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ORIGINAL

ANÁLISIS DE LAS FASES DEL RESCATE ACUÁTICO COMO ELEMENTO DISCRIMINATIVO DEL RENDIMIENTO

ANALYSIS OF THE PHASES OF LIFESAVING AS A DISCRIMINATIVE ELEMENT OF PERFORMANCE

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ABSTRACT

Purpose: The aim of this study was to analyze the different phases of a water rescue, their influence in the whole lifesaving and if lifeguards could be differentiated according to their abilities during a water rescue. **Methods**: A cross-sectional study was carried out to analyze the different phases and lifeguard's abilities of a simulated water rescue of 100 m. Thirty-four professional lifeguards performed the test and the time was recorded for the first phase (swimming to the victim), the second phase (towing back the victim) and the third phase (extracting the victim). A discriminant analysis was conducted in order to classify lifeguards in two groups (high or medium level of abilities during the water rescue) and the times were compared on each phase. **Results**: The time during the second and the third phase classify correctly the lifeguards according to their level of abilities. Lifeguards with higher level of abilities performed the water rescue significantly faster, specifically during the second (p < 0.001, ES =1.38, large) and the third phase (p =0.002, ES = 1.09, medium), but no differences were found in the first part of the water rescue (p > 0.05). **Conclusion**: The time of a simulated water rescue seems to be a good method to classify lifeguards according to their abilities. These findings could allow rescue teams to know the skills of their lifeguards and design strategies in order to decrease risks and enhance lifesaving.

Keywords: lifeguard; drowning; emergency medicine.

RESUMEN

Objetivo: Analizar las diferentes fases del rescate para conocer su influencia sobre el resultado final y categorizar a los socorristas de acuerdo a su competencia acuática. **Métodos**: Se realizó un estudio cruzado simulando un rescate a 100 metros con 34 socorristas, analizando las tres fases del rescate: nado hacia la víctima, traslado a tierra y extracción. Se realizó un análisis discriminante para clasificar a los socorristas según el tiempo de rescate. **Resultados**: La segunda y la tercera fase clasificó correctamente a los socorristas de acuerdo al tiempo empleado. La mayor competencia fue determinada especialmente en la segunda fase del salvamento (p<0,001, TE=1,38, grande) y en menor medida de la tercera fase (p=0,002, TE=1,09, mediano). **Conclusión**: El tiempo empleado en la segunda fase parece ser un buen método para clasificar la competencia de los socorristas durante el rescate. Estos hallazgos proporcionan información relevante para el entrenamiento y organización de equipos de rescate.

PALABRAS CLAVE: socorristas; ahogamiento; rescate acuático; rendimiento.

1. INTRODUCTION

Prevention is the most important task to avoid drowning. One of the most common consequences of the lack of prevention in water environments is drowning (Denny et al., 2019; Szpilman et al., 2014) defined as submersion or immersion in a liquid, causing breathing difficulties(van Beeck, Branche, Szpilman, Modell, & Bierens, 2005). The severity of drowning depends on systemic hypoxia, alveolar damage caused by the water and, of course, the delay in the interruption of the process(Szpilman, Bierens, Handley, & Orlowski, 2012). Lifeguards are responsible for water security and lifesaving, so when prevention fails they must act as safe and soon as possible (Kalén et al., 2017). Previous research have reported that most rescues occurred between 50 and 100 meters of the shore(Gulbin, Fell, & Gaffney, 1996; Morgan & Ozanne-Smith, 2013), so lifeguards have to respond fast and have high levels of physical fitness and abilities in water environments(Prieto Saborit et al., 2010; Standards, 2011). The physical fitness of the rescuers has been described as one of the main factors influencing the water rescue(López-García, Ruibal-Lista, Palacios-Aguilar, Santiago-Alonso, & Prieto, 2021). Lifeguards are professionals in emergency but moreover they are required to have a high level of physical fitness, since water rescues have high physiological demands (Abelairas-Gómez et al., 2017; Barcala-Furelos et al., 2020; Barcala-Furelos et al., 2016; Kalén et al., 2017), with exhausting efforts and high levels of blood lactate(Abelairas-Gómez et al., 2017;

