ORIGINAL ARTICLE

Quick Rescue self-inflating flotation device for rescuing sea swimmers in distress versus conventional tube or buoy rescues

Silvia Aranda-García[1,2], Ernesto Herrera-Pedroviejo[3-5]

Objectives. To compare the efficacy of the new self-inflatable Quick Rescue (QR) flotation device to conventional tube and buoy devices. To compare lifeguard fatigue after rescues with different flotation devices.

Methods. Forty lifeguards participated in this quasi-experimental field study. Each performed simulated rescues of sea swimmers in distress under 4 conditions (no device, the QR device, a tube, and a buoy) assigned in random order. The swimmer in distress was located at a distance of 100 m. Ambient conditions, victim type, and beach were standardized. Participants underwent training to use the inflatable QR float and all other devices. Expertise was defined as a score of at least 3 on a Likert scale of 1 to 5. We recorded rescue times (total, and approaching, securing and towing back the distressed swimmer) as well as the lifeguards' perceptions of effort (overall and for each stage).

Results. Most rescue times did not differ between conditions, with the exception of time needed to secure the victim, which was shorter by 3 seconds when no device was used ($P<.05$). The rescuers did not perceive differences between devices in overall effort or effort during any of the phases.

Conclusions. The new self-inflating QR device is as useful as other flotation devices in terms of rescue times and effort expended by lifeguards. We can therefore recommend its use for rescuing sea swimmers in distress.

Keywords: Drowning. Emergency responders. Rescue. Lifeguards. Open source.

Eficacia del Quick Rescue (dispositivo flotante autoinflable para el rescate de ahogados en el mar) en comparación con el tubo y la boya de rescate

Objetivos. El Quick Rescue es un nuevo dispositivo flotante de rescate (DFR) autoinflable. Se compara su eficacia frente al tubo y la boya de rescate ante una víctima con distrés en el mar, y la fatiga del socorrista tras los rescates con los distintos DFR.

Método. Estudio cuasiexperimental con aleatorización de condiciones (sin DFR, con tubo de rescate, con boya de rescate y con Quick Rescue). Cada participante realizó cuatro rescates de víctima con distrés a 100 m en el mar, con estandarización de las condiciones ambientales, tipo de víctima y playa. Se registró el tiempo de rescate (total, aproximación, control de víctima y remolque) y la percepción del esfuerzo (total y segmentaria) de los socorristas.

Resultados. En general, no hubo diferencias entre las cuatro condiciones en los tiempos de rescate. A excepción del tiempo de control de la víctima, que sin material fue en torno a 3 segundos inferior que en las tres condiciones con DFR ($p < 0,05$). No hubo diferencias en la percepción del esfuerzo total ni segmentaria entre condiciones.

Conclusiones. El DFR autoinflable Quick Rescue presenta una validez similar a los DFR habituales en relación a los tiempos de rescate y la fatiga. Por lo tanto, recomendamos su uso para víctimas distrés en el mar.

Palabras clave: Ahogamiento. Personal de emergencias. Rescate. Guardavidas. Socorrista. Código abierto.

Author affiliation:
[1]Research Group on Physical Activity and Health (GRAFIS), INEFC-Barcelona, Spain.
[2]Institut Nacional d'Educació Física de Catalunya (INEFC), Universitat de Barcelona (UB), Barcelona, Spain.
[3]Research group GRFBE, UIC-Sant Cugat del Vallès, Spain.
[4]Universitat Internacional de Catalunya, Sant Cugat del Vallès, Spain.
[5]Blanquerna Faculty of Health Sciences, Universitat Ramon Llull, Barcelona, Spain.

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Corresponding author:
National Institute of Physical Education of Catalonia (INEFC)
Av. de l'Estadi, 12-22 08038 Barcelona, Spain.

E-mail:
silvia.aranda.garcia@gmail.com

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Introduction

Drowning is a major public health issue[1] that kills 372,000 people worldwide each year[2]. However, not all drownings, understood as respiratory failure due to immersion[3], end in death because a person may be under stress (distress) at sea and survive with or without morbidity[4]. Lifeguards devote most of their work to prevention[4,5] which is crucial to avoid drowning[6]. Although rescues account for only 0.1-2% of lifeguard interventions[4,5], it is imperative to stop the process as soon as possible because of the temporary dependence on drowning[7]. To this end, once the distress in the aquatic environment has been detected, the victim is provided with a flotation device to prevent submersion and to remove him/her from the water[6].

