Journal of Exercise Physiologyonline

June 2014
Volume 17 Number 3

Official Research Journal of the American Society of Exercise Physiologists

ISSN 1097-9751

JEPonline

Physiological and Metabolic Responses to Rescue Simulation in Surf Beach Lifeguarding

Amadeo F. Salvador[1], Rafael Penteado[1], Felipe D. Lisbôa[1], Rogério B. Corvino[1], Eduardo S. Peduzzi [2], Fabrizio Caputo[1]

[1]Human Performance Research Group, Santa Catarina State University. Florianópolis - SC – Brazil, [2]Military Fire Department of Santa Catarina – Division of Aquatic Rescue. Florianópolis - SC - Brazil

ABSTRACT

Salvador AF, Penteado R, Lisbôa FD, Corvino RB, Peduzzi ES, Caputo F. Physiological and Metabolic Responses to Rescue Simulation in Surf Beach Lifeguarding. **JEPonline** 2014;17(3):21-31. The aim of this study was to characterize the physiological and metabolic demands of a rescue simulation and identified the determinants. Eight male beach lifeguards performed in different days: (a) an incremental test on a treadmill determine maximal heart rate (HR max), maximal oxygen uptake (VO_2 max), and blood lactate concentration ([La]) profile; (b) a 300-m maximal specific swimming test in the pool; and (c) two rescue simulation performances in a surf beach without (RS1) and with a rescue tube (RS2). The performance time and $[La]_{PEAK}$ for pool testing (386 ± 54 sec and 13.5 mMol·L^{-1}), RS1 (351 ± 70 sec and 14.1 mMol·L^{-1}), and RS2 (360 ± 47 sec 13.5 mMol·L^{-1}) were not significantly different. No significant correlations were found between the laboratory-based measures and pool performance testing with both rescue performances. Significant correlation was found between R1 and R2 (r = .83). It is concluded that the simulated rescue on the surf beach showed a high physiological and metabolic demand and seems to be strongly independent of environment conditions, thus requiring a different set of swimming skills compared to those acquired only with pool-swimming training.

Key Words: Lifeguards, Swimming Ability, Performance, Physical Demand

INTRODUCTION

The guidelines for safe recreational water environment show that the prognosis for survival of a drowning victim depends more on the effectiveness of the initial rescue and resuscitation than the quality of subsequent hospital care (23). This means that the responsibility and demand required of the beach lifeguard (BLG) are high. Yet, by default, the BLG occupation is primarily a stationary position that requires constant mental surveillance and alertness. When a rescue is required, in a short period of time, the BLG must be able to react at a high physical intensity and endurance. It is of interest that some BLGs are more physically fit than others, given that BLGs represent a diverse group of individuals with varying fitness levels. No doubt there are aerobic and strength standards required of every BLG (18) to help ensure the safety of the swimmers.

Daniel and Klauck (6) assessed 17 BLGs in a 50-m indoor pool. They demonstrated that the physiological demands (blood lactate and heart rate responses) associated with a still water rescue simulation (25-m sprint swimming, 2-m diving to pick a dummy, and 25-m towing the dummy) are similar to those observed in competitive swimmers. Moreover, Gulbin et al. (8) showed that ironmen and professional BLGs had significantly better swimming skills than the surf lifesavers. That is, they had better swimming economy found in skilled swimmers when compared with recreational swimmers (5). However, it has been suggested that swimming in surf beach requires a different set of skills not directly associated with pool swimming. This implies that lifeguard training must to be in the same place where the rescues are likely to be performed (22). In line with this thinking, it should be expected that pool swimming ability (i.e., a controlled environment condition) not corresponding totally with the ability to swim and tow a casualty in surf beaches (i.e., an uncontrolled environment condition, with influence of waves and sea currents). Thus, the knowledge about the effects of the environment, along with the physiological and metabolic demand of a lifesaving rescue in surf beaches, could further contribute to BLGs training prescription.

