

THE USE OF AUTOMATIC COMPRESSION DEVICE ON THE CARDIOPULMONARY RESUSCITATION BY LIFEGUARDS

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ABSTRACT

The purpose of the study was to analyse how the auxiliary rescue material and the automatic compression mechanism influence cardiopulmonary resuscitation (CPR). The sample of our research is composed of a group of 78 lifeguards (50 men and 28 women). An initial test was performed which consisted in the execution of 5 min of CPR. The sample was divided in two groups. Each group performed a second test; water rescue and subsequent 5 min of CPR. One group performed the rescue without material and manual CPR. The other one, the water rescue with flippers and rescue tube and the CPR with an automatic compression mechanism. The use of the automatic compression mechanism improves the conditions in the correct compressions ($p < 0.001$). There was no significant difference in the correct breathing ($p = 0.56$). During the water rescue men were faster when compared to women ($p < 0.001$). When the rescuers are equipped with flippers and a rescue tube, the gender is not as significant ($p = 0.26$). The rescue material is a key to reduce the time water rescue, and the automatic compression mechanism to improve the quality CPR.

Key Words: lifeguard, physical fatigue, rescue material, automatic compression device, quality CPR performance.

RESUMEN

El objetivo de este estudio fue analizar la influencia del material auxiliar de rescate y del uso de mecanismos automáticos de compresión en la reanimación cardiopulmonar (RCP). La muestra estuvo compuesta por 78 socorristas (50 hombres y 28 mujeres). Se realizó un primer test que consistió en 5 min de RCP. Posteriormente la muestra se dividió en dos grupos. Cada grupo llevó a cabo un segundo test; un rescate acuático y a continuación 5 min de RCP. Un grupo realizó el rescate sin material y la RCP de forma manual. El otro grupo, realizó el rescate acuático con aletas y tubo de rescate y la RCP con un cardiocompresor. El uso del cardiocompresor aumentó el número de compresiones correctas ($p < 0.001$). No hay diferencias significativas en las ventilaciones correctas ($p = 0.56$). Respecto al rescate, los hombres fueron más rápidos que las mujeres ($p < 0.001$). Cuando los socorristas hacen uso de material de rescate, no existen diferencias de tiempo en cuanto al género ($p = 0.26$). El material de rescate es clave para reducir el tiempo del salvamento, y el uso de mecanismos automáticos de compresión para mejorar la calidad de la RCP.

Palabras clave: socorrista, fatiga física, material de rescate, cardiocompresores, calidad de la RCP.

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INTRODUCTION

Drowning is one of the leading causes of death worldwide, particularly in children who are under 20 years old (Towner & Scott, 2008). It is the second leading cause in Europe Union (MacKay & Vincenten, 2009), and in United States, it is among the first three (Centers for Disease Control and Prevention - National Center for Injury Prevention and Control, 2012).

The rescuer's intervention usually has two parts: the water rescue and the first aid. Water rescue in natural areas may include a section on the sand. It is the distance that the lifeguard covers until he gets to the water, but the main part of a rescue is the water phase, because that is where the rescuer takes a physical effort to drag the victim. For the rescue, lifeguards can use auxiliary floating material or the auxiliary propulsion material. The choice of material is not based on scientific evidence but on local traditions (The United States Lifeguard Standards Coalition, 2011). On some beaches the lifeguards use flippers, on others, they have torpedo buoy or rescue tube, and some combine both elements; many others, either because of the bad funding or because they do not know how to utilize them, do not use any element of support. When there is a danger of drowning, the intervention that has been reported as the most effective is the immediate ventilation. The lifeguard can face with a victim who does not breathe in water. Respiratory failure caused by drowning will trigger a cardiac arrest. The feasibility and potential benefits of commencing resuscitation with drowning victim still in the water have been shown (Szpilman & Soares, 2004).

Currently, rescuers do not have sufficient evidence or some specific guidelines; therefore, they use the general recommendations to intervene in an emergency situation, but these protocols are generic and may not suit the type of intervention that is being performed.

Technological progress allows us to have, for training and intervention, different materials that provide immediate feedback. Furthermore, the studies of biomechanics, hydrodynamics and physical condition in swimming, have contributed to improvement of conditions with which the swimmer faces the water displacement. The ideal rescue could be in a perfect mid-point of the optimizing the water rescue phase, reducing rescue time and intervening with a high-quality CPR, helped by devices that provide quality of chest compression and minimize accumulated lifeguards fatigue (Ong et al., 2012).

