Occupational fitness standards for beach lifeguards. Phase 1: the physiological demands of beach lifeguarding

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Introduction

Although the standards used internationally to select beach lifeguards (BLGs) are similar, it is difficult to determine the scientific rationale that underpins them. Many have been produced as a result of consultation with experienced lifeguards. While this approach has merit, such standards can also be based on a systematic investigation of the tasks involved in beach lifeguarding.

There is a paucity of literature relating to BLGs; most of that which has been written describes their physical and physiological characteristics. Gulbin et al. [1] provide a physiological profile of 55 Australian elite surf iron men, full-time lifeguards and patrolling volunteer surf life savers. They conclude that not all of the latter group would be capable of undertaking all modes of rescue in all surf conditions, and that life savers should have ‘good’ aerobic fitness (oxygen consumptions of 3.55 l/min for 20-year-old males, 2.3 l/min for 20-year-old females). However, these authors did not determine the physical demands of the tasks associated with surf life saving as a basis for these conclusions.

Daniel and Klauck [2] investigated the demands of casualty rescue with 17 lifeguards who performed a simulated rescue involving a sprint swim of 25 m, a 2-m dive to retrieve a dummy and a tow of 25 m. They concluded that life-saving training and events are endurance predominant, and require training similar to competitive swimming; the major difference being the requirement to tow a casualty during life saving; the addition of passive drag while towing requires a contribution from anaerobic energy sources with consequent earlier fatigue.

Unlike many physically demanding occupations, beach lifeguarding mostly involves being at rest (surveillance),

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but with the occasional requirement to move to high intensity activity and casualty handling in a compressed period of time.

This project was designed to identify the minimum level of fitness required to become a BLG based on a tasks analysis of the most physically demanding generic tasks associated with beach lifeguarding in the South West of the UK.

Methods

The project was divided into three phases:

(i) Beach survey and structured interviews to identify the most physically demanding, essential and generic activities undertaken by BLGs.

(ii) A theoretical analysis to determine the time frame in which BLGs must undertake rescue tasks.

(iii) Measurement of the metabolic cost of the most demanding activities.

Ethical approval for each phase was obtained from the University of Portsmouth Ethics Committee. Written informed consent was