Original paper

Quality of chest compressions during cardiopulmonary resuscitation in various professional health care and rescue groups

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Abstract

Introduction: Skills in correctly performing cardiopulmonary resuscitation (CPR) are a key predictor of its effectiveness. Both the acquisition of appropriate skills during training and regular practice significantly impact the accuracy of CPR execution, both in real-life scenarios and simulated conditions.
Aim of the research: The study aimed to assess the quality of CPR performed by various professional groups. Factors that could statistically significantly influence the quality of resuscitation procedures and the overall outcome of the exercises were investigated.
Material and methods: A retrospective analysis was conducted on data collected during training sessions using a Laerdal QCPR manikin equipped with a real-time quality feedback system for CPR. The gathered data were subjected to statistical analysis using PQStat software.
Results: The study sample included 49 participants: 20 nurses, 16 paramedics, and 13 firefighters. Statistically significant differences were observed in CPR quality between the groups of nurses and paramedics, as well as between nurses and firefighters ($p = 0.00567$ and $p = 0.005291$, respectively). Additionally, it was noted that male participants performed CPR better than female participants ($p = 0.020456$). A statistically significant difference in the change in mean arterial pressure due to physical exertion was observed between nurses and paramedics ($p = 0.012518$).
Conclusions: Different professional groups demonstrate varying predispositions for achieving high-quality results in CPR procedures. The gender of individuals performing CPR influences the quality of execution. The BMI index does not affect CPR performance quality.

Introduction

Chest compressions in first aid

Skills in properly performing cardiopulmonary resuscitation (CPR) are a key predictor of its effectiveness. Both acquiring the correct skills during CPR training and engaging in regular practice impact the accuracy of its execution in both real and simulated conditions. An essential element of training for personnel performing CPR is the regular assimilation of the latest guidelines in this field [1].

Many factors can influence the ability to perform CPR correctly. These factors may depend on the individuals performing CPR, including modifiable and non-modifiable elements, the condition of the patient being resuscitated, and the infrastructure present during the emergency. One of the crucial factors determining the success of CPR is the time elapsed since the last training session in this area [2].

It is also worth emphasising that out-of-hospital cardiac arrest (OHCA) and the lack of adequate assistance provided by bystanders constitute a significant public health issue. Many patients lose their lives or experience a drastic decline in quality of life because CPR was not initiated in a timely manner [3]. Positive health outcomes from CPR interventions are rarely observed. Only 10% of individuals who suffer sudden cardiac arrest (SCA) survive until hospital discharge [4].

The tragic nature of this phenomenon is reinforced by several factors involved in the process. Specifically, the patient must receive immediate assistance from bystanders who begin CPR within 4 minutes of the SCA event. The patient must then receive continued care from Emergency Medical Services (EMS), be transported to the emergency room (ER), followed by the intensive care unit (ICU), and finally be admitted to an appropriate hospital department, where symptomatic treatment and diagnostic investigations will be conducted to determine the cause of the OHCA. At each of these stages, another SCA event may occur, and if life functions cannot be restored, the patient will not survive [5].

In the event of SCA, direct witnesses of the incident experience strong emotions that accompany such a situation. Even calling for help can be challenging due to communication difficulties and stress as a reaction to witnessing a tragic event involving a person in their immediate surroundings. Although first aid is just one of the initial – but most crucial – links in the chain of survival, summoning help itself presents a significant challenge for bystanders [6].

Quality cardiopulmonary resuscitation system

The Laerdal Quality Cardiopulmonary Resuscitation – QCPR® is a real-time feedback software system that measures the quality of CPR. It can be wirelessly connected to a Laerdal training manikin [7]. According to the authors' knowledge, there are no data indicating the requirement to use such a manikin in first aid training programs [8, 9].

Aim of the research

The aim of this study is to determine the significance of factors related to the quality of cardiopulmonary resuscitation, as assessed by the QCPR system.

Research hypotheses

1. There is variation in the accuracy of CPR execution depending on the professional group performing it.
2. The accuracy of CPR execution varies based on the gender of the individuals performing it. Individuals with a normal BMI perform CPR more accurately than those with an abnormal BMI.
3. CPR performers exhibit varying physiological responses to exertion, reflected in changes in mean arterial pressure and heart rate.