The distance that a BLG is responsible for covering (i.e., patrolled area) should be accessible in 3.5 min in order to prevent complications and return to the beach in ~10 min, at most (18). Thus, the rescue duration is measured like a period of extreme metabolic perturbation as a result of high-intensity exercise (7) to rescue someone in danger of drowning. The intensity of the rescue in such a short period of time produces a significant concentration of lactic acid. While the accumulation of blood lactate itself may not cause muscle fatigue and a decline in force development (2), the accompanying accumulation of hydrogen ions and pH decrease may elicit such decrements in performance (7). In this way, blood lactate concentration ([La]) has a remarkable importance for the knowledge of the metabolic demands on the lifeguards in situ to allow coaches to effectively structure training programs (14) and recovery strategies during saving and training (15). To date, while a few studies have investigated the metabolic and physiological demands associated with lifesaving simulation (8,17,18), they did not use a complete rescue (i.e. with running, approach swimming, and tow swimming) nor did they use a swimming style particular to rescue that decreases ecological validity.

Basing on these previous studies, the physical demand during the rescue seems to be different than others cyclic modalities (e.g., isolated running or swimming). Furthermore, the presence of different swimming abilities and specific sea conditions make the rescue a high-intensity exercise at which the performance is essential for the success of the occurrence. Therefore, the aim of the present study was determine the physiological and metabolic demands of a simulated rescue and identify the determinants of rescue performance in a surf beach. We hypothesized that the rescue performance in surf beach would be strongly influenced by the sea conditions and poorly related to pool swimming performance.

METHODS

Subjects

Eight male BLG (age, 29.1 ± 4.6 yrs; height, 177 ± 5 cm; weight, 74.0 ± 5.5 kg) volunteered to participate after being informed of potential risks and discomforts of participation. Each subject signed a written informed consent. The study was approved by the Institutional Research Ethics Committee (reference number 181/2011). All subjects were healthy, nonsmokers, free from injury and not taking any medication. They were advised to maintain a regular diet and avoid heavy training 24 hrs before testing. Each subject was familiarized with the rescue techniques and with the local surf beach. All tests were performed with a constant verbal encouragement interspersed by 2-day rest period. Each subject performed 4 different tests in 3 sessions.

Procedures

The first test session involved anthropometrics measurements and an incremental running test on treadmill (SUPER ATL, Inbrasport, Brasil). The incremental test started at a velocity of 8 $km \cdot h^{-1}$ and was increased to exhaustion by 1 $km \cdot h^{-1}$ every 3rd min. All stages were followed of 30-sec period of rest. During this period, an earlobe capillary blood samples were taken and immediately analyzed for [La] using an enzyme electrode system (YSI, 1500 Sports, Yellow Springs, OH, USA). During the test the treadmill grade was kept at 1%. The breath-by-breath gas samples (Cosmed Quark CPET, Rome, Italy) were averaged every 15 sec and VO_2 max was defined using the criteria proposed by Howley et al. (12). The onset of blood lactate accumulation (OBLA) was determined as the intensity corresponding to 4 $mMol \cdot L^{-1}$ of blood lactate (10). The peak treadmill velocity (V_{PEAK}) was determined according to the equation: V_{PEAK} ($km \cdot h^{-1}$) = velocity at last stage completed ($km \cdot h^{-1}$) + [(the completed time of the final stage ÷ step duration) × step increment ($km \cdot h^{-1}$)].

In the second visit, the BLG perform a 300 m specific swimming test (25-m indoor swimming pool) in order to analyze the swimming rescue performance in controlled condition. After a 10-min self-paced crawl warm-up, the subjects wore fins of similar characteristics and the test started with a push start, which the first 150 m was performed using an approaching swimming (AS) (front crawl face out of the water) and the last 150 m was performed using a tow swimming (TS) without victim, (i.e., leg crawl kicking on the side position with the arms positioned simulating to hold a casualty). Front crawl turns were not permitted and the submerse gliding after turns could not be longer than 5 m.

In the last visit the subjects performed two rescue simulations on the local surf beach, the first simulation with fins only (RS1) and the second simulation with fins and a rescue tube (RS2). In order to reproduce the exact localization of the casualty for each test, a buoy (with a flag) was fixed using an anchor, and the distance from the shore was measured by GPS system (eTrex, Garmin, Taiwan). All distances used in this study agreed with the mean of distance performed by BLG to reach a casualty in the local beach according of Santa Catarina Life Saving Association. The beach was classified as moderate beach surf with wave height of 0.5 to 1 m with a water temperature of 20º C.