Barcala-Furelos, Abelairas-Gomez, Romo-Perez, & Palacios-Aguilar, 2013; López-García et al., 2021; Prieto Saborit et al., 2010). Thus, in recent years the research in this field has been directed to improve the knowledge about professional lifeguards' performance, with strategies and procedures only used in professional sports practice up to date (Barcala-Furelos et al., 2020). Moreover, the use of new materials such as rescue tubes and fins have increased the velocity and efficiency of the response during a water rescue, decreasing the differences between good and bad swimmers(Abelairas-Gómez et al., 2017). Lifeguards usually work in teams, but the role of each rescuer in the team is not defined and their abilities and profile are not taken into consideration in a water rescue. In addition, although it has been recommended to test lifeguards prior to work in order to know their skills(Standards, 2011), there is no strategy based on lifeguards' abilities to respond more effectively to an emergency. In a rescue, the lifeguard must swim, control the victim, tow them to the shore and extract them out of the water to a safe place. In that moment, the intervention is not finished since the lifeguard must assess the victim and in some situations perform first aids and even starting cardiopulmonary resuscitation(Abelairas-Gómez et al., 2017; Barcala-Furelos et al., 2016). However, there is a lack of knowledge about the importance of each phase in the total time of the rescue. Therefore, the aim of this study was (1) to analyze the different phases of a water rescue and whether one of them has more influence than others and (2) if lifeguards could be differentiated according to their abilities during a water rescue.

2. METHODS

A cross-sectional study was carried out to analyze the different phases and lifeguards' abilities of a simulated water rescue.

2.1 Sample

A convenience sample of 34 professional lifeguards (76.5% men and 23.5% women) participated in this study. The mean of demographic characteristics was: age 22±2 years, weight 74±1 kg, height 175±7 cm, and Body Mass Index (BMI) 24.1±3.

Lifeguards performed a 100 m round trip water rescue. All subjects were informed about the procedures before the water rescue, and they provided both verbal and written informed consent to use their data for investigation. This research was conducted according to the Declaration of Helsinki and approved by the Ethics Board of the Faculty of Education and Sports Science, University of Vigo (code: 15-0721).

2.2 Water rescue

The water rescue was performed by lifeguards with wetsuit (3/2 mm), fins (Mares Avanti Super-Chanel model) and rescue tube (Marpa model, dimensions 100 x 16 x 9 cm and weight 760 g). Locate test was in Cabeceira beach (Pontevedra, Spain) during December, 2020 (latitude: 42º 25' 27.0'' N – longitude: 8º 40' 59.1'' W) and under similar conditions with calm sea and waves < 0.5 m (Douglas scale value 0-2), wind speed < 5 m/s, water temperature between 13º C and 14º C and ambiental temperature between 15º C and 16º C. The weather was reported by the local forecast agency (MeteoGalicia www.meteogalicia.gal/). The water rescue was based on previous studies(Barcala-Furelos et al., 2020; Claesson, Karlsson, Thorén, & Herlitz, 2011) and consisted of starting on the shore, swimming 100 m to the unconscious victim, controlling the victim with the rescue tube, towing the victim to the shore and carrying the victim 15 m to the dry sand. The victim was represented by other lifeguard with similar weight (±5 kg, interval [65-85 kg]) who simulated being unconscious and did not help the rescuer.

2.3 Variables

The time of the rescue was analyzed in three different phases: (1) time swimming and controlling the victim (T1), time towing back the victim (T2) and time extracting the victim to the dry sand (T3). The mean velocity was estimated for each phase with the formula $v = s \cdot t^{-1}$. Specifically, subjects were located on the shore and upon an audible signal they began the simulation of the rescue, at which time the time for the first phase began to count down. Once they reached and controlled the victim, the time of the second phase began to count, establishing that control of the victim ended when the rescue tube was correctly positioned. As soon as the rescuers had set foot on the shore and changed the transfer technique to dragging the victim to land, the time for the third phase was counted, which ended when the victim was placed on dry sand.

In order to classify subjects according to the total rescue time, a k-means Cluster analysis was used, and two groups were created: lifeguards with high level of water abilities (N1) (n = 17) and lifeguards with medium level of water abilities (N2) (n = 17). The description of the procedure and selection of groups are depicted in Figure 1.