Currently, both the European Resuscitation Council (ERC) and the American Heart Association promote, rapid intervention, and quality CPR performance as determinant factors for survival (Nolan et al., 2010; Koster et al., 2010; Travers et al., 2010). After a water rescue, rescuer may have to perform CPR for a prolonged period of time, as the response of the Emergency Medical Service (EMS) takes 5-8 min-

utes on average (Weisfeldt et al., 2010; Koster et al., 2010) and sometimes it even may reach 20 minutes (Adelborg, Dalgas, Grove, Jørgensen, Al-Mashhadi & Løfgren, 2011). In the market, devices that help the rescuers to achieve a high-quality CPR can be found. An example would be the aforementioned LUCAS device. Chest compressions are often done incorrect (Ochoa, Ramalle-Gómara, Lisa, & Saralegui, 1998) and one-way of potentially improving the quality of chest compression is with automatic mechanical devices (Halperin & Carver, 2010).

Therefore, the objective of this research is to analyse the different conditions under which a rescuer can perform a water rescue; to evaluate the effect of fatigue and auxiliary material both in swimming and in the CPR, to determine the factors that approach to ideal rescue.

METHOD

Participants

Seventy-eight professional rescuers (see table 1) trained at the Universities of A Coruña and Vigo form the sample of this research. All rescuers were trained and updated on the recommendations of the ERC Guidelines for Resuscitation, 2010. Their assignment to the survey was voluntary and disinterested. The research project was presented and approved by the Department of Physical Education and Sport of the University of A Coruña, respecting the ethical principles of the Helsinki Convention. Each participant authorized by informed consent the transfer of data and parameters necessary for this research.

Instrumentation

The dependent variables were the time of rescue and CPR (compressions and ventilations). To analyse the CPR performance, the instrument used was the Laerdal Resusci Anne, with Laerdal PC Skill Reporting. This model records the compressions and ventilations while at the same time it determines whether they are correct or not. For verification of compressions, the dummy controls the depth, frequency, hands position and chest re-expansion. The vents are checked by measuring the air volume and flow rate. All this was performed under the recommendations of the ERC Guidelines for Resuscitation 2010.

The automatic compression device used was the Lund University Cardiac Arrest System (LUCAS) device. It performs cycles of 30 compressions spaced by 4 seconds, under the recommendations of the ERC Guidelines for Resuscitation 2010.

Study design

Firstly, we proceeded to record the gender, height, age, weight and body mass index of the 78 lifeguards.

All lifeguards performed the same first test which consisted of the realization of 5 min of CPR (rested) according to the ERC Guidelines for Resuscitation 2010.

To realization of the second test, the sample was randomly divided into two groups: group of lifeguards 1 (GL1) and group of lifeguards 2 (GL2). GL1 and GL2 had to perform a water rescue an immediately after, initiated 5 min of CPR (exhausted). GL1 had no rescue equipment and executed a manual CPR. GL2 used flippers and rescue tube to perform the water rescue, and LUCAS device to execute CPR (figure 1).

The water rescue consisted of running 50 m to enter the water, swim 75 m to the victim, drag her 75 m to the shore and taking her out of the water. A rescue manikin was used as a victim, which is used in competitions regulated by the International Life Saving Federation.

All participants performed the test in the Oza beach – Spain (Latitude: 43.34815, Longitude: -8.38174) under similar conditions: sea in calm (value 0 in the Douglas scale), average water temperature of 14°C, average environment temperature of 22°C and wind speed below 3 m•s⁻¹. These data were reported by the weather forecasts.

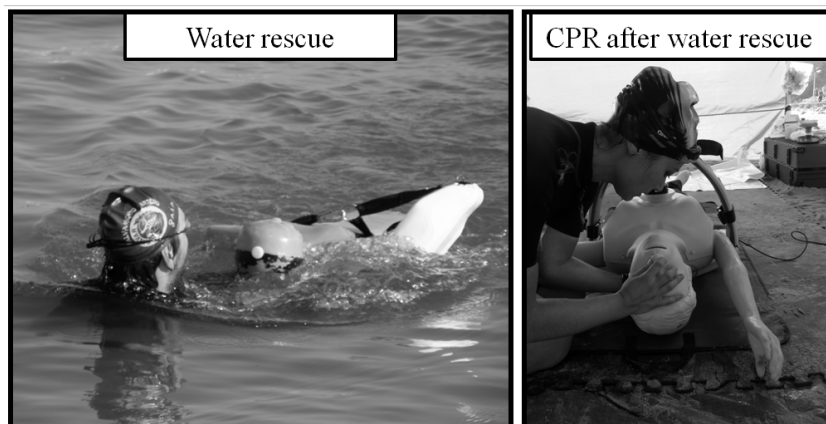


FIGURE 1: GL2. Water rescue and cardiopulmonary resuscitation with Lund University Cardiac Arrest System.