The rescue simulation was divided in three parts: (a) running phase; (b) approaching swimming phase; and (c) towing phase. The rescue simulation started with a run of 80 m holding the fins on the sand beach parallel to sea followed by a turn left toward the sea (the turn point was fixed by a flagpole in front of the buoy positioned inside the sea) until BLG felt comfortable to wear the fins (i.e., when the depth of water was next to the knee). The variability of the point that the BLG wore the fins was no longer than 5 m. The duration consisted of the 'beginning' of the test until the BLG started to swim (after wearing the fins), which was further analyzed as running time (RT). After the BLG was wearing the fins, he started to swim to the offshore to reach the casualty (65 kg and 1.72 m) who was positioned next to a buoy anchored at 150 m from the beach. The duration of beginning the swimming until reaching the casualty was considered the approaching swimming (AS). After reaching the casualty, the BLG started to tow him towards the flag positioned at the beach. The victim could not help the BLG during the rescue. The duration between from the point of towing until the BLG reached the flag on the beach was considered the towing swimming (TS). The two rescue simulations were performed at maximum effort and were interspersed by a period of 30 min for each subject. All rescue simulations were recorded using a 60 Hz camera (Panasonic PVGS65; São Paulo, Brazil), positioned in upper front view for further analysis of each phase of the test.

During all tests, the subjects' HR was recorded (Polar Vantage NV, Kempele, Finland) at 5-sec intervals during the exercise and HR_{PEAK} was considered the highest 5-sec average HR value achieved during test. In the second (pool testing) and the last visit (rescue simulations) the BLGs wore a Lycra Shirt coupled with a chest belt for HR monitoring, and the peak blood lactate concentration ($[La]_{PEAK}$) was determined from earlobe capillary blood samples (25 µl) taken immediately 3 and 5 min post exercise. All subjects were encouraged to perform the tests as fast as possible, using the preferable pacing strategy.

Statistical Analysis

The results were expressed as mean ± standard deviation (SD). The normality distribution of the data was checked with Shapiro-Wilk test. One way analysis of variance (ANOVA) with repeated measures was used to identify differences in the overall performance times, and for analyzing each phase performance time (RT, AS, and TS) a two way ANOVA with repeated measures was performed. When significant differences occurred, the Tukey *post hoc* signed rank test was used. Paired *t* test was used to compare peak values of HR during rescue with and without rescue tube. Pearson's correlation coefficient was used to compare the physiological responses between the tests. For all statistical analyses, a P value of 0.05 was set as the level of significance.

RESULTS

Group mean values for VO_2 max and V_{PEAK} were 55.6 ± 4 $mL \cdot kg^{-1} \cdot min^{-1}$ and 15.4 ± 1.2 $km \cdot h^{-1}$, respectively. The HR_{PEAK} reached during the incremental test was 195 ± 8 $beats \cdot min^{-1}$, and the speed corresponding to the OBLA was 12.5 ± 1.8 $km \cdot h^{-1}$. The coefficients correlations are presented in Table 1. A significant correlation was found between VO_2 max and TS pool performance (r = 0.82), and for RS2, RT was negatively correlated with V_{PEAK} (r = -0.86) and OBLA (r = -0.94).

The $[La]_{PEAK}$ measured in the pool (13.5 $mMol \cdot L^{-1}$) test was positively correlated with $[La]_{PEAK}$ measured in both RS1 (14.1 $mMol \cdot L^{-1}$)(r = 0.83) and in RS2 (13.5 $mMol \cdot L^{-1}$)(r = 0.96), and the $[La]_{PEAK}$ measured in the rescue simulations were also significantly correlated (r = 0.82) between each other. But, $[La]_{PEAK}$ was not significantly correlated with any performance or incremental test variables. The mean HR response during the RS2 is plotted in Figure. 1. On the other hand, the mean HR response throughout the RS1 cannot be demonstrated because part of HR data was lost in several subjects, probably due to communication failure between the chest belt and HR monitor. However, HR_{PEAK} during RS1 (177 ± 14 beats·min^{-1}) and RS2 (178 ± 10 beats·min^{-1}) were similar and significantly correlated (r = 0.92).

Table 1. Correlation Matrix of Variables. *Significant correlation at the 0.05 level; †Significant correlation at the 0.01 level.

