International Journal of Aquatic Research and Education

Volume 11 | Number 3 Article 6

3-1-2019

Validation of a New Incremental Swim Test as a Tool for Maximum Oxygen Uptake Analysis in Lifeguards

Brais Ruibal-Lista
University of A Coruña, A Coruña, Spain, brais.ruibal@udc.es

José Palacios-Aguilar
University of A Coruña, A Coruña, Spain, palacios@udc.es

José Antonio Prieto
University of Oviedo, Oviedo, Spain, josea@facultadpadreosso.es

Sergio López-García
Pontifical University of Salamanca, Salamanca, Spain, slopezga@upsa.es

José Antonio Cecchini-Estrada
University of Oviedo, Oviedo, Spain, cecchini@uniovi.es

See next page for additional authors

Recommended Citation

Ruibal-Lista, Brais; Palacios-Aguilar, José; Prieto, José Antonio; López-García, Sergio; Cecchini-Estrada, José Antonio; Santiago-Alonso, Miguel; and Abelairas-Gómez, Cristian (2019) "Validation of a New Incremental Swim Test as a Tool for Maximum Oxygen Uptake Analysis in Lifeguards," *International Journal of Aquatic Research and Education*: Vol. 11 : No. 3 , Article 6.
DOI: 10.25035/ijare.11.03.06
Available at: https://scholarworks.bgsu.edu/ijare/vol11/iss3/6

Validation of a New Incremental Swim Test as a Tool for Maximum Oxygen Uptake Analysis in Lifeguards

Cover Page Footnote
We appreciate the effort and motivation of all the lifeguards who participated in this study

Authors
Brais Ruibal-Lista, José Palacios-Aguilar, José Antonio Prieto, Sergio López-García, José Antonio Cecchini-Estrada, Miguel Santiago-Alonso, and Cristian Abelairas-Gómez

Abstract

This study was designed to validate an incremental test predicting maximum oxygen uptake for lifeguards. A maximum incremental test was performed in the laboratory (i.e., treadmill run) and in the pool (i.e., swim) by 10 certified lifeguards. The values of maximum oxygen uptake (VO_2Max), maximum heart rate (HRMax), and lactate (LaMax) achieved during both tests were analyzed. The VO_2Max (0.87, $p = .001$), HRmax (0.85, $p = .002$) and LaMax (0.67, $p < .05$) values showed significant correlations between the laboratory tests and the pool tests. These results showed that the Incremental Pool Test for Lifeguards (IPTL) was valid (i.e., concurrent validity) for obtaining the maximum oxygen uptake of a rescuer. Using this swim test, lifeguards and their supervisors will be able to individualize their training in order to improve their performance in a water rescue and perhaps reduce the numbers of fatal drownings.

Key words: lifesaving, lifeguards, maximum oxygen uptake, physical fitness

Introduction

Lifeguards are one of the rescue groups in charge of safety in the aquatic environment. Their main objective is reducing the third leading cause of unintended accidental death worldwide: drowning (World Health Organization, 2014). The rescue of drowning victims might put lifeguards' lives at risk (Ducharme & Lounsbury, 2007); therefore, rescuers are required to meet minimum physical fitness standards for the performance of their tasks (Reilly Iggleden, Gennser, & Tipton, 2006a; Schwebel, Jones, Holder, & Marciani, 2010).

In this sense, different studies have analyzed psychological, technical, and physical variables with the aim of improving the training of first responders such as lifeguards (Abelairas-Gómez, Romo-Pérez, Barcala-Furelos, & Palacios-Aguilar, 2013; Barcala-Furelos, Abelairas-Gomez, Queiroga, & García-Soidán, 2014; Barcala-Furelos, Szpilman, Palacios, Costas-Veiga, Abelairas-Gómez, Bores-Cerezal, López-García, & Rodríguez-Núñez, 2016). In the field of physical fitness, the influence of VO_2Max on the efficiency of professional performance has been widely demonstrated (Williams-Bell, Villar, Sharratt, & Hughson, 2009; Thornton & Sayers, 2014).

Obtaining the VO_2Max can be done through direct or indirect methods. The direct method offers the advantage of precise analysis. However, measuring the aerobic power in the water (pool) entails high costs in equipment and time (Reilly, Iggleden, & Tipton, 2006b) and make difficult the performance of swimming techniques (Salvador, Penteado, Lisboa, Corvino, Peduzzi, & Caputo, 2014). For this reason, indirect VO2max production has been studied in different rescue groups in both terrestrial and aquatic environments (Prieto, Del Valle, González, Montoliu, Nistal, & Egocheaga, 2010; Salvador et al., 2014).