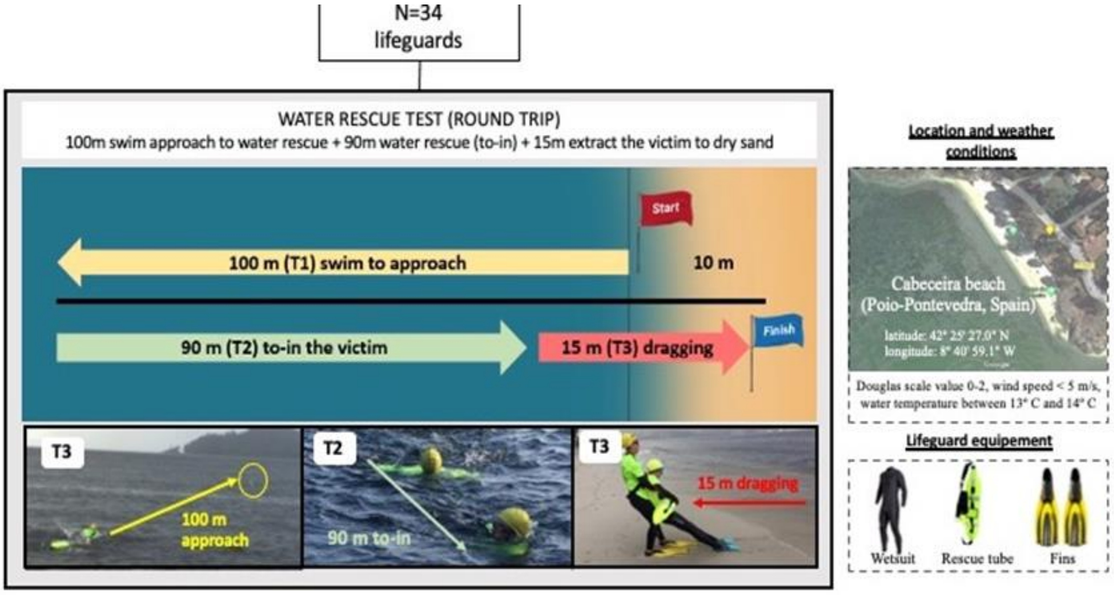

Figure 1. Flow chart outlining the intervention and procedures.

2.4 Statistical analysis

All statistical analysis was conducted with SPSS for Macintosh (version 25.0., Armonk, NY: IBM Corp). The normality of distribution was analyzed both graphically and with the Shapiro-Wilk test. Data were presented by mean ± standard deviation. The relationship between T1, T2 T3 and total time was analyzed using Pearson bivariate correlation coefficient. The magnitude of effect for the correlation coefficients was interpreted in accordance to (Hopkins, Marshall, Batterham, & Hanin, 2009) as trivial (<0.10), small (0.10 to 0.29), moderate (0.30 to 0.49), large (0.50 to 0.69), very large (0.70 to 0.89) and extremely large (≥ 0.90).

Differences in performance during the three phases of the water rescue (T1, T2, T3) according to the group (N1, N2) were assessed by a repeated-measure analysis of variance (ANOVA). *Partial eta squared* (η_p^2) was selected to calculate the effect size of each factor (phase and group), as well as their interaction.

An effect of $\eta_p^2 \geq 0.01$ indicates a small effect, ≥ 0.059 a medium, and ≥ 0.138 a large effect (J., 1988). Pair-wise comparisons were conducted via Bonferroni post-hoc test, using Cohens' *d* to calculate effect sizes. These effects were classified according to (Hopkins et al., 2009) as trivial ($d < 0.2$) small (0.2 - 0.6), moderate (0.6 – 1.2), large (1.2 – 2.0), very large (2.0 – 4.0), and extremely large (≥ 4.0).

In addition, a discriminant analysis was conducted to explore each independent variable (T1, T2 and T3) and how they discriminate according to the group (N1 or N2). By means of structural coefficients (SC), variables which better discriminate subjects with high or medium level of water abilities were identified. Specifically, it was considered as relevant for the interpretation of the linear vectors SC ≥ 0.30. For all analysis, the significance value was set at $p \leq 0.05$.