Material and methods

The study was conducted using data collected during CPR training sessions involving adult volunteers, including paramedics (EMS), nurses (NURSE), and volunteer firefighters (FIREFIGHTERS). The aforementioned volunteers participated in a free refresher course aimed at improving skills acquired in earlier education stages, first aid courses, or qualified first aid training in basic life support procedures.

Before the training exercises, which consisted of a 6-minute chest compression session without rescue breaths (focusing solely on proper compressions), non-invasive data collection was conducted. This included measuring participants' weight and height using a medical scale with a height attachment, allowing for BMI calculation.

Additionally, before and immediately after the training, non-invasive measurements were taken using a Zoll cardiac monitor to assess blood pressure, heart rate, and oxygen saturation levels.

Statistical analysis

Statistical analysis was performed using PQStat v.1.8.6. The initial results were recorded in a Microsoft Excel spreadsheet after being retrieved from the Laerdal QCPR system. To present the results, figures and tables were created to illustrate numerical values and statistical differences between the study groups.

The normality of data distribution (univariate normality) was verified using the Kolmogorov-Smirnov test. Statistical analyses included the Kruskal-Wallis ANOVA, the Mann-Whitney U test, and one-way ANOVA for independent groups. A significance level of $p < 0.05$ was adopted.

Results

Results of the study were presented in Figures 1–7 and Tables 1–8.

Discussion

The above considerations have demonstrated that CPR skills vary depending on the professional group performing such procedures. An interesting aspect is also the change in these skills over time following a refresher training, which aims to maintain a high

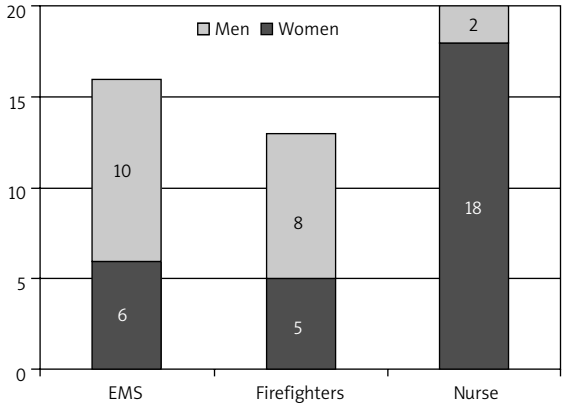

Figure 1. Number of study groups by gender

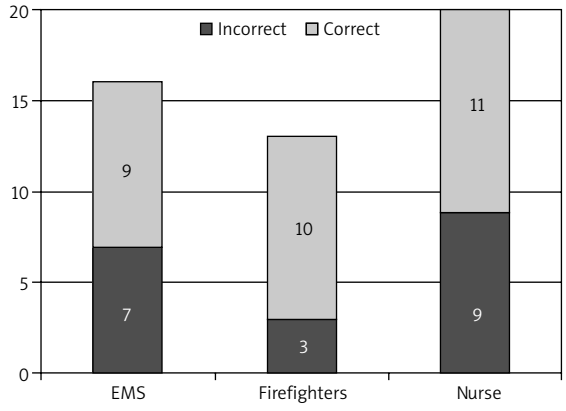

Figure 2. Body mass index in the study group

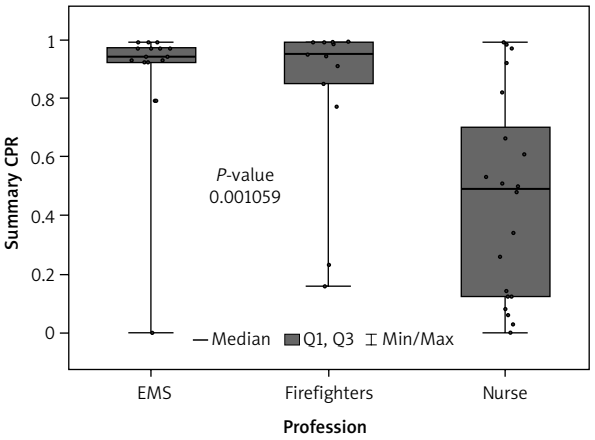

Figure 3. Correctness of performing cardiopulmonary resuscitation (CPR) in individual professional groups