Indirect continuous tests for swimmers have been designed and validated (Deminice, Papoti, Zagatto, & Prado-Júnior, 2007; Veronese-da-Costa, Costa, Carlos, Guerra, Silva, & Barbosa, 2012). Swimming tests may not be valid for water rescue tasks since the techniques of swimming and towing used by lifeguards have important differences that need to be taken into account. The specific technique of swimming with the head out in rescue should be included in the training control programs (Prieto et al., 2010).

It is necessary to design and validate a specific aquatic rescue test to obtain valid and effective information about the VO_2Max of lifeguards in order to improve their physical conditioning and therefore their training. Thus, the objectives of this study were to design and validate an incremental test for lifeguards that allows prediction of VO_2Max.

Method

Participants

A convenience sample of 20 professional lifeguards was included in our study. The inclusion criteria to qualify as a participant were to have official certification and at least two years of professional experience. The study was approved by the local ethics committee. All participants signed the approved informed consent document on the conduct of the tests and the subsequent use of the data obtained.

Design and Procedures

Laboratory tests were carried out on two consecutive days during the same time of day (i.e., 10:00 am – 2:00 pm) and under the same circumstances (air temperature = 21° C (70^{o} F) and relative humidity = 60%).

Criterion laboratory test. The land-based criterion laboratory test (TestLab) consisted of an incremental test on a treadmill (Excite Med-Run, TecnhoGym ©) using velocities ranging from 0.4 to 25 km/h and slopes of 0 to 18% with constant slope increments of 1%. The protocol began at a speed of 5.4 km/h and 1% of constant slope. The test involved increases of 0.33 km/h every 20 seconds, simulating a ramp test (López-Chicharro & Fernández-Vaquero, 2006; Sáinz-Fernández & Rabadán-Ruíz, 2013). During the test analyses of heart rate, expired gases, and lactic acid concentration were carried out.

Heart rate was recorded second by second throughout the test using an electrocardiogram (ECG) with 12 cardiac electrodes placed on the torso (WelchAllynCardioperfect) and a heart rate monitor (Ambit 3 RUN, Suunto © compatible with FirstBeat Sports ©) that recorded heart rate variability and

DOI: 10.25035/ijare.11.03.06

maximal heart rate (HRMaxLab). Maximum heart rate was defined as the highest value achieved during the test (Tanaka, Monahan, & Seals, 2001).

The gas exchange was measured with a gas-analyzer (Medical Graphics CPX-Plus, Medical Graphics Corporation, St. Paul, Minnesota, USA) with breath-to-breath recording (Breeze software 6.4) during test. Maximum oxygen uptake (VO_2MaxLab) was established as the highest oxygen uptake achieved during the test. Blood lactate accumulation (LaMaxLab) was measured at minutes 1, 3, 5 and 7 of recovery with a portable automatic analyzer (Lactate Pro 2, Arkray) with a measurement range of 0.5 to 25.0 mmol/L.

Incremental Pool Test for Lifeguards (IPTL). The proposed lifeguard water test was carried out in a pool 25 m long, 20 m wide and 2 m deep. All pool trials were performed one week after the land-based laboratory testing on two consecutive days at the same time of day (10:00 am – 2:00 pm) and under the same circumstances (water temperature = 27.8º – 27.9° C (82º F) and relative humidity = 26.9 – 27.0%). The protocol of the IPTL consisted of repeatedly swimming a distance of 25 meters at a pre-established and progressive pace using an acoustic sound alert as both ends of the pool.

Each intensity level of the test increased progressively after 4 repetitions of 25 meters (100 m) were completed until the participant was not able to maintain the pace of the test. The beginning of each set of 4 x 25 meters within each intensity level (i.e., same speed of swimming) was indicated to a participant with an acoustic sound alert. The beginning of a new intensity level (i.e., faster speed of swimming) was indicated with a different acoustic sound alert. The speeds of each intensity level can be seen in Table 1.

Each ITPL session was considered complete when the participant was not able to maintain the pace established by the acoustic signals during two consecutive 25-meter length or when he voluntarily stopped the test. The maximum distance was defined by adding all distances (series of 25 m) to the last completed series within the set pace. Finally, the maximum time of the test was defined as the time that the last series of 25 meters was completed within the established pace. A specific swimming technique, the crossing crawl (swim with the face in the water while regularly lifting the head to look forward when getting a breath), was required during the execution of the test with the participant wearing a silicone cap, optional swimming goggles, and wearing medium-length swim fins (50-55 cm in length and 17-20 cm wide).