3. RESULTS

For a 100 m-water rescue, the mean time was 217.68 ± 26.06 s. Specifically, T1 was 69.41 ± 7.15 s, representing the 32% of the rescue, T2 was 103.47 ± 22.00 s and represented the 43 % of the total time and T3 was 44.79 ± 13.67 s; being the 21% of the total time of the rescue. Considering the relationship between time and distance, T3 was the slowest phase. T1 was performed with an estimated velocity of 1.44 m/s, T2 with an estimated velocity of 0.87 m/s and T3 with an estimated velocity of 0.33 m/s. In summary, T1 accounts for 1/3 the total time and T2 2/3 of the total time.

Results from the repeated-measure ANOVA showed significant differences in lifeguards' performance between groups N1 and N2 ($F = 66.361$; $p < 0.001$; $n_p^2 = 0.675$, large), among the different phases of the water rescue ($F = 135.164$; $p < 0.001$; $n_p^2 = 0.809$, large) and in the interaction between group and moment ($F = 5.448$; $p = 0.007$; $n_p^2 = 0.145$, large).

As described in Table 1, lifeguards from N1 group were 26 s faster in T2 ($d = 1.38$) and 13 s faster in T3 ($d = 1.09$) in comparison with N2. On contrary, there were no significant differences between N1 and N2 in T1 ($p > 0.05$). Regarding the velocity, lifeguards in N1 were faster than N2 in T1 (1.47 m/s vs 1.42 m/s), T2 (0.87 m/s vs 0.77 m/s) and T3 (0.39 m/s vs 0.29 m/s). In addition, T2 and T3 represented for N1 an advantage of 0.10 m/s (Figure 2).

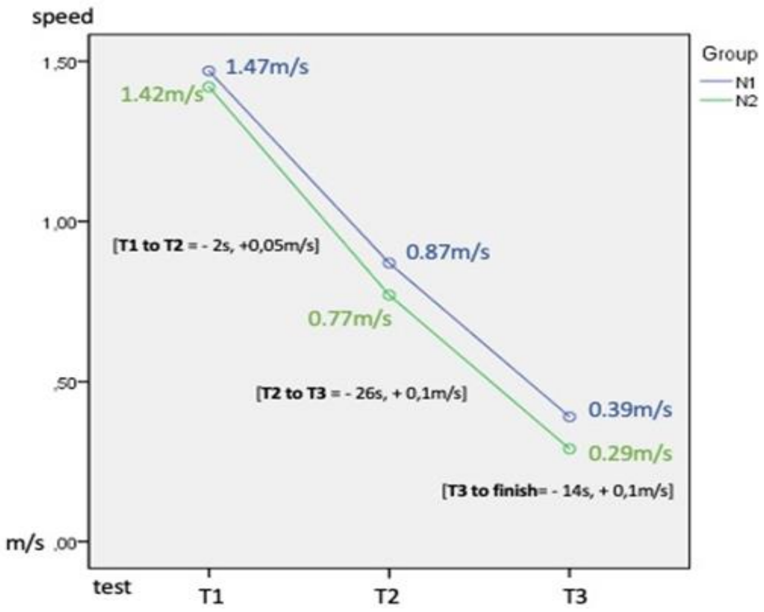

Figure 2. Analysis of the differences in velocity and their impact on time saving.

Table 1. Differences in performance between groups (N1 and N2) among the different phases of the water rescue (T1, T2, T3).

	N1 (N=17)	N2 (N=17)	P-VALUE	ES
T1 (*s*)	68.18 ± 7.69	70.64 ± 6.56	0.321	0.34$_{\text{small}}$
T2 (*s*)	90.41 ± 20.74	116.52 ± 14.33	0.001	1.38$_{\text{large}}$
T3 (*s*)	38.00 ± 13.07	51.58 ± 10.80	0.002	1.09$_{\text{medium}}$

ES*: effect size*

The time distribution on the three different phases between N1 and N2 is depicted in Figure 3. In both groups, T2 was significantly higher than T1 and T3 ($p < 0.001$) and significant differences were also found between T1 and T3 ($p < 0.001$). In this sense, each phase represented a similar percentage over the total time for both groups.