The lifeguard is the emergency professional responsible for the rescue of the victim, and must do so in the shortest possible time and under the safest conditions. The rescue time is influenced by the fitness of the lifeguard, the mastery of the victim's control techniques[8] or the use of equipment such as flippers or floating rescue devices (FRDs)[9,10]. In fact, the combination of fins with FRDs favours a faster and safer/floating rescue than without material[9,10], thus preventing submersion and stopping drowning, thus favouring the prognosis[1,6]. Both the fins and the usual FRDs (tube and rescue buoy) are used on more than 96% of Spanish beaches

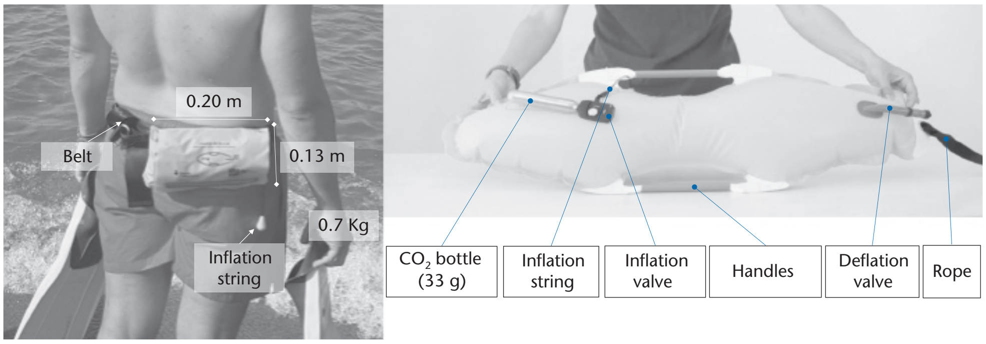

Figure 1. The new Quick Rescue device. On the left folded and on the waist with measurements and weight. On the right inflated with the detail of the elements that conform it.

with the Blue Flag quality label[11]. Although they can be an added burden in their daily preventive tasks (dynamic surveillance, recommendations to swimmers,...), the lifeguard will carry them in case he/she has to perform a rescue.

The creation of a new FRD that allows for the rescue of victims in similar or better conditions than the usual FRD and that can also be more comfortable for the rest of the tasks could be interesting for the professional performance and security of all citizens. A new FRD called Quick Rescue[12] has been developed by Dipsalut on a non-profit basis[13]. This device is transported folded, is small in size and weight, and is worn at the waist like a fanny pack (Figure 1). When the lifeguard needs a flotation device in a rescue, he can auto-inflate it with a small CO_2 bottle.

In the last link of the drowning survival chain, we find mitigation, in which the lifeguard and other emergency personnel must assist the victim by providing the necessary care[6]. In the most serious drownings, the lifeguard will perform cardiopulmonary resuscitation (CPR), which will be of poorer quality if the person is fatigued[14-16]. Although a water rescue in itself involves a high energy expenditure and physiological stress[15,17], it is necessary to assess whether a rescue with Quick Rescue involves greater fatigue than a rescue performed with other FRDs.

Therefore, the objectives of this study were: to compare the effectiveness of Quick Rescue with the commonly used FRDs (tube and rescue buoy) when faced with a distressed victim at sea, and to compare the effort referred by the lifeguard with Quick Rescue and the usual FRDs.

Method

Quasi-experimental field design with randomization of conditions. All participants signed the informed consent form before the start of the study, which was approved by the Clinical Research Ethics Committee of the Catalan Sports Administration (number 14_2018_CEICGC). The participants had to be aquatic lifeguards, not have any physical impediment to develop the study tests with normality and attend the two days of registration. The flow of participants from the recruitment of lifeguards from the Catalan coast to the 40 participants finally analysed can be seen in Figure 2.

Each participant performed four simulated rescues distributed in two sessions (Figure 3). The four rescue conditions were randomized according to the type of