Data collection

We recorded information on sex, age, height, weight, body mass index, total chest compressions (TCC), correct chest compressions (CCC), incorrect chest compressions (ICC), total breath rescue (TBR), correct breath rescue (CBR), incorrect breath rescue (IBR) and water rescue time (WRT). Those variables of the CPR were measured during 5 min of CPR.

Statistical analysis

Data were analysed using SPSS for windows version 20 (SPSS Inc. IBM, USA). The results are presented as the mean and standard error (Mean \pm SE). We performed the following statistical analyses: Checking the normal distribution of the sample by the Shapiro-Wilkes statistic; for comparison between GL1 vs GL2 and men vs women, the unpaired t-test for continuous variables was used. For comparison between CPR in pretest (rested) and CPR in test (exhausted) t-test for paired groups was used. In all analyses, a significance level of $p < 0.05$ was considered.

RESULTS

Demographic data

The sample was composed of 78 lifeguards. 50 were men and 28 were women. The mean age was 22.5 ± 0.47 years for men and 21.4 ± 0.64 years for women ($p = 0.19$). The men were higher ($p < 0.001$), heavier ($p < 0.001$) and had a higher BMI ($p < 0.001$) than the woman (see table 1).

As for the CPR without prior physical fatigue, no significant differences between men and women were found in chest compression: TCC ($p = 0.30$), CCC ($p = 0.97$) ICC and ($p = 0.63$) during 5 min, or in the Breath Rescue: TBR ($p = 0.13$), CBR ($p = 0.15$) and IBR ($p = 0.49$) during 5 min (see table 1).

TABLE 1
Descriptive statistic of data collection. Anthropometric data and rested CPR

Variables	All (N=78)		Female (n=28)		Male (n=50)		t-test
	Mean	SE	Mean	SE	Mean	SE	p-value
Age^a	22.1	0.39	21.4	0.64	22.5	0.47	0.190
height^b	173.0	1.21	162.0	1.08	179.0	0.96	< 0.001
weight^c	70.6	1.48	58.7	1.22	77.8	1.28	< 0.001
BMI^d	23.5	0.29	22.1	0.29	24.4	0.37	< 0.001
TCC	388.0	4.93	396.0	9.63	383.0	7.61	0.300
CCC	276.0	11.79	276.0	22.29	277.0	14.50	0.970
ICC	112.0	11.82	121.0	23.36	107.0	16.37	0.630
TBR	25.0	0.35	25.0	0.60	24.0	0.60	0.130
CBR	14.0	0.73	16.0	1.35	13.0	1.18	0.150
IBR	11.0	0.80	10.0	1.14	11.0	1.27	0.490

CPR: Cardiopulmonary resuscitation; BMI: Body mass index; TCC: Total chest compression; CCC: Correct chest compression; ICC: Incorrect chest compression; TBR: Total breath rescue; CBR: Correct breath rescue; IBR: Incorrect breath rescue; ^a: Age in years; ^b: Height in cm; ^c: Weight in Kg; ^d: Body mass index in kg·m⁻².

Rescue time previous to CPR

Both groups (GL1 and GL2) had to perform the same water rescue. GL1 realised the test without equipment and GL2 with flippers and rescue tube.

The total time of recovery was lower in GL2 ($232.4 \text{ s} \pm 11.70$) than the time of GL1 ($281.7 \text{ s} \pm 7.26$; $p = 0.001$). Analysing the results between men and women, we find statistically significant differences in favour of males in GL1 ($p < 0.001$) but none in GL2 ($p = 0.26$).

CPR performance

The CPR performance is conducted based on a comparative analysis. Test GL1 (exhausted manual CPR) vs. GL2 (exhausted CPR with mechanical chest compression).

The use of an automatic mechanical chest compression device has a significant influence in CCC (manual: 260 ± 22.28 ; mechanical: 368 ± 15.91 ; $p < 0.001$) and ICC (manual: 156 ± 20.55 ; mechanical 35 ± 15.76 ; $p < 0.001$). However, there are no differences between groups GL1 and GL2 in TCC ($p = 0.87$), TBR ($p = 0.34$), CBR ($p = 0.56$) and IBR ($p = 0.36$) (see table 2).