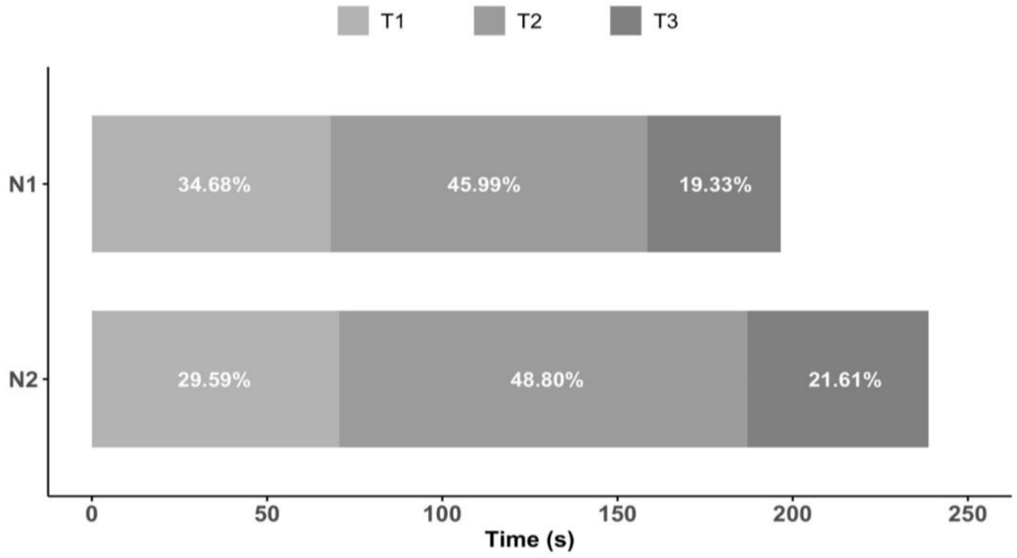

Figure 3. Duration of each phase of the water rescue in both groups.

Table 2. Structural coefficients for the discriminant analysis for T1, T2 and T3 between N1 and N2.

VARIABLES	FUNCTION 1
T1	0.071
T2	1.213*
T3	1.123*
Eigenvalue	2.511
Wilks' Lambda	0.285
Canonic correlation	0.846
Chi-square	38.304
Degrees of freedom	3
***p*-value**	0.001

** SC ≥ 0.30*

Table 2 describes SC of the discriminant analysis. The discriminant function was statistically significant (*p* > 0.001) and classified correctly 94.1% of subjects for N1 or N2. This analysis determined that T2 was the phase with higher discriminatory power (SC = 1.213), followed by T3 (SC = 1.123). However, T1 did not have influence when discriminating lifeguards in groups (SC = 0.071). Regarding the total time, it was significantly lower (*p* < 0.001, d = 2.79, very large) in N1 (196.59 ± 16.09 s) in comparison with N2 (238.76 ± 14.03).

The Pearson correlation coefficients are showed in Figure 4. Significant correlations were obtained between total time and T1 (p = 0.026, *r* = 0.381, moderate), T2 (p < 0.001, *r* = 0.747, very large), and T3 (p = 0.002, *r* = 0.505, large). Moreover, a significant correlation was also found between T1 and T3 (p = 0.042, *r* = 0.35, moderate).