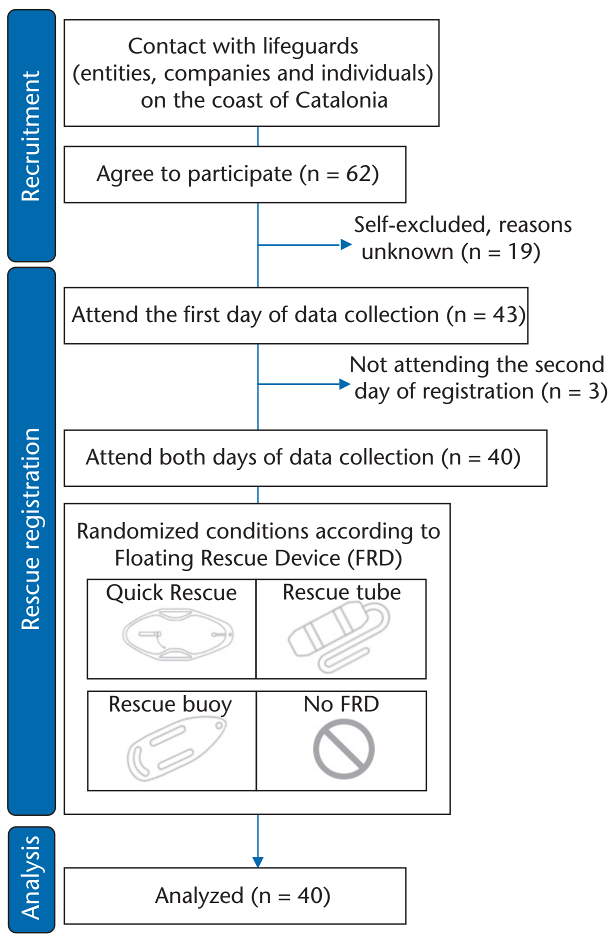

Figure 2. Flowchart of participants: recruitment, attendance at tests and participants analysed.

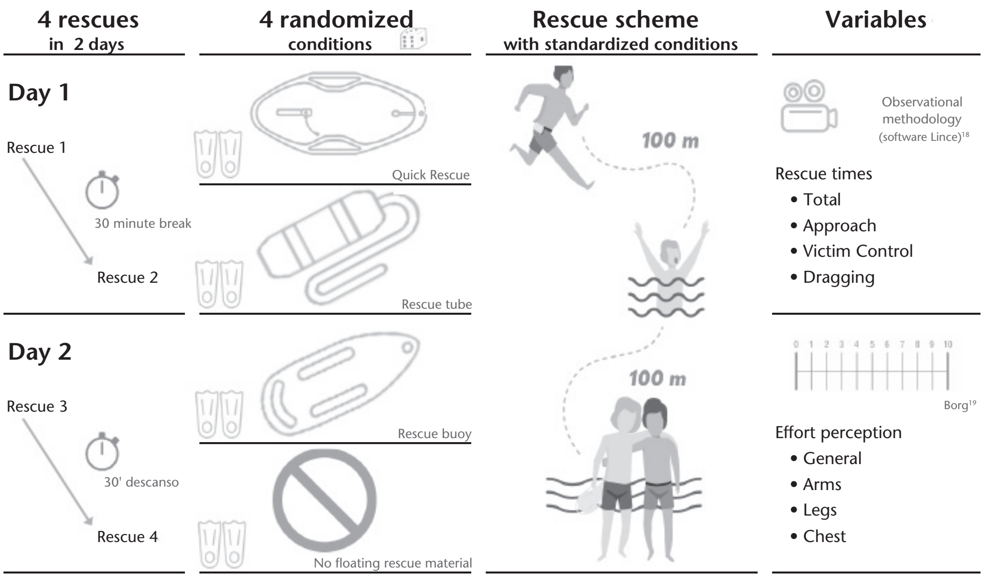

Figure 3. Diagram of the rescue procedure.

FRD: no FRD, with a rescue buoy, with a rescue tube, and with Quick Rescue. The different order combinations of the four rescue conditions were previously established. Each combination was assigned a number, and each participant was randomly assigned a combination (opaque bag with numbers). At the beginning of the first session, the participants' descriptive variables were recorded. Before starting the rescues, participants were trained in the use of Quick Rescue. It consisted of 20 minutes of training for learning: adjustment of the device at the waist, activation of the self-inflating system, entry into the sea with the device attached to the waist, discerning when to activate the self-inflating system, control of the drowned victim, buoyancy of the victim and pulling to the sand. To ensure adequate mastery of the three FRDs, it was established that they should report a perception of mastery of the material of 3 or more on a 5-point Likert scale (5: perfect mastery) for the rescue of an aquatic victim in distress.