TABLE 2
Univariate analysis for the variables associates with differences between whole worse/better conditions for the rescue (exhausted)

Variables	GL1		GL2		<i>t</i> -test	
	Mean	SE	Mean	SE	<i>t</i>	<i>p</i> -value
TCC	417.0	7.61	403.0	1.69	1,74	0.870
CCC	260.0	22.28	368.0	15.91	-3.93	< 0.001
ICC	156.0	20.55	35.0	15.76	4.68	< 0.001
TBR	26.0	0.52	25.0	0.12	0.97	0.340
CBR	9.0	1.05	10.0	1.26	-0.59	0.560
IBR	17.0	1.20	15.0	1.20	0.92	0.360
WRT	281.6	7.26	232.4	11.70	3.57	0.001

GL1: Group of Lifeguards 1; GL2: Group of Lifeguards 2; TCC: Total chest compression; CCC: Correct chest compression; ICC: Incorrect chest compression; TBR: Total breath rescue; CBR: Correct breath rescue; IBR: Incorrect breath rescue. WRT: Water rescue time in seconds.

As far as gender is concerned, in group GL1 test, in the worse conditions for the rescue, there are no significant differences in any variable of CPR. The same is true to GL2 (see table 3).

TABLE 3
Univariate analysis for the variables associates with gender

Variables		Female		Male		<i>t</i> -test	
		Mean	<i>EE</i>	Mean	<i>EE</i>	<i>t</i>	<i>p</i> -value
GL1	TCC	424.0	10.63	413.0	10.34	0.710	0.480
	CCC	244.0	37.83	270.0	27.96	-0.560	0.580
	ICC	180.0	32.38	143.0	26.54	0.870	0.390
	TBR	26.0	0.84	26.0	0.67	-0.030	0.980
	CBR	11.0	1.41	8.0	1.43	1.080	0.290
	IBR	15.0	1.65	18.0	1.63	-0.950	0.350
	WRT	317.1	10.93	261.7	6.94	4.490	< 0.001
GL2	TCC	401.0	3.03	405.0	1.99	-1.280	0.210
	CCC	398.0	2.97	352.0	24.32	1.400	0.170
	ICC	3.0	0.61	53.0	23.99	-1.556	0.130
	TBR	26.0	0.19	26.0	0.16	-0.490	0.630
	CBR	13.0	2.83	9.0	1.10	1.760	0.090
	IBR	13.0	2.41	17.0	1.23	-1.850	0.070
	WRT	250.1	24.44	222.6	12.07	1.830	0.260

GL1: Group of Lifeguards 1; GL2: Group of Lifeguards 2; TCC: Total chest compression; CCC: Correct chest compression; ICC: Incorrect chest compression; TBR: Total breath rescue; CBR: Correct breath rescue; IBR: Incorrect breath rescue; WRT: Water rescue time in seconds.

DISCUSSION

This paper analyses the rescuers intervention since two perspectives: the water rescue time and the quality CPR after water rescue.

In our study, rescuers had to swim 75 meters to the victim and tow it properly until they reached dry sand. The men were significantly faster than women ($p < 0.001$). These data are consistent with the study of Claesson et al. (2011) who performed a similar study in which men also were faster. If the lifeguards use flippers and rescue tube, women are still slower, but not significantly ($p = 0.26$). If the rescue without equipment and the rescue with the auxiliary material are compared, the influence of the flippers and a rescue tube is remarkable, as they significantly improve the outcome in 50 s ($p = 0.001$). Prieto et al. (2010) didn't found differences between using rescue material or not using it. However, in their study, lifeguards only used torpedo buoy. The International Life Saving Federation proposed that the lifeguard should be able to rescue a victim 100 m from coast (International Life Saving Federation, 2000). In addition, some research suggests that the drowning victims normally are between 50 and 100 m (Gulbin, Fell & Gaffney, 2011); so that does not seem a great distance to a swimmer. However, the relatively short distances, generate a physiological stress which accumulates large amounts of lactic acid. In tests of 400 m freestyle, swimmers reach their peak of lactate in the 100 meters ($14.9 \text{ mmol}\cdot\text{l}^{-1}$) (Laffite, Vilas-Boas, Demarle, Silva, Fernandes & Billat, 2004).

During water rescue, water ventilations are recommended for the treatment of a drowning person, since the immediate ventilation is important for survival (Szpilman & Soares, 2004; Soar et al., 2010; Szpilman, Bierens, Handley & Orlowski, 2012). In our study, we indicated to the rescuers that they should not perform ventilations in the water. The reason was the following: we wanted to avoid breaks that might diminish the physiological demands of the rescue.