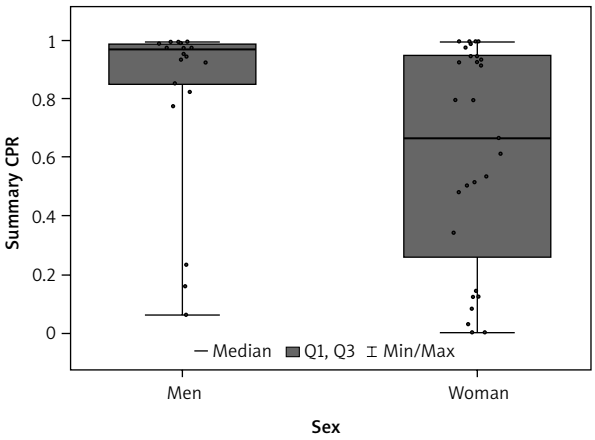

Figure 4. Correctness of performing cardiopulmonary resuscitation (CPR) depending on sex

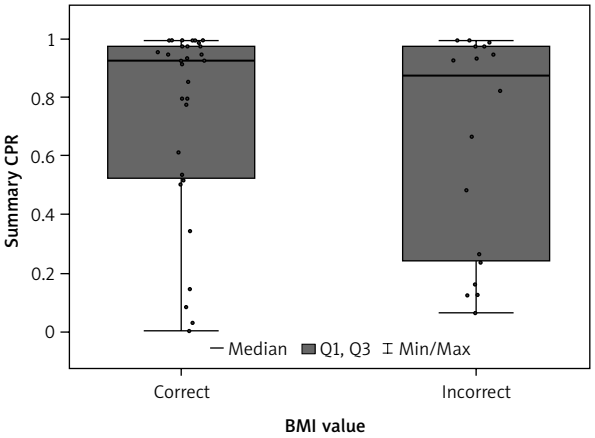

Figure 5. Correctness of performing cardiopulmonary resuscitation (CPR) depending on BMI value

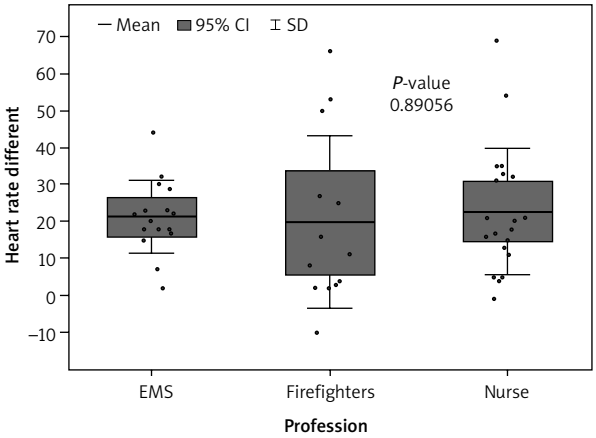

Figure 6. Difference in heart rate due to cardiopulmonary resuscitation performed

level of CPR effectiveness. This issue was explored by the authors of the study *Effectiveness of a Short Refresher Course on the Retention of Cardiopulmonary Resuscitation-Related Psychomotor Skills (REF-CPR)*. They observed a study group of 38 individuals, including 19 men and 19 women. The study group predominantly comprised nurses (n = 21), followed by physicians (n = 15) and paramedics (n = 2). The study methodology included an initial assessment of CPR knowledge and skills, followed by training that ensured participants achieved 100% competency in CPR. After 6 months, the group was randomized into two subgroups: an intervention group that underwent a refresher course at 6 months and a control group that did not receive additional training. When comparing CPR skills using a scoring system (0–100%) based on the Laerdal QCPR system, the skill retention ratio between the in-