The new self-inflating FRD Quick Rescue is inspired by the traditional torpedo-shaped rescue buoy with two handles (Figure 1). However, unlike this one, it is lighter and folded into a small bag with a velcro system that allows it to be carried at the waist like a fanny pack. When the lifeguard needs buoyancy for a rescue he will activate the inflation valve that will pierce the 33 g CO_2 cylinder, it will inflate completely in 2.3 seconds and will be attached to the lifeguard's waist by a 1.85 m line. The technical report details that the Quick Rescue provides a sea buoyancy of 266.7 kg (2613.8 Nw). The visual guide for use is available on the DipSalut Quick Rescue App[12].

Between each rescue there was a minimum of 30 minutes rest to minimize the effects of fatigue. Each simulated rescue was performed from the detection of the victim to the extraction to the sand. The lifeguard had to enter the water (always with his own fins between 12 and 38 cm, without neoprene and with FRD depending on the randomized condition), swim to the victim, perform the control of the victim providing him with flotation and drag him to the sand.

Rescues took place in the usual working environment of the lifeguards, and attempts were standardized by controlling the beach (each participant performed all four rescues on the same beach) and environmental conditions (calm sea with waves < 0.5 m: < 0-2 Douglas scale, no wind or very light: < 5 m/s and no currents). Each participant performed the four rescues with the same person, playing the role of a victim at a distance of 100 m in the sea (victims: 70-90 kg of weight, 1.65-1.85 m of height). In a previous meeting, the type of simulation to be performed by the victims was established (distressed, conscious, on the surface and uncooperative in the propulsion) and the clothing (swimsuit without neoprene). During the tests there were always research staff and lifeguards to ensure the standardization of conditions and safety of participants.

For each rescue, the total rescue time and the partial approach times (from the start of the rescue until the lifeguard stops swimming because he is close to the victim), victim control (the time needed to contact the victim, give him/her buoyancy and prepare to start pulling) and dragging (from the time the lifeguard has the victim under control until they reach the sand) were calculated. Rescue times were extrapolated from the video recording using an observational methodology with the Lince software[18]. After each rescue, each participant was asked about their perception of the effort with the modified Borg 10-point scale for general and segmental fatigue of legs, arms and chest[19].

After checking the normality of the distribution of the variables with the Kolmogorov-Smirnov test, the variance was analysed. The differences between each rescue condition was investigated by means of post-hoc tests, adjusting the multiple comparisons with the Bonferroni test. Linear regressions were used for the analysis of possible confounding variables (sex, age, body mass index -BMI- and the beach where the rescue took place). The description of the variables was done with central tendency (mean) and dispersion (SD) measures. The statistical analysis was performed with SPSS for Windows (version 20). Statistical significance was established when p < 0.05.

Results

The 40 participants were between 18 and 45 years old, measured between 1.56 and 1.93 m, weighed between 53 and 105 kg, and had a BMI of between 19.6 and 30.4 kg-m-2 (Table 1). Thirty percent were women.

When analyzing rescue times by condition, in general there were no statistically significant differences between the four rescue conditions (Table 2), except for the fact that rescue without material takes about three seconds less to control the victim than with the three conditions with FRD (tube: p = 0.006, buoy: p = 0.044, Quick Rescue: p = 0.011).

Analysis of fatigue perception showed no statistically significant differences between the four conditions, either general or segmental -arms, legs and chest- (Table 2).

As complementary results, Table 3 presents the relationship of possible confounding variables of the participants (age, sex, BMI) with rescue times and perceived effort. Thus, the older the participant, the longer the rescue time (total and approximation) and the more effort perceived, regardless of the rescue condition. Women needed about 4 seconds more to approach the victim (p = 0.06), about 1.5 seconds less to control the victim (p = 0.02) and reported less perceived effort than men in the arms (-1.12; p < 0.01) and chest (-0.76; p < 0.01). The higher the BMI, the less effort was perceived (except for arm effort), but without differences in rescue times and always regardless of the rescue condition.

Table 1. Age and anthropometric data of participants

	All N = 40 Mean (SD)	Women N = 12 Mean (SD)	Men N = 28 Mean (SD)	Sig.
Age (years)	30.3 (8.7)	27.8 (8.2)	31.4 (8.7)	0.019
Hight (m)	1.73 (0.08)	1.64 (0.05)	1.77 (0.07)	< 0.001
Weight (Kg)	70.9 (11)	60.5 (4.9)	75.4 (9.9)	< 0.001
BMI ($Kg{\cdot}m^{-2}$)	23.5 (2.3)	22.2 (1.5)	24.1 (2.4)	< 0.001

BMI: body mass index; Sig.: p value in the t-test gender difference

Discussion

Participants took the same time to approach the victim at 100 m with Quick Rescue as with the other FRDs (tube and rescue buoy) or without FRD. When the lifeguard swims in the sea without waves, the absence of differences in this phase wearing a rescue tube or not has been previously studied swimming with[9] or without fins[20]. Our findings extend the knowledge showing that there is also no difference with Quick Rescue or with a rescue buoy. It was necessary to study whether Quick Rescue would allow swimming at a similar speed to swimming without material, because instead of going afloat behind the lifeguard as the usual FRDs, it is folded and attached to the waist, which could generate resistance to the advance. However, our results show that the Quick Rescue design does not generate additional resistance when swimming in a modified crawl style for rescue.