	Incremental			**Pool test**				**Rescue Simulation 1**					**Rescue Simulation 2**				
	VO_2	V_{PEAK}	OBLA	Total	AS	TS	[La]	Total	RT	AS	TS	[La]	Total	RT	AS	TS	[La]
VO_2	**1.00**																
V_{PEAK}	0.87†	**1.00**															
OBLA	0.77*	0.81*	**1.00**														
Total	-0.32	-0.12	-0.01	**1.00**													
AS	-0.60	-0.55	-0.63	0.17	**1.00**												
TS	0.81*	0.68	0.67	0.93†	-0.19	**1.00**											
[La]	0.43	0.37	-0.15	0.42	0.07	0.39	**1.00**										
Total 1	-0.13	-0.39	-0.36	-0.54	-0.22	-0.51	-0.22	**1.00**									
RT 1	-0.15	-0.36	-0.39	0.18	0.14	0.15	0.27	0.58	**1.00**								
AS 1	-0.43	-0.61	-0.70	-0.64	0.25	0.90†	-0.23	0.75*	0.28	**1.00**							
TS 1	0.06	-0.16	-0.07	-0.51	-0.50	-0.31	-0.28	0.94†	0.47	0.52	**1.00**						
[La] 1	0.08	0.26	-0.12	0.34	-0.22	0.29	0.83*	-0.06	0.34	-0.13	-0.10	**1.00**					
Total 2	0.19	-0.06	0.00	-0.41	-0.29	-0.10	-0.14	0.83*	0.70	0.46	0.81*	0.10	**1.00**				
RT 2	-0.65	0.86*	0.94†	-0.15	0.73	-0.64	0.10	0.51	0.35	0.74	0.08	-0.12	-0.11	**1.00**			
AS 2	0.01	-0.30	-0.39	-0.06	0.34	-0.03	0.39	0.42	0.78*	0.41	0.21	0.35	0.58	0.36	**1.00**		
TS 2	0.45	0.41	0.53	-0.38	-0.73	0.15	-0.37	0.51	0.18	0.02	0.69	-0.03	0.74*	-0.70	0.07	**1.00**	
[La] 2	-0.10	0.07	-0.34	0.51	0.26	0.29	0.96†	-0.38	0.20	-0.20	-0.50	0.82*	-0.34	0.24	0.31	-0.56	**1.00**