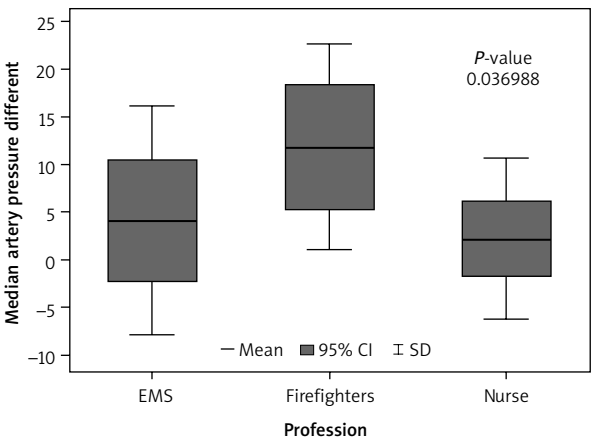

Figure 7. Difference in median artery pressure (MAP) due to cardiopulmonary resuscitation performed

Table 1. Body weight in the study group

Group	Body weight [kg]		
	Min.	Max	Mean
EMS	57	131	79
Firefighters	51	120	72
Nurse	43	101	70

tervention and control groups was as follows: baseline 72.7% vs. 75.8% ($p = 0.638$), after 6 months 87.2% vs. 88.5% ($p = 0.682$), and after 12 months 93.8% vs. 79.4% ($p = 0.01$). These findings demonstrated that the most effective strategy for maintaining CPR skills is a 6-month interval between refresher training sessions. Statistically significant differences were found when comparing skill retention between those who underwent refresher training at 6- and 12-month intervals, with a significant advantage in skill retention observed in the 6-month training group [10]. Access to specialized manikins that measure chest compression depth during CPR may be limited for the general population but is widely available to medical students and professionals undergoing CPR training. In contrast, non-medical individuals may have fewer opportunities to learn or refresh CPR skills. An innovative and noteworthy approach was introduced by the authors of the study *Enhancing Cardiopulmonary Resuscitation Training for the Community with Foam Pillows: A Promising Approach*. They designed and tested a dedicated foam pillow that simulates the resistance provided by a manikin during chest compressions in a simulated environment, aiming to replicate the actual resistance of a human chest during real-life resuscitation scenarios. The pillow featured a designated hand placement area for compressions, ensuring proper technique in both simulated and real-life situations. Additionally, the pillow was designed to mimic chest recoil, allowing users to experience the elasticity similar to that of a human chest.

Participants who practiced chest compressions using the foam pillow were subsequently assessed with the QCPR system on a standard manikin. Notably, they achieved an average of 93% accuracy in chest compression depth and 100% accuracy in chest recoil. These results indicate that the foam pillow is an effective, budget-friendly alternative for practicing CPR skills while maintaining satisfactory technical outcomes. A particularly intriguing aspect of this study was the recruitment of participants with no prior CPR experience via WhatsApp and Instagram. These individuals were provided with the foam pillows for practice and later evaluated on a QCPR manikin, yielding highly favourable performance outcomes [11]. Another study that examined CPR skills over a 6-month period was *Basic Life Support and External Defibrillation Competences After Instruction and at 6 Months: Comparing Face-to-Face and Blended Training – Randomized Trial*. This research analysed differences in CPR skill retention based on two distinct training approaches. The control group participated in a traditional 6-hour instructor-led course, which included theoretical instruction, guided practice, and hands-on CPR training using a manikin without QCPR feedback. In contrast, the experimental group received blended learning, combining multimedia-based self-learning (including an e-learning platform and a dedicated website with text-based content and instructional videos) with

Table 2. Mean arterial pressure (MAP) in the study group before and immediately after starting the exercise

Group	Mean arterial pressure value before starting exercise			Mean arterial pressure value before starting exercise		
	Min.	Max.	Mean	Min.	Max.	Mean
EMS	80	130	95	86	111	99
Firefighters	66	103	88	88	123	100
Nurse	77	128	97	80	99	118

Table 3. Heart rate in the study group before and immediately after exercise

Group	Heart rate					
	Before starting the exercise			Immediately after exercise		
	Min.	Max.	Mean.	Min	Max.	Mean
EMS	76	120	94	85	142	115
Firefighters	57	108	85	73	174	105
Nurse	60	127	88	66	142	111

Table 4. Statistical analysis divided into professional groups in terms of the correctness of cardiopulmonary resuscitation (CPR)

