H6) was proven incorrect, since there was not correlation between the content of opinions and the teachers age.

There were asked 142 parents about first aid education immediately after our programme. Based on the children's report, the majority of the parents had positive opinion about our training. On the other hand, the majority of the parents supported that children can learn firs aid in the kindergarten or in the primary school.

Discussion

In this study we measured the effectiveness of our first aid education programme among kindergarten children and primary school children. Theoretical knowledge, practical skills and attitude were also measured, and in addition we measured the opinions about the programme.

Overall, approximately the half of the children correctly performed all of the topics immediately after training. Based on these results our firs hypothesis (H1) was proven correct. In all of the topics there was a significant improvement. According to these results our programme was effective.

Previous studies demonstrated that young children are able to call for help and give basic first aid (Bánfai et al, 2014; Plant and Taylor, 2013; De Buck et al, 2015). In our study approximately half of the participants were able to decide whether it was necessary to call the ambulance in the pre-test. The higher rate of kindergarten children could recall the correct emergency phone number after more than one year than in the baseline. Our second hypothesis (H2) was proven correct, since the programme had long term effects in some of the knowledge.

We measured both CPR knowledge and CPR practical skills of all participants. A significant correlation was found between chest compression depth and primary school children's age, weight, height, and BMI. Only the one-tenth of participants were able to effectively ventilate the patient. Quality of ventilation correlated significantly with the primary

school children's age, weight, height, and BMI. Based on these results our third hypothesis (H3) was proven correct in primary school children. Similar results were demonstrated in previous studies (Jones et al, 2007; Abelairas-Gomez et al, 2014). Children under age of 10 years could not perform effective CPR because of their physical abilities, but can learn the cognitive parts of BLS as well as older children. BMI and other physical factors did not influence knowledge and cognitive skills. According to previous studies, CPR training should start at the age of 10-12 years (Böttiger et al, 2016; Lucas et al 2016). No previous study investigated CPR skills of kindergarten children. However, we believe that teaching BLS under the age of 10 years can be useful. The majority of these children cannot perform effective CPR but they can learn some aspects of resuscitation (e.g. assessment of breathing, correct hand position).

Belgian Red Cross-Flander's evidence-based recommendation supports AED training for children (Dieltjens et al, 2013). In our study in baseline approximately 10-35% of participants could use correctly the AED without any prior knowledge. Our results demonstrated than more than half of the participated children could use the AED after training.

Immediately after training more than three-quarter of the participants were able to establish the correct recovery position in our study. It was independent of the sex of the children, so our fourth (H4) hypothesis was proven correct. Previous studies showed similar outcomes: more than three-quarters of 6-7-year-old children and approximately half of 4-5-year-old children performed the correct recovery position after training (Bollig et al, 2009; Bollig et al, 2011). In our study children assessed the breathing of an unconscious patient more often than they did in the BLS scenario. The reason for the greater willingness to assess breathing could be that the patient in the BLS scenario was a manikin whereas another child or an adult imitator played the victim in the situation with the unconscious patient.

Most important part of manage severe bleeding is direct pressure to the wound. More than half of the children in our study were able to apply a correct bandage to minimize bleeding.

Improving first aid knowledge can improve attitudes towards giving help. In our study less than half of the participants had willingness to help another person before our programme. Immediately after the programme and at 4 and 15 months it was significantly higher than in baseline. Based on these results our fifth hypothesis (H5) was proven correct. The reason of this can be the increased self-confidence which is due to the learnt knowledge.

For wider implementation support from parents and teachers is also needed. The majority of programme-related opinions were positive. Based on the answers of the children, the parents and the teachers it was useful. In contrast to the prior assumption there was no difference in the opinion of teachers of different ages, so our sixth hypothesis (H6) was proven incorrect.

In conclusion, first aid education in childhood can have wide social impacts (e.g. improve the number of “active bystanders”). Beginning some aspects of first aid education in the kindergarten or primary school could be useful. The children who participated our first aid education programme could learn the basics of giving help. These children cannot be “professional bystanders” immediately after our training but the programme can be an introduction and sensitisation of first aid. The most important thing for young children to be able recognise emergency situations and call for help. The benefit of our programme that it could include not only the transfer of knowledge and skills but also could motivate children to perform first aid and develop their helping attitude. Positive opinions about the programme are also promising.

Novel findings and practical applications

- This study was the first comprehensive study with high number of participants in Hungary and at international level which examinded widely the first aid knowledge and skills of all age groups of kindergarten children and primary school children (5-14 years old).
- To the best of the authors' knowledge, this study was the longest longitudinal study so far conducted on the effectiveness of first aid programme.
- To the best of the authors' knowledge, this study had the largest number of participants which contained first aid education programme for kindergarten children. We measured also the effects of this programme.
- In this study there were measured theoretical knowledge, practical skills and also helping attitude. It is useful because most of the previous studies measured only the knowledge, the skills or attitude individually instead of measuring these factors together.
- We measured also the effectiveness of CPR among children younger than 10 years old. Altough the results were probable than these children are unable to perform effective CPR it is important, because there were no previous measurements, only some conclusions. Our results were positive because some of the children younger than 10 years were able to perform effective CPR.
- Based on our results as young as 5 years are able to learn some basics of first aid. It can be useful in the future.
- Our results can be useful to spread first aid widely. In this case we can also use the programme-related opinions.

Suggestions

Based on the results our suggestions are listed below:

- We recommend to perform furher researches which can serve useful results for the development of the most effective method (e.g. measure the effectiveness of digital learning materials).
- It would be recommended to extend our programme with further first aid requiring situations to get more informations.
- It would be important to spread first aid education widely in childhood, even in kindergarten (so earlier than in national school curriculum).
- In case of wide spreading coherence would be important. Every children in the same age group should learn the same knowledge (to do this national support is required). National school curriculum includes some informations to obtaining first aid knowledge but in our opininon clarification would be necessary to know which knowledge and skills should learn the children.
- The support of parents and teachers is necessary to spread first aid education widely so promoting this topic among them is also important. Our results showed that opinions about our programme were better than general opinions about first aid education in childhood so parents and teachers can be persuaded.

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Publications related to the thesis:

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