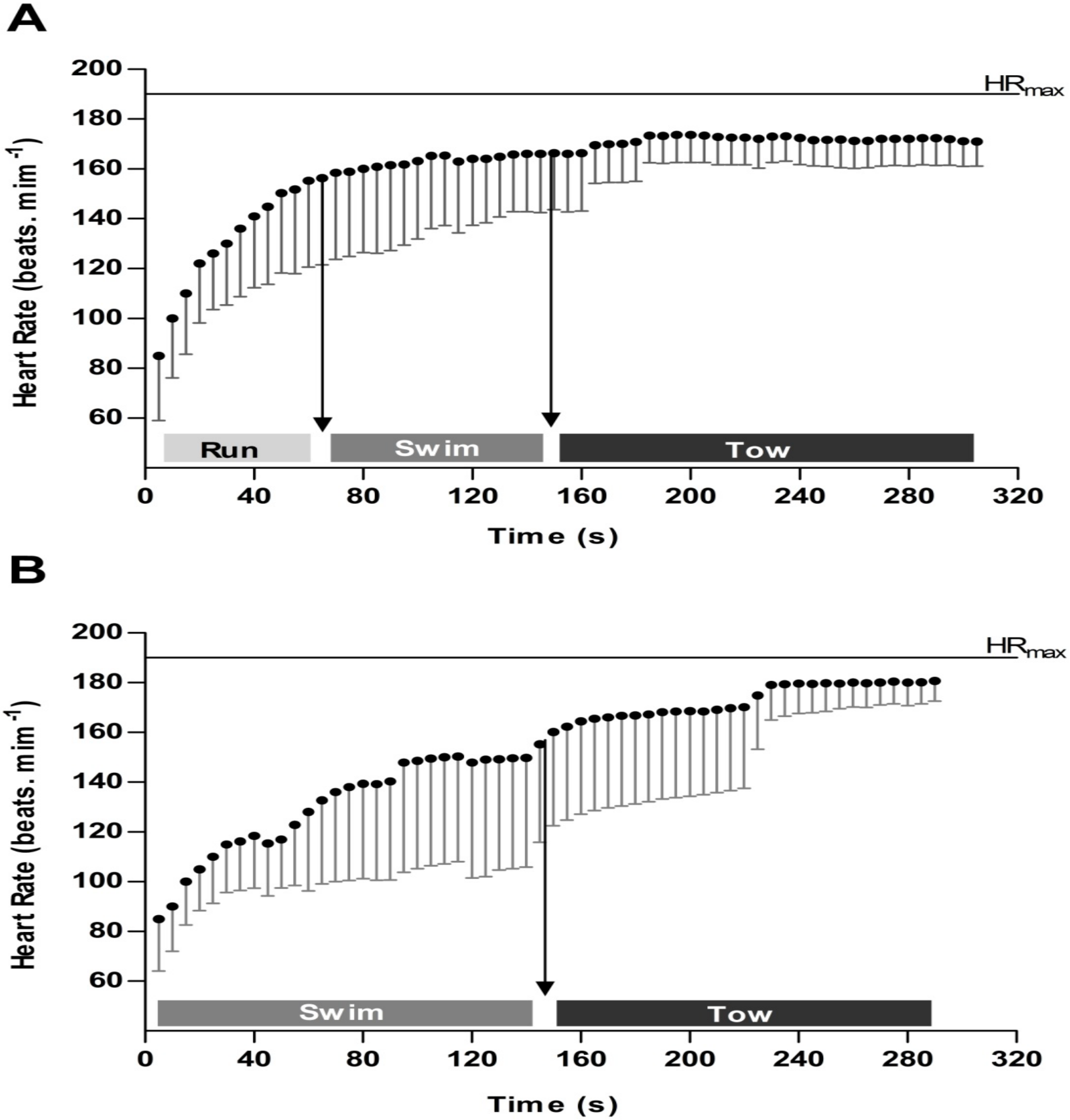

Figure 1. Group Mean Heart Rate Response to Rescue Simulation without Rescue Tube (Panel A) and in the Pool Testing (Panel B). Data points are 5-sec average values, and bar errors represent one SD. Horizontal solid lines indicate maximum heart rate (220-age) in both conditions. Vertical solid arrows at panel A indicate the division between run, swim, and tow mean times. In panel B the vertical solid arrow indicates the division between swim and tow mean times.

Total and Partial times for each condition are presented in Table 2 and the coefficients of correlations found between these variables are presented in a correlation matrix (Table 1). No significant correlation was found between TS in pool testing with both rescue simulations. However, for all conditions, TS was significantly higher than AS (P<0.01), and TS was significantly higher in the pool (P<0.01) than in the beach.

Table 2. Individual Performance Times for the Three Testing Conditions.

		POOL (sec)				RS1 (sec)				RS2 (sec)	
BLG	**AS**	**TS**	**Total**	**RT**	**AS**	**TS**	**Total**	**RT**	**AS**	**TS**	**Total**
1	114	271	385	59	105	226	390	65	103	236	404
2	115	260	375	79	119	286	484	85	114	249	448
3	132	314	446	62	68	170	300	66	68	202	336
4	117	322	439	74	76	187	337	62	119	196	377
5	108	249	357	45	97	219	361	69	54	195	318
6	133	303	436	56	69	142	267	69	97	138	304
7	121	266	387	47	89	151	287	54	81	208	343
8	149	218	367	67	139	179	385	98	117	133	348
Mean	125	276*	386	61	95	195*	351	71	94	194*	360
SD	14	38	54	12	25	47	70	14	24	41	47

BLG = Beach Lifeguards; **POOL** = Pool Testing; **RS1** = Rescue Simulation 1; **RS2** = Rescue Simulation 2; **RT** = Running Time, **AS** = Approaching Swimming, **TS** = Towing Swimming; *****Significant difference between the TS and AS for each condition (P<0.01).

DISCUSSION

The purpose of this study was to assess the physiological and metabolic demands of a rescue simulation in a surf beach and identify the performance determinants. The main findings are: (a) the elevated $[La]_{PEAK}$ after exercise along with a high relative HR indicate that the BLG is a high-intensity occupation when it requires the rescue of a casualty of drowning as fast as possible; and (b) the lack of significant correlations between the pool testing performance with the surf beach rescue performances indicate that swimming in surf beach and handling a casualty require a different set of skills and physiologic responses to those required in a pool situation.