The heart rate was recorded during the swims using a heart rate monitor (Ambit 3 RUN, Suunto © compatible with FirstBeat Sports ©) with an analysis of heart rate variability determined and maximal heart rate (HRMaxIPTL) defined as the highest value reached during the performance of the test. At the end of the test, blood lactate accumulation (LaMaxIPTL) was measured at 1, 3, 5 and 7 minutes of recovery through a capillary blood sample (15 µl) with the same device as during the laboratory test. The maximum lactate concentration (LcMaxLab) was established as the highest value recorded after the test.

Table 1 Protocol of the Incremental Test in Pool for Lifeguards (ITPL).

Phase	Distance	Total distance	Speed	Time each 25 m	Phase time	Total time
1	4 x 25 (100 m)	100 m	0,78 m/s	32 s	128 s	128 s
2	Idem	200 m	0,83 m/s	30 s	120 s	248 s
3	Idem	300 m	0,89 m/s	28 s	112 s	360 s
4	Idem	400 m	0,96 m/s	26 s	104 s	464 s
5	Idem	500 m	1,04 m/s	24 s	96 s	560 s
6	Idem	600 m	1,13 m/s	22 s	88 s	648 s
7	Idem	700 m	1,25 m/s	20 s	80 s	728 s
8	Idem	800 m	1,39 m/s	18 s	72 s	800 s
9	Idem	900 m	1,56 m/s	16 s	64 s	864 s
10	Idem	1000 m	1,78 m/s	14 s	56 s	920 s
11	Idem	1100 m	2,08 m/s	12 s	48 s	968 s
12	Idem	1200 m	2,5 m/s	10 s	40 s	1008 s

m: meters; m/s: meters per second; s: seconds

The values of HR recorded were used to approximate the VO_2 during the pool test. This calculation was carried out through the HR / VO_2 ratio obtained during the maximum test in the laboratory (TestLab) (linear relation Y = bX - a) (Prieto et al., 2010) where Y is the dependent variable (i.e., VO2 value to be determined), X is the value of the independent variable (i.e., HR already recorded during the pool test), a & b are constant values and r^2 is the linear correlation calculated from this equation.

Statistical Procedures

The data were stored and analyzed using the SPSS statistical package (Windows Version 21.0). Normality was verified by the Kolmogorov-Smirnov test. All variables showed normal distributions. Descriptive analyses were performed to calculate means and standard deviations of each variable. In order to analyze the relationship between all the variables, a hierarchical cluster analysis was performed in order to identify relatively homogeneous groups of variables based on the characteristics selected, using an algorithm that started with each variable in a different cluster and combined the clusters until only one was left. As measures for interval data, the Euclidean distance was used. The Ward method was used and the variables were transformed into z scores. The Bland-Altman technique (Bland & Altman, 1986) was used to determine the most highly correlated variables, which allowed us to examine the mean difference between VO_2lab and VO_2IPTL, the concordance limits (mean difference ± SD 2) and the slope of the difference of means with respect to the value average VO_2lab and VO_2IPTL.

Results

From the 20 rescuer participants, ten were excluded because they did not complete all the tests. The final study sample included 10 male rescuers. Demographic data are shown in Table 2.

Table 2 Demographic and anthropometric data

Demographic/ Anthropometric Variables	*Mean*	*SD*
Age (years)	26.10	2.84
Height (cm)	177.23	4.30
Weight (kg)	75.68	5.99
BMI (kg/m^2)	24.11	1.72
Skinfolds (mm)	90.65	27.98
Fat mass (%)	15.82	3.01
Lean body mass (%)	44.06	2.49

The mean absolute (4.05 ± .60 L/min) and relative (53.48 ± 6.51 L/min) maximum oxygen uptake (VO_2Max) were analyzed at the end of the test. The mean maximum heart rate (HRmax) was also analyzed (197.4 ± 7.70 ppm) as well as the maximum speed reached (4.78 ± .40 m/s). The maximum lactate values reached at the end of the test (14.10 ± 2.12 mmol/L) were calculated. All physiological registered data are presented in Table 3.

Table 3 Results of Laboratory Test.

Laboratory Test (TestLab)	*Mean*	*SD*
Absolute maximum oxygen uptake (L/min)	4.05	.60
Relative maximum oxygen uptake (ml/kg/min)	53.48	6.51
Maximum heart rate (ppm)	197.40	7.70
Percentage of Maximum HR in anaerobic threshold	92.00	2.00
Maximum speed (running) (m/s)	4.78	.40
Maximum time reached (s).	783.00	89.44
Maximum blood lactate (LaMáx) (mmol/L)	14.10	2.12

Table 4 shows the results of the IPTL in the pool. The mean estimated relative maximum oxygen uptake was (45.40 ± 5.36 ml / kg / min) and the mean maximum heart rate reached was (184.90 ± 9.84 ppm). The maximum velocity was 1.27 ± .24 m / s; the maximum time 700.00 ± 106.87 s and the maximum lactate 11.87 ± 2.31 mmol / L.