In recent years, different automatic compression mechanisms have appeared in the market (Halpering & Carver, 2010), adapted to Guidelines for resuscitation 2010, which can substitute for human compressions and is an attractive alternative. Automatic compression mechanisms let to eliminate the rescuer fatigue factor, and the need to stop CPR during rescuer changes (Ong et al., 2012).

When we are comparing group GL1 with group GL2, there are no significant differences in total number of compressions ($p = 0.87$). All other variables are considerably better, getting a lot more quality compressions ($p < 0.001$) and significantly reducing incorrect compressions ($p < 0.001$). Incorrect compressions can lead to complications in the subsequent recovery of the victim (Van Hoeyweghen et al., 1993). The ventilations are bad in GL1 and GL2. Half of ventilations are incorrect in both groups. There are no significant differences either in TBR or in TCC. Seems that the cumulative fatigue worsens ventilatory control technique and the rescuer is not able to recover immediately in order to start quality ventilation.

Fatigue induced by a rescue influences the quality of CPR. When the lifeguard begins tired, he makes less correct chest compression. The lifeguard can compensate this by using an automatic compression mechanism. Lifeguards should perform quick rescue as every second counts. Anyway, they should not arrive exhausted to the beach, since they may have to perform a CPR. (Reilly, Wooler & Tipton, 2006). The rescue material can help in reducing the fatigue since it makes the rescue faster. Diverse investigations have attempted to relate anthropometric aspects with the CPR quality (Russo et al., 2011; Ochoa et al., 1998). It seems reasonable that the lifeguard should have a good physical condition to deal with the rescue and to perform a quality CPR. It has been suggested that a trailer can be made at 70% of maximal oxygen consumption, equivalent to running about 3 m/s (Reilly et al., 2006). Despite this, the reality of the lifesaving is such that it is very difficult to determine the intensity of each rescue as the distance and conditions vary.

In addition to CPR performed by lifeguards or bystanders, we must also take into account when to activate the EMS. There is a strong relationship between the delay of the EMS and survival of the victim (Lyon, Cobbe, Bradley, & Grubb, 2004; Herlitz, Svensson, Engdahl, Anquist, Silfverstolpe & Holmberg, 2006). Therefore, it is essential to call for EMS immediately (Szpilman et al., 2012), because the re-

sponse time may vary depending of the location and the exact location description of emergency (Claesson, Svensson, Silfverstolpe, & Herlitz, 2008).

Limitations of the study

The real scenario simulation is never exactly like reality. There are many variables that can't be exemplified. The use of a dummy as a victim does not cause the same effect as a human victim.

CONCLUSIONS

In our study, during the water rescue, when lifeguards are not using any auxiliary propulsion material, male are faster than female. Women can achieve more times like those of men if they use flippers and a rescue tube. Usage of flippers significantly reduces the time when the victim is in water.

The quality of CPR performed by the rescuers is not great, but when they perform a rescue without auxiliary materials, it is significantly worse. Fatigue over a 75 meter water rescue increases the amount of compression when done manually; it also increases the number of incorrect compressions. This situation can be corrected if they have an automatic compression mechanism in the coast. Use of this mechanism improves the quality of the compression provided by a lifeguard, whether the rescuer is fatigued or not. The ventilations don't have too much quality, but they are always worse when there is accumulated fatigue. Therefore, the best values are achieved when the lifeguard is rested.

As general recommendations that approach the ideal rescue, we propose: (1) If there is lifeguard who doesn't have auxiliary material, it better be man. Men are faster. (2) If there is a lifeguard with flippers and with a rescue tube, the man is still faster, but the woman reduces the difference gap by 50%. (3) If there are two rescuers with or without auxiliary material and one of them is a man, a man should swim and the other one should begin CPR. (4) If there are two rescuers without flippers and with an automatic compression mechanism, preferably a man swims and chest compression will be performed by automatic compression mechanism. Ventilations should be started by the rescuer who has not swum. (5) Two rescuers with flippers and an automatic compression mechanism would be the ideal rescue. Either of them could swim (but preferably it should be the man), the chest compression will be performed by the device. Ventilations should be started by the rescuer who has not swum.

There may be exceptional situations in which these recommendations have no validity, but if we observe a simple statistical normality, we can deduce that our proposal is more likely to approach to the ideal rescue. However, it is important that the

coordinators and heads of rescuers know the level of each and every one of them in order to be able to determine the best protocol in their workplaces.

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