P-value	EMS	Firefighters	Nurse
EMS		1	0.005674
Firefighters	1		0.005291
Nurse	0.00567	0.005291	
Summary			
Group	**EMS**	**Firefighters**	**Nurse**
Cardinality	16	13	20
Median	0.94	0.95	0.49
Lower quartile	0.92	0.85	0.12
Top quartile	0.97	0.99	0.7

practical exercises using a QCPR-feedback-equipped manikin. The experimental group's direct interaction with an instructor was limited to 45 minutes, whereas the total training duration for both groups was identical at 6 hours. Initial post-training results for both groups were comparable. However, after 6 months, a significant decline in skills was observed in both groups, with a more pronounced decrease in the conventionally trained group that received 6 hours of instructor supervision. More detailed analysis revealed that the experimental group, trained with modern technology including QCPR feedback, achieved better chest compression depth immediately after training [12].

As demonstrated by the literature cited above, the present study has several limitations. Firstly, it is a retrospective analysis based on data collected during training observations of various professional groups.

Table 5. Statistical analysis divided into sex in terms of the correctness of cardiopulmonary resuscitation (CPR)

Summary		
Group	**Men**	**Women**
Cardinality	20	29
Median	0.96	0.66
Lower quartile	0.8425	0.26
Top quartile	0.9825	0.94
P-value	0.020456	

Table 6. Statistical analysis divided into BMI value in terms of the correctness of cardiopulmonary resuscitation (CPR)

Summary		
Group	**Correct**	**Incorrect**
Cardinality	31	18
Median	0.92	0.87
Lower quartile	0.52	0.2375
Top quartile	0.97	0.97
P-value	0.715591	

Secondly, it does not involve continuous follow-up but rather relies on single-instance assessments recorded during professional training exercises. Despite these limitations, significant differences in CPR skill levels among different professions were identified. The referenced studies provide valuable insights that will guide future research and facilitate the development of prospective observational studies focusing on factors influencing CPR quality.

Table 7. Statistical analysis of differences in heart rate changes related to the effort undertaken by individual professional groups

Summary			
Group	**EMS**	**Firefighters**	**Nurse**
Cardinality	16	13	20
Arithmetic mean	21.25	19.769231	22.7
Standard error of the mean	2.45034	6.461081	3.848513
Standard deviation	9.80136	23.295757	17.211074
–95% CI for the middle group	16,027224	5.691745	14.64497
+95% CI for the middle group	26.472776	33.846716	30.75503
***P*-value**	**EMS**	**Firefighters**	**Nurse**
EMS		0.818498	0.802477
Firefighters	0.818498		0.634379
Nurse	0.802477	0.634379	

Table 8. Statistical analysis of differences in median artery pressure (MAP) changes related to the effort undertaken by individual professional groups

Summary			
Group	**EMS**	**Firefighters**	**Nurse**
Cardinality	16	13	20
Arithmetic mean	4.1666667	11.794872	2.21667
Standard error of the mean	2.996912	2.998466	1.894324
Standard deviation	11.987648	10.811121	8.471676
–95% CI for the middle group	–2.2211	5.261777	–1.7482
+95% CI for the middle group	10.554433	18.327967	6.181533
***P*-value**	**EMS**	**Firefighters**	**Nurse**
EMS		0.054283	0.576808
Firefighters	0.054283		0.012518
Nurse	0.576808		

Conclusions

Different professional groups responsible for performing CPR exhibit varying levels of predisposition to achieving high-quality outcomes in resuscitation procedures. There is a variation in the quality of CPR performed depending on the gender of the individuals performing it. Body mass index (BMI) does not influence the quality of resuscitation procedures performed during CPR. Individuals performing CPR respond differently to the physical effort required, being better or worse predisposed depending on their fitness level, physical endurance, and experience gained through the frequency of such interventions in their professional duties.

Funding

No external funding.

Ethical approval

This research did not require approval from a Bioethics Committee because it was conducted through the collection of non-invasive data gathered during training exercises in academic or professional settings. Participation in the training was voluntary, and each participant provided informed consent. All participants were informed about the nature and methodology of the training exercises.

Conflict of interest

The authors declare no conflict of interest.

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