The aerobic fitness level of the BLGs in the present study, as indicated by VO_2 max values (55.6 ± 4 $mL \cdot kg^{-1} \cdot min^{-1}$) obtained by incremental test, is similar to the values reported by Gulbin et al. (8) in the Australian BLGs study, by Hanon et al. (9) regarding recreational runners (9), and by Platanou (16) with water polo players (16). However, no significant correlations were found between laboratory-based incremental test variables and the surf beach rescue performances. This suggests that endurance running should not be the main aerobic training for BLGs, even though a transfer of the central adaptation (e.g., improved bulk O_2 delivery to the exercising muscle) could be obtained by endurance running training primarily in the less fit BLGs (3).

However, it is still reasonable to suspect that aerobic ‘running’ fitness should have an important influence on rescues that require longer running distances or when a complete period of recovery between two rescues is not permitted. The negative significant correlations found between both V_{PEAK} and OBLA with the running time only for RS2 support this latter statement, thus indicating that when a rescue is performed after another prior rescue the lower running times were achieved by the participants with the higher aerobic fitness.

Methodological differences found between studies about lifesaving rescues make direct comparisons and characterization of swimming pool performance difficult. The time taken to perform the first 150 m in the pool by the BLGs could be characterized as a moderate swimming ability (19). However, this ability seems to be enough to rescue a casualty since all BLGs performed the beach rescues simulation in a lower time than suggested by the Fitness Standards for Beach Lifeguards (18). The lack of significant correlation between the pool and beach testing for AS performance may be explained, in addition to the environmental differences, by the fact that BLGs performed a technique called “duck dive,” which is a technique used by BLG to dive under an oncoming wave to arrive at the casualty as quickly as possible (4).

Furthermore, no significant correlations were found for TS between the pool testing and both rescue simulations. These findings apparently represent the different set of determinants of rescue performance (e.g., environment conditions background; the swimming abilities at different places; the sea influence on performance), and that surf swimming and rescue performance could not be predicted by onshore (22) and pool tests, which confirms our first hypothesis. In this way, while pool-swimming workouts could be done to improve general swimming ability, specific inshore swimming workouts (i.e., AS and TS) should be frequently included in the BLG training program in order to improve the specific abilities linked to rescue performance.

In this study we analyzed the influence of a prior rescue exercise on the subsequent rescue performance, a situation that could be possible for a lifeguard. Although no significant difference was found between RS1 and RS2, the significant correlation ($r = 0.82$) achieved between the two tests was lower than other laboratory-based tests ($r = >0.95$) where performances of similar duration were performed with, at least, a 3 hr recovery period (1,11,13). Even though the recovery interval time (30 min) between the rescue simulations were not long enough to return the [La] to resting levels (7), which suggests negative implications on RS2, the general aerobic training status of the BLGs should not be overlooked. Furthermore, the use of the rescue belt during RS2 may have facilitated the towing swimming and counteracted the fatigue effects from prior exercise contributing to an unchanged overall performance. Taken together these findings suggest that both changes in the sea conditions (e.g., number of waves and/or sea currents) and the ability to recover from a previously high-intensity exercise (i.e., the first rescue) may influence a subsequent rescue performance.

The high [La] values observed in the present study were similar to previous lifesaving studies (8,18) and those found in recreational swimmers after 400 m swimming performance (20). The HR responses during all tests are in accordance with the peak heart rate reported by Gulbin et al (8) in a competition of BLGs (21). These findings indicate the high metabolic stress and the remarkable physiological demand required of BLGs in reaching and towing a casualty. Therefore, it is likely that the rescue simulations in the present study were performed at or near maximal aerobic power due the exercise time (6 to 7 min), $[La]_{PEAK}$ (~13 $mMol.L^{-1}$) and HR >90% HR_{PEAK}.

CONCLUSION

The 150 m rescue simulated on the surf beach showed a high physiological demand that is similar to other high-intensity exercises. Moreover, it is clear that the rescue by the lifeguards is strongly dependent of the sea conditions (i.e., uncontrolled environment) that require a different set of swimming skills vs. swim training in a pool. Further training studies are needed to verify the effectiveness of specifics inshore swimming workouts to improve the rescue performance in surf beaches.

Address for correspondence: Amadeo Félix Salvador, Human Performance Research Group, Santa Catarina State University, Av. Pascoal Simone, 358, Coqueiros – Florianópolis - SC - Brazil CEP 88080-350 Telephone: +55 48 33218641, Email: amadeofelixsalvador@gmail.com

REFERENCES

1. Bishop D and Jenkins DG. The influence of recovery duration between periods of exercise on the critical power function. ***Eur J Appl Physiol Occup Physiol.*** 1995;72:115-120.