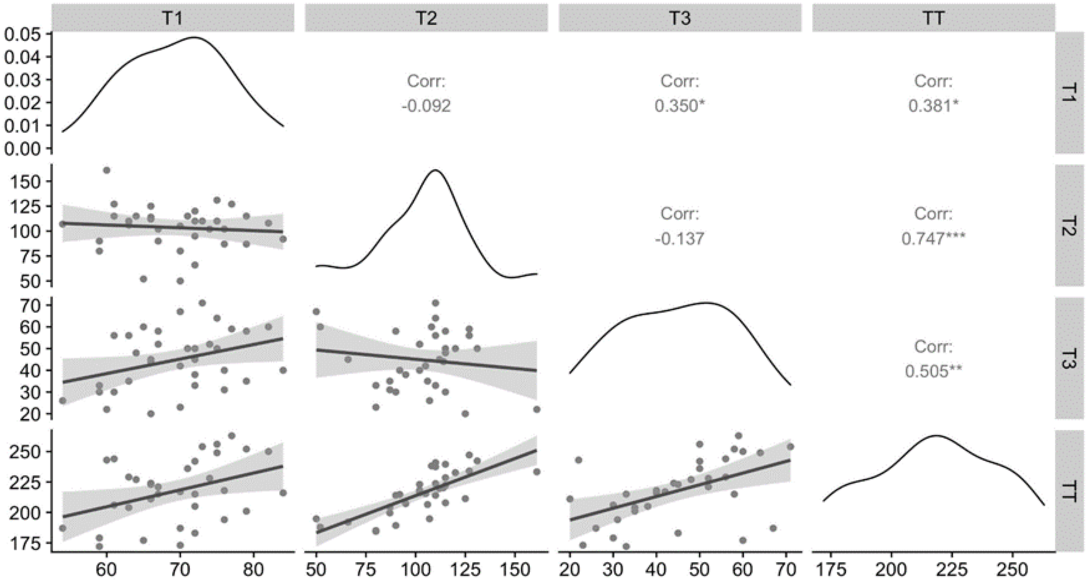

Figure 4. Correlations of T1, T2 T3 and TT.

4. DISCUSSION

The aim of this investigation was to analyze the different phases of a water rescue and use them to assess the abilities of the lifeguards. The main findings suggest that a) there are no significant differences in T1 between lifeguards with high level of abilities and medium level of abilities (N1 vs N2), so in an hypothetical aquatic incident the drowning process could be interrupted at the same time by lifeguards from both groups; b) lifeguards with high level of abilities (N1) perform the water rescue about 40 s faster (save around 1/5 of time) than lifeguards with medium level of abilities (N2) and c) T2 and T3 determine whether lifeguards are classified in N1 or N2.

The drowning process and water rescue have been largely investigated up to date, with greater improvements in the knowledge of rescue and prevention. However, to the best of our knowledge, this is the first study assessing the different phases of a water rescue including the victim extraction to a safe place, and for the first-time lifeguards' profile and abilities are taking into consideration. Simulation test have been largely studied and valued by professional of emergency, and in case of lifeguards these test could act as an indicator of their abilities(Standards, 2011), which is relevant to ensure the adequate physical condition and to avoid risks during the water rescues (Prieto Saborit et al., 2010). In this regard, a strategy for lifeguards during the water rescue had never been considered in prior research, although some recommendations have been pointed out in this sense, specifically for the on-the-job requirements(Standards, 2011). Recent investigation produced by Carballo-Fazanes & Bierens (Carballo-Fazanes, Bierens, & Behaviour, 2020) analyzed a large number of drowning events and reported that drowning lasts from 34 s to 132 s (mean 90 s). One of the main results of this study state that in a 100 m water rescue there are no differences between lifeguards when swimming to the victim, which is consistent with our findings suggesting that all participants arrived to the victim at the same time (over 70 s). However, it has been shown the main factor influencing the drowning outcome is the time of submersion, demonstrating that submersions shorter than 5 minutes are related to favorable outcomes(Quan et al., 2016). For these reasons and according to the present findings, lifeguards and rescue professionals should consider that the rescue time is of great importance, every second counts and in addition to the high physical condition, the abilities during the water rescue are crucial to achieve a successful lifesaving (Gergana, Jaime, & Konstantinos, 2022).

The lifeguards with higher level of abilities are over 40 s faster than lifeguards with medium level of abilities. Specifically, towing phase (T2) represents 42% of the total time of the rescue and influenced the most the discrimination of the rescuers in two groups. Accordingly, results of this study suggest that T2 is a good indicator of the ability of a lifeguard, classifying correctly 91.4 % of lifeguards in the two groups, so it could be interesting to analyze this variable in a team to determinate who have better water competences and develop a strategy for the emergency situations.

Moreover, the second phase has been described as the most exhausting of a water rescue, since the lifeguards tow the victim and usually they only swim with the legs propulsion (Barcala-Furelos et al., 2020). This phase requires a high aerobic capacity(López-García et al., 2021), with anaerobic power, strength and endurance (Standards, 2011)[which cause levels of blood lactate about 10 mmol·l^{-1} in professional lifeguards (Abelairas-Gómez et al., 2017; Barcala-

Furelos et al., 2013; Barcala-Furelos et al., 2016). Tools such as rescue tubes or fins could help in this phase to decrease its difficulty, helping the lifeguard to swim faster and with less effort(Abelairas-Gómez et al., 2017).