Table 4 Results of Incremental Pool Test for Lifeguards (IPTL)

Incremental Pool Test for Lifeguards (IPTL)	*Mean*	*SD*
Maximun Oxygen Uptake (ml/kg/min)	45.40	5.36
Maximum heart rate (ppm)	184.90	9.84
Maximum swimming speed (m/s)	1.27	.24
Maximum swimming time reached (s).	700.00	106.87
Maximum blood lactate (LaMáx) (mmol/L)	11.87	2.31

A visual presentation of the data set obtained is included in Figure 1. Each element of the matrix describes a value for a respective variable (columns) and a subject (rows). Each variable converted to z scores by scaling them to mean 0 and variance 1. Therefore, elements with grays tending to black indicate low values of the given variable, whereas the larger values are presented with grays tending to the target.

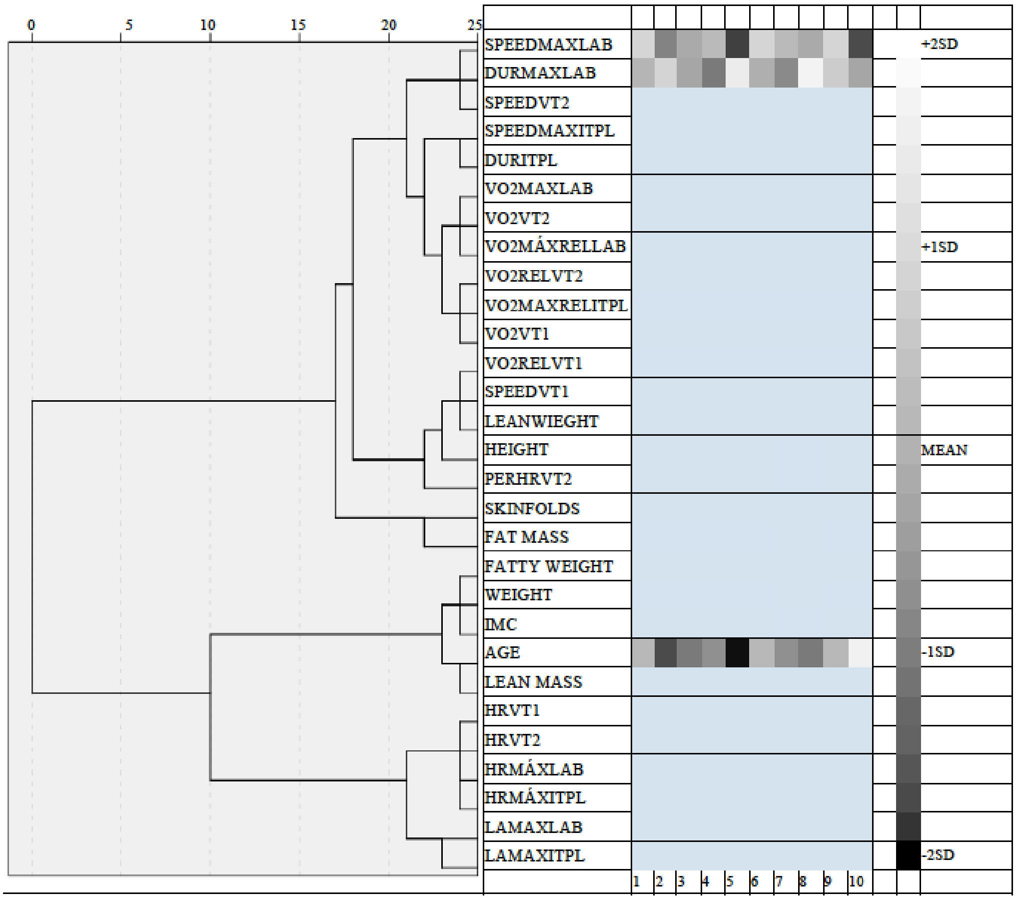

Figure 1. Analysis of hierachical conglomerates

The tree on the left side of the matrix describes how the variables are related to each other according to the cluster analysis. The shorter the branches, the stronger the association among the variables. Statistically significant correlations were found between VO_2Lab and VO_2IPTL (0.87, p =.001). Using the Bland-Altman technique (Bland & Altman 1986), we examined the mean difference between VO_2Lab and VO_2IPTL, the concordance limits (mean difference ± SD 2) and the slope of the mean differences between VO_2Lab and VO_2IPTL. For the data obtained the mean difference was 8.08 ml · kg-1 · min-1 and the s was 2.88 ml · kg-1 · min-1. The differences were between d - 2s and d + 2s (Fig. 2).