However, in pool rescues it may be slower to approach the victim with a buoy than without FRD[17,21], because of the 3.5-5.1 seconds it takes the lifeguard to put on the harness[21], or because of the resistance to swimming with the FRD afloat in a wave pool[17]. Previous authors recommended developing self-inflating Quick Rescue style FRDs that fold up during approach to minimize wave resistance and maintain buoyancy/safety advantages during towing[17].

At this point in the rescue process, the lifeguard advances in the water, providing the victim with buoyancy to reach the sand safely. During this stage we also find no difference in rescue times between conditions, which could be explained by the similar buoyancy performance of the FRDs or by the type of propulsion

Table 2. Comparison of rescue times (seconds) and effort perception (0-10) for each rescue condition

	Without FRD Media (DE)	Quick Rescue (Q) Media (DE)	Rescue buoy (B) Media (DE)	Rescue tube (T) Media (DE)	Value of F	Value of P
Rescue times						
Total rescue	265.7 (38.9)	284.0 (53.2)	278.0 (47.4)	276.9 (39.4)	1.143	0.334
Approach	84.6 (12.03)	90.3 (28.9)	87.5 (13.3)	86.5 (11.4)	0.709	0.548
Victim control	5.4 (4.8)	8.7 (4.1)	8.2 (4.8)	9.0 (5)	4.893	0.003*
Removal	175.7 (30.7)	185.0 (33.5)	182.3 (36.4)	181.5 (31.9)	0.551	0.648
Effort perception						
General	7.4 (1.4)	6.9 (1.4)	7.0 (1.3)	6.8 (1.6)	1.440	0.233
Legs	7.4 (1.8)	6.8 (1.8)	7.0 (1.8)	6.9 (1.7)	0.866	0.460
Arms	5.1 (2.2)	4.7 (2.1)	4.8 (2.0)	4.7 (2.1)	0.285	0.836
Chest	6.3 (2.0)	5.9 (2.3)	6.1 (2.0)	6.0 (1.9)	0.269	0.829

*Bonferroni's post hoc test showed that FRD was significantly lower than Q (p = 0.011), B (p = 0.044) and T (p = 0.006).
DFR: floating rescue device.

Table 3. Relationship of age, sex and body mass index (BMI) with rescue times and effort perception

	B	Common error	t	Sig
Age				
Total rescue time	0.88	0.45	1.94	0.05
Approach time	0.48	0.19	2.53	0.01
Victim control time	0.03	0.05	0.59	0.55
Towing time	0.36	0.35	1.03	0.31
Overall effort	0.11	0.01	8.21	< 0.01
Arm effort	0.06	0.02	2.88	0.01
Legs effort	0.08	0.02	4.77	< 0.01
Chest Effort	0.11	0.02	5.30	< 0.01
Sex				
Total rescue time	7.22	5.25	1.38	0.17
Approximation time	4.12	2.22	1.86	0.06
Time control victim	–1.45	0.62	–2.32	0.02
Towing time	4.55	4.09	1.11	0.27
Overall effort	–0.25	0.16	–1.57	0.12
Arm effort	–1.12	0.25	–4.44	< 0.01
Legs effort	–0.17	0.21	–0.83	0.41
Chest Effort	–0.76	0.23	–3.25	< 0.01
BMI				
Total rescue time	–1.75	1.75	–1.00	0.32
Approximation time	–0.58	0.74	–0.78	0.44
Time control victim	–0.30	0.21	–1.44	0.15
Towing time	–0.88	1.37	–0.64	0.52
Overall effort	–0.24	0.05	–4.59	< 0.01
Arm effort	–0.01	0.08	–0.11	0.91
Legs effort	–0.20	0.07	–2.86	< 0.01
Chest Effort	–0.24	0.08	–3.13	< 0.01