However, this is still a challenge since the second phase represents almost a half of the total time of the rescue, despite the use of swimming or flotation aids. Previous studies have demonstrated that the use of flotation aids decrease the rescue time in 100 m from 30 to 60 s (Abelairas-Gómez et al., 2017; Barcala-Furelos et al., 2016). Therefore, probably the time of T2 could be increased and the differences in lifeguards' skills could be enhanced without equipment. The importance of this second phase in the water rescue is remarkable since the victim has to be assessed as soon as possible and in sever stages of drowning the delay of the attention might worsen the condition of the victim(Claesson, Lindqvist, & Herlitz, 2014).

On the other hand, this study also shows that the slowest phase of the water rescue is the extraction (T3), which is also the shorter part as lifeguards only carried out the victim during 15 m (5 m on the water – 10 m on the sand). This distance might vary in different stages, but it seems reasonable to include it in this analysis since it represents the end of the water rescue, carrying the victim to a safe place. In this phase, the exertion of the lifeguards has been increased since the help of the water disappears, and the aid elements are not helpful in this part. In fact, the fins might make more difficult the performance of this phase.

In addition, results of this study show that the extraction (T3) is also a good variable to discriminate between lifeguards with high or medium level of abilities, which might be related to the physical fitness of the lifeguards, although further research is needed in this regard. This finding is consistent with previous research, which described that strength is one of the main characteristics a lifeguard should have and rescues in water environments are very demanding in terms of physiology and physical condition(López-García et al., 2021; Szpilman et al., 2014), and the quality of the rescue has also been highly related to the physical condition of the lifeguards(Avramidis, Butterly, & Llewellyn, 2007).

In summary, the differences between a lifeguard with high and medium abilities arises in towing and in extraction. Developing strategies focused on improving these parts of the water rescue and reducing the differences between lifeguards in a team could decrease significantly the rescue time and therefore save lives, especially in the towing phase which lifeguards often perform with no help. In the case of extraction phase, other lifeguards or even people around might help lifeguards.

4.1 Practical applications

Despite the existence of international standards for selection and training of lifeguards, sometimes is difficult to support them with scientific literature and significant findings (Reilly, Wooler, & Tipton, 2006) and therefore important bias appear when optimizing the performance of a team of lifeguards. This investigation opens a new way for the selection of rescuers in accordance with their abilities, discriminating them according to the rescue phases and lifeguards' skills. Interrupting the drowning process once it is detected depends on several factors, such as the surveillance, number of bathers or velocity of the lifeguards arriving to the event. However, the time carrying the victim to a safe place will depend largely on the physical condition of the lifeguards and their skills in adverse conditions such as cold water, long distances, and warm weather. This study tries to contribute to understand better the importance of the abilities of lifeguards, and to develop strategies based on them. Lifeguards with higher level of water abilities should cover the areas with farther drowning events. Besides, lifeguards could benefit from a specific strength training since according to the results presented the shorter phase (T3) is also the slowest one. This study has been carried out with the aim of helping the rescue teams to design trainings and test to organize the lifeguards in accordance with their abilities and with more information than before.

4.2 Limitations

Several limitations of this investigation must be considered. First, the small and convenience sample size. In addition, the conditions of the water rescue were controlled by researchers, and other distances, locations or climate conditions could provide different results. Our data are not applicable to all the lifeguards and only represent a rescue simulation. Another factor to consider is that patricians wore a wetsuit during the rescue since water was colder than 15º C.

5. CONCLUSION

In a water rescue, 2/3 of the total time are spent on towing the victim, and the extraction of the victim from the shore to a safe place is the slowest part. There are significant differences between lifeguards in the total time of the rescue, besides in the time of swimming back and the time of extraction, so those lifeguards with better swimming abilities should be the first option to perform the water rescue. The specific training of each phase should be considered by lifeguards' teams in order to decrease time and offer the rescuer a plan adapted to their capacities and limitations. Those rescue teams which perform selection test for their team of lifeguards should complete test which include each phase of the rescue, and not only swimming.

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