We note that:

- 2 s = 8.08 - (2 x 2.88) = 2.32
- 2 s = 8.08 + (2 x 2.88) = 13.88

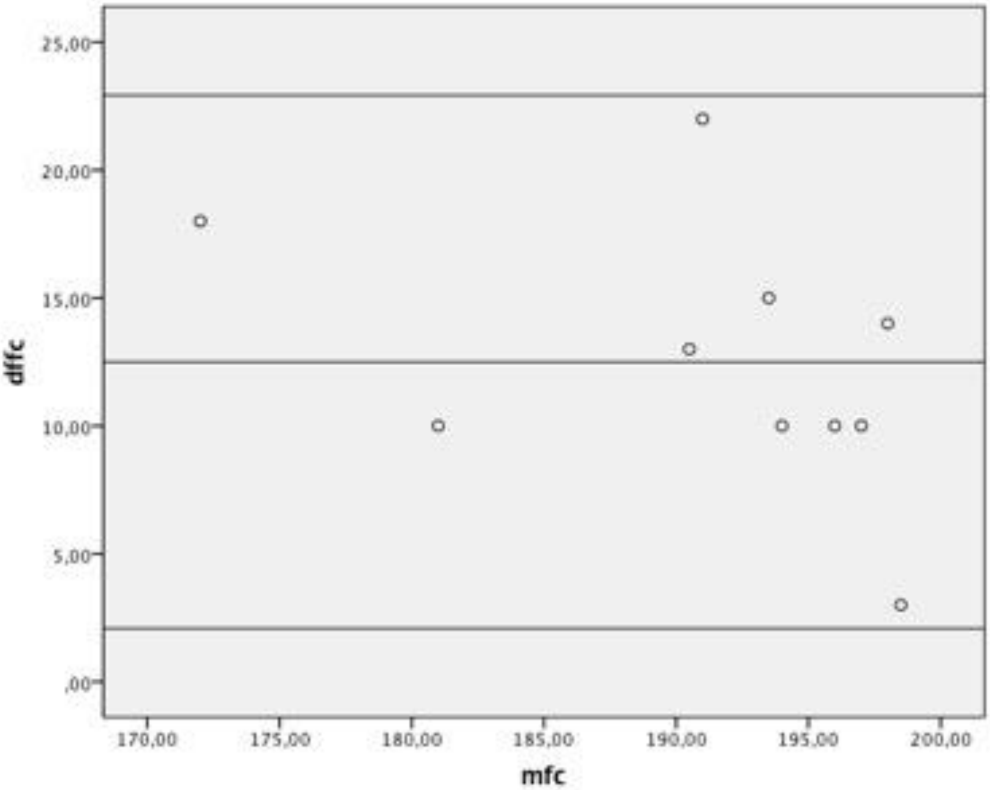

Figure 2 – Simple dispersion diagram between the difference of means with respect to the average value between the maximum oxygen uptakes in the laboratory and in the pool.

The VO_2Max also correlated positively with the test time in both cases (0.67, p <.05). Significantly high correlations were found between HRLab and HRIPTL (0.85, p = .002). For the data obtained the mean difference was 12.5

ppm and s was 5.21 ppm. Therefore, the limits of agreement oscillated between 2.08 and 22.92 bpm (Fig. 3). The slope of the difference of means with respect to the average value was, y = -62.85 - 0.26 * x, p = .218. Finally, the analysis of lactate in the laboratory and in the pool field test also showed significant correlations (0.67, p <.05).

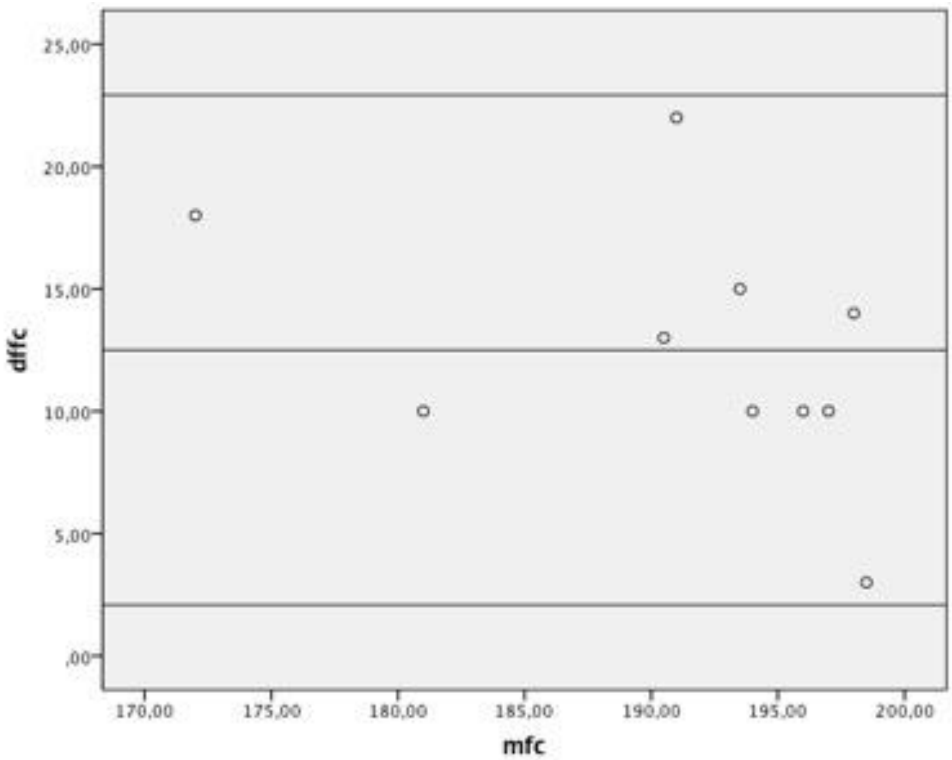

Figure 3 – Simple dispersion diagram between the mean differences in the mean heart rate in the laboratory and in the pool.

Discussion

Our study showed the design of an Incremental Pool Test for Lifeguards for the estimation of VO2max with statistically significant correlations with direct laboratory tests. Validity is the main characteristic that a field test must fulfill (Currell & Jeukendrup, 2008). Our results showed significant correlations between the physiological variables studied and high concordance levels between the variables of VO_2Max and HR obtained in the laboratory and IPTL. In addition, the performance time of the test was shown as a predictor of VO_2Max. These results show that the IPTL is valid as a specific swimming test of aerobic fitness in lifeguard first responders.

Lifeguards also used fins, a recue material recommended for the security of the rescuer and for its utility to reduced the livesaving time (Abraldes, Soares, Barroso, Fernandes, & Vilas-Boas, 2007; Palacios, 2008; Abelairas-Gómez et al, 2017).

The variables VO2Max, HR and lactate were necessary for the standardization with protocols of previous studies on incremental tests since these demonstrate security and coherence regarding validity (Veronese-Da-Costa et al., 2012; Veronese-da-Costa, Costa, Fernandes-Melo, Lima-de-Albuquerque, Pereira-Guimaraes, & Barbosa, 2013). It has recently been claimed that the use of actual VO_2max and HR values collected from a submaximal test protocol can provide accurate predictions using indirect formulas (Mazzoleni, Battaglini, Martin, Coffman, Ekaidat, & Wood, 2017). At the same time these variables were essential for analyzing the physical condition of lifeguard first responders. Current evidence suggests that in order to obtain valid VO_2Max values, continuous incremental testing should last at least five minutes (Mazzoleni et al., 2017); in this sense an optimal physical condition of lifeguard first responders would ensure control of this variable. At the same time, it has been suggested that the assessment of one’s physical condition through HR and lactate allows us to know the minimum values to consider that a test is really maximal (Midgley, McNaughton, Polman, & Marchant, 2017).

In the current study the results of VO_2Max obtained during the laboratory test confirmed a high level of physical condition in the sample studied. The mean values recorded were higher than the recommended minimum for the aptitude of professional lifeguards (Prieto, Nistal, Méndez, Abelairas-Gomez, & Barcala-Furelos, 2015). The results were similar to those found in previous studies of other rescue workers (Prieto et al., 2010, Salvador et al., 2014) and higher than those achieved by other rescue groups such as firefighters or first responder groups (Prieto, González, Del Valle, & Nistal, 2013). The data of HR have allowed us to know at what point in HR the anaerobic threshold (VT2) is produced and thus to establish the aerobic - anaerobic transition. In our case, like other studies with first-aiders (Prieto et al., 2010, Prieto-Saborit, Egocheaga-Rodríguez, González-Díez, Montoliu-Sanclement, & Alameda, 2001) VT2 is at a very high value (92.7 ± 1.9% HRMáx), which indicates that these lifeguards were able to tolerate high intensity exercises without achieving a state of metabolic acidosis. This aspect becomes especially relevant considering that previous research had suggested that rescuers should not end aquatic rescue in a state of high acidosis that could impair performance in subsequent tasks (Reilly et al., 2006a) such as the strenuous performance of cardiopulmonary resuscitation (CPR) (Abelairas-Gómez et al., 2013, Claesson, Karlsson, Thorén, & Herlitz, 2011).