used. On the one hand, according to its technical report, the buoyancy of the Quick Rescue is 2613.8 Nw (266.7 Kg) at sea and is adequate to rescue a drowned person safely. On the other hand, the lifeguard will propel himself with his fins during the towing in all rescue conditions. Our participants took about 180 seconds to tow the victim the 100 m to the sand, a very similar figure to the only previous comparable study we have found in which they took an average of 183 seconds with fins and 162 seconds with fins and snorkel[9]. However, in wave rescues, towing with a buoy is faster than without FRD due to the momentum of the waves from the increased buoyancy (-11 seconds in 55 m)[17]. Thus, in the two phases involving the movement of the lifeguard while swimming, a rescue with Quick Rescue is performed in the same time as with the traditionally used FRDs.

In the victim control phase, the responder must hold the FRD and take control of the victim by providing buoyancy to initiate dragging. The technique for distressed victim control using any of the three FRDs is very similar, while the technique for holding a regular FRD compared to Quick Rescue is slightly different. In a regular FRD, the lifeguard grabs the rope that connects him to the material floating behind him, while with the Quick Rescue, he pulls the inflation rope at the waist, opening the CO_2 bottle, and within 2.3 seconds the FRD is inflated beside him. In spite of the different particularities, and the absence of differences between Quick Rescue and tube/float in the control time, it follows that the initial training of 20 minutes was adequate to master the Quick Rescue. It should be noted that with all three FRDs, participants took about 3 seconds longer to check the victim than without FRD. Despite this difference, it is recommended to always use an FRD as it provides buoyancy, which is key to a safe rescue and to stopping the drowning process[4].

In our study we found no difference in the total rescue time with Quick Rescue compared to the tube, the buoy or not using FRD. Likewise, other authors also found no difference when incorporating tube9 or buoy compared to no FRD[20]. Although in the total rescue time and in the times of the different phases of the rescue there were no differences between conditions with FRD, according to our results, Quick Rescue is as recommended as the tube or the rescue buoy to rescue a victim with distress at sea.

Rescue time is extremely important in stopping the drowning process and correlates with the prognosis of the victims[1,22]. The fatigue of the rescuer after a rescue is also relevant due to its relationship with the quality of the actions to be performed after the extraction of the victim, especially in CPR[14-16]. On the one hand, our participants indicated a perception of effort of around 7 (out of 10) in all rescue conditions. This is a result similar to previous studies conducted after rescue at sea[9,20], which broadens our knowledge of the great physiological stress and physical strain involved in performing an aquatic rescue[15,17]. On the other hand, and of greater interest, our participants did not become more tired with Quick Rescue than with the rest of the conditions, which makes it just as recommendable as the usual FRDs.

We have seen how this new self-inflating rescue buoy meets the highest standards expected of this type of material: providing buoyancy to improve rescue safety and stop the drowning process as much or better than the usual FRDs. Although our study focuses on the effectiveness of Quick Rescue during an aquatic emergency situation in a real sea environment, it aims to generate scientific knowledge and open a path for the development of rescue material that will improve the professional performance of the lifeguard in terms of drowning prevention. The development of Quick Rescue has been promoted by DipSalut, a public health organization, through a non-profit project and open source. This will ensure that if Quick Rescue is useful for prevention and aquatic emergencies, it can be accessible and easily distributed for professional use.

In the future, it would be interesting to assess the usefulness of Quick Rescue or other self-inflating FRDs for rescuing other types of victims, or in other types of environmental conditions (intercontinental waters; oceans with waves, wind or currents). The theoretical advantage of being folded while not requiring buoyancy should also be studied to see if it might favour the professional performance of the rescuer (portability, combination with other rescue elements, safety in the event of accidental impact, use in rescue transport, etc.).

This study has its limitations. The sample size was conditioned by the complexity of the data collection, the availability of the participants and the environmental conditions. The lifeguards had to be willing to participate in four physically demanding rescues in 2 days. When we carried out the study in the real working environment, we had to postpone several sessions because we did not comply with the stipulated maritime or environmental conditions. In addition, our findings must be interpreted based on the type of environment/conditions in which the study was conducted and cannot be extrapolated to others.

In conclusion, the new self-inflating Quick Rescue method is as valid as other common FRDs (tube and rescue buoy) for distressed victims at sea due to its design (buoyancy, dimensions, weight). Its use would be recommended both because of the good results in rescue times (total, approach, control of the victim and removal), and in the perception of the effort (general and segmental) after the rescue.

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