2. Cairns SP. Lactic acid and exercise performance: Culprit or friend? ***Sports Med.*** 2006;36:279-291.

3. Caputo F and Denadai BS. Effects of aerobic endurance training status and specificity on oxygen uptake kinetics during maximal exercise. ***Eur J Appl Physiol.*** 2004;93:87-95.

4. Claesson A, Karlsson T, Thoren AB, et al. Delay and performance of cardiopulmonary resuscitation in surf lifeguards after simulated cardiac arrest due to drowning. ***Am J Emerg Med.*** 2011;29:1044-1050.

5. Costill DL, Kovaleski J, Porter D, et al. Energy expenditure during front crawl swimming: Predicting success in middle-distance events. ***Int J Sports Med.*** 1985;6:266-270.

6. Daniel K and Klauck J. Physiological and biomechanical load parameters in life saving. ***Biomech Med Swim.*** 1992:321-325.

7. Green HJ. Mechanisms of muscle fatigue in intense exercise. ***J Sports Sci.*** 1997;15:247-256.

8. Gulbin JP, Fell JW, and Gaffney PT. A physiological profile of elite surf ironmen, full time lifeguards and patrolling surf life savers. ***Aust J Sci Med Sport.*** 1996;28:86-90.

9. Hanon C, Lepretre PM, Bishop D, et al. Oxygen uptake and blood metabolic responses to a 400-m run. ***Eur J Appl Physiol.*** 2010;109:233-240.

10. Heck H, Mader A, Hess G, et al. Justification of the 4-mmol/l lactate threshold. ***Int J Sports Med.*** 1985;6:117-130.

11. Hodges K, Hancock S, Currell K, et al. Pseudoephedrine enhances performance in 1500-m runners. ***Med Sci Sports Exerc.*** 2006;38:329-333.

12. Howley ET, Bassett DR, Jr., and Welch HG. Criteria for maximal oxygen uptake: Review and commentary. ***Med Sci Sports Exerc.*** 1995;27:1292-1301.

13. Jensen K and Johansen L. Reproducibility and validity of physiological parameters measured in cyclists riding on racing bikes placed on a stationary magnetic brake. ***Scand J Med Sci Sports.*** 1998;8:1-6.

14. Landers GJ, Blanksby BA, Ackland TR, et al. Morphology and performance of world championship triathletes. ***Ann Hum Biol.*** 2000;27:387-400.

15. Pelayo P, Mujika I, Sidney M, et al. Blood lactate recovery measurements, training, and performance during a 23-week period of competitive swimming. ***Eur J Appl Physiol Occup Physiol.*** 1996;74:107-113.

16. Platanou T. Cardiovascular and metabolic requirements of water Ppo. ***Serb J Sports Sci.*** 2009;3:85-97.

17. Reilly T, Iggleden C, Gennser M, et al. Occupational fitness standards for beach lifeguards. Phase 2: The development of an easily administered fitness test. ***Occup Med (Lond).*** 2006; 56:12-17.

18. Reilly T, Wooler A, and Tipton M. Occupational fitness standards for beach lifeguards. Phase 1: The physiological demands of beach lifeguarding. ***Occup Med (Lond).*** 2006;56:6-11.

19. Robertson E, Pyne D, Hopkins W, et al. Analysis of lap times in international swimming competitions. ***J Sports Sci.*** 2009;27:387-395.

20. Schnitzler C, Ernwein V, Seifert L, et al. Comparison of spatio-temporal, metabolic, and psychometric responses in recreational and highly trained swimmers during and after a 400-m freestyle swim. ***Int J Sports Med.*** 2007;28:164-171.

21. Sinclair WH, Kerr RM, Spinks WL, et al. Blood lactate, heart rate and rating of perceived exertion responses of elite surf lifesavers to high-performance competition. ***J Sci Med Sport.*** 2009;12:101-106.

22. Tipton M, Reilly T, Rees A, et al. Swimming performance in surf: The influence of experience. ***Int J Sports Med.*** 2008;29:895-898.

23. World Health Organization. Guidelines for safe recreational water enviroments, In ***Guidelines for Safe Recreational Water Environments*****.** Geneva, 2003.

Disclaimer