The high relevance and significance of this study was determined because all the physiological variables analyzed in the laboratory and in the IPTL were significantly correlated with each other: Maximum oxygen uptake, heart rate and lactate levels achieved in the laboratory were strongly related to the data obtained in the pool test. In the case of HR obtained in the aquatic environment, it has been controversial in several investigations due to the influence that the aquatic medium and horizontal swimming body position can have on the heart rate. It has been described that different factors like horizontal position and mammalian or facial reflex could produce bradycardia of between 8 – 12 ppm (Prieto et al., 2010). The results of the present study showed significant correlation between the HR obtained in the laboratory and in the incremental pool test. Equally, the slope of means with respect to the mean value suggested that the incremental pool test was valid for obtaining maximum HR at least among skill swimmers and lifeguards.

Limitations

The main limitation of this study was the sample. On the one hand, only men participated because in our town, the number of female lifeguards is very few. On the other, the final number of lifeguards who completed the tests was lower than we expected. The realization of this type of studies with heterogeneous and higher samples can favor the validity and extrapolation to the professional field.

Conclusion

We concluded that our Incremental Pool Test for Lifeguards (IPTL) was valid for obtaining the VO_2Max of skilled lifeguard rescuers. These results represent a novel and essential tool for the periodization of lifeguard training which may allow individuals and supervisors to individualize training functions by knowing their individual fitness characteristics. With improved and individualized training, lifeguards should be able to perform faster, stronger, and safer rescues and subsequent resuscitation efforts; therefore they could contribute to decreases the number of fatal-drownings subsequent to rescues.

References

Abelairas-Gómez, C., Barcala-Furelos, R., Mecías-Calvo, M., Rey-Eiras, E., López-García, S., et al. (2017). Prehospital Emergency Medicine at the Beach: What Is the Effect of Fins and Rescue Tubes in Lifesaving and Cardiopulmonary Resuscitation After Rescue? *Wilderness Environment Medicine, 28*(3): 176-184.

Abelairas-Gómez, C., Romo-Pérez, V., Barcala-Furelos, R., & Palacios-Aguilar, J. (2013). Effect of lifeguard fatigue on the first 4 minutes of cardiopulmonary resuscitation after wáter rescue. *Emergencias, 25*: 184-190.

Abraldes, J. A., Soares, S., Barroso, A., Fernandes, R., & Vilas-Boas, J. (2007). The Effect of Fin Use on the Speed of Lifesaving Rescues. *International Journal of Aquatic Research & Education, 1*(4): 329-340.

Barcala-Furelos, R., Abelairas-Gomez, C., Queiroga, A. C., & García-Soidán, J. L. (2014). CPR quality reduced due to physical fatigue after a water rescue in a swimming pool. *Signa Vitae, 9*: 25-31.

DOI: 10.25035/ijare.11.03.06

Barcala-Furelos, R., Szpilman, D., Palacios, J., Costas-Veiga, J., Abelairas-Gómez, C., Bores-Cerezal, A., et al. (2016). Assessing the efficacy of rescue equipment in lifeguard resuscitation efforts for drowning. *American Journal of Emergency Medicine*, *34*: 480-485.

Bland, J. M., & Altman, D. (1986). Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*, *327*(8476): 307-10.

Claesson, A., Karlsson, T., Thorén, A. B., & Herlitz, J. (2011). Delay and performance of cardiopulmonary resuscitation in surf lifeguards after simulated cardiac arrest due to drowning. *American Journal of Emergency Medicine*, *29*(9): 1044-1050.

Currell, K., & Jeukendrup, A. E. (2008). Validity, reliability and sensitivity of measures of sporting performance. *Sports Medicine*, *38*(4): 297-316.

Deminice, R., Papoti, M., Zagatto, A. M., & Prado-Júnior, M.V.D. (2007). Validity of 30 minutes test (T-30) in aerobic capacity, stroke parameters and aerobic performance determination of trained swimmers. *Revista Brasileira de Medicina do Esporte*, *13*(3): 195-199.

Ducharme, M. B., & Lounsbury, D. S. (2007). Self-rescue swimming in cold water: the latest advice. *Applied Physiology Nutrition Metabolism*, *32*: 799-807.

López-Chicharro, J., & Fenández-Vaquero, A. (2006). Fisiología del ejercicio. (6ª ed). Editorial Panamericana. Barcelona.

Mazzoleni, M. J., Battaglini, C. L., Martin, K. J., Coffman, E. M., Ekaidat, J. A., & Wood, W. A., et al. (2017). A dynamical systems approach for the submaximal prediction of maximum heart rate and maximal oxygen uptake. *Sports Engineering*, *21*(1): 1-11.

Midgley, A., McNaughton, L., Polman, R., & Marchant, D. (2007). Criteria for determination of maximal oxygen uptake: A brief critique and recommendations for future research. *Sports Medicine*, *37*(12): 1019-1028.

Palacios, J. (2008). Socorrismo acuático profesional: Formación para la prevención y la intervención ante accidentes en el medio acuático. Santiago de Compostela: Salud y Deporte de Galicia. *Publicaciones Didácticas* (2ª ed.).

Prieto-Saborit, J. A., Egocheaga-Rodríguez, J., González-Díez, V., Montoliu-Sanclement, M. A., & Alameda, J. C. (2001). Determinación de la demanda energética durante un salvamento acuático en playa con y sin material auxiliar [Determination of the energetic demand during a rescue in the sea with and without auxiliary equipment]. *Selección*, *10*(4): 211-220.

Prieto, J. A., Del Valle, M., González, V., Montoliu, M. A., Nistal, P., & Egocheaga, J., et al. (2010). Physiological response of beach lifeguards in a rescue simulation with surf. *Ergonomics*, *5*(9): 1140-1150.

Prieto, J. A., González, V., Del Valle, M. & Nistal, P. (2013). The influence of age on aerobic capacity and health indicators of three rescue groups. *International Journal of Occupational Safety and Ergonomics, 19*(1): 19-27.

Prieto, J. A., Nistal, P., Méndez, D., Abelairas-Gomez, C., & Barcala-Furelos, R. (2015). Impact of error self-perception of aerobic capacity in the safety and efficacy of the lifeguards. *International Journal of Occupational Safety and Ergonomics*, 22(1): 159-163.

Reilly, C., Iggleden, M., Gennser, M., & Tipton, M. (2006a). Occupational fitness standards for beach lifeguards. Phase 1: The physiological demands of beach lifeguarding. *Occupational Medicine*, *56:* 6-11.

Reilly, C., Iggleden, M., Gennser, M., & Tipton, M. (2006b). Occupational fitness standards for beach lifeguards. Phase 2: the development of an easily administered fitness test. *Occupational Medicine*, *56*: 12-17.

Sainz-Fernández, L., & Rabadán-Ruíz, M. (2013). Valoración de la condición aeróbica del corredor de orientación a pie de alto nivel español. *Archivos de Medicina del Deporte, 30*(6): 359-364.

Salvador, A., Penteado, R., Lisboa, F., Corvino, R., Peduzzi, E., & Caputo, F. (2014). Physiological and Metabolic Responses to Rescue Simulation in Surf Beach Lifeguarding. *Journal of Exercise Physiology, 17*(3): 21-31.

Schwebel, D. C., Jones, H. N., Holder, E., & Marciani, F. (2010). Lifeguards: A Forgotten Aspect of Drowning Prevention. *Journal of Injury and Violence Research*, *2*(1): 1-3.

Tanaka, H., Monahan, K. D., & Seals, D. R. (2001). Age-predicted maximal heart rate revisited. *Journal of the American College of Cardiology, 37*: 153-156.

Thornton, K. E., & Sayers, M. G. (2014). Unfit for Duty? Evaluation of 4 Years of Paramedic Preemployment Fitness Screening Test Results. *Prehospital Emergency Care*, *18*(2): 201-206.

Veronese-da-Costa, A., Costa, M. C., Carlos, D. M., Guerra, L. M., Silva, A. J., & Barbosa, T. M. (2012). Reproducibility of an aerobic endurance test for nonexpert swimmers. *Journal of Multidisciplinary Healthcare, 5*(1): 215-221.

Veronese-da-Costa, A., Costa, M. C., Fernandes-Melo, S., Lima-de-Albuquerque, F., Pereira-Guimaraes, F. J., & Barbosa, T. M. (2013). Validation of an equation for estimating maximal oxygen consumption of nonexpert adult swimmers. *Open Access Journal of Sports Medicine, 4*:19-25.

Williams-Bell, F. M., Villar, R., Sharratt, M., & Hughson, R. (2009). Physiological Demands of the Firefighter Candidate Physical Ability Test. *Medicine & Science in Sports & Exercise*, *41*(3): 653-662.

World Health Organization (WHO) (2014). *Global report on drowning. Preventing a leading killer*. Geneva. Switzerland: Bloomberg Philanthropies.

DOI: 10.25035/ijare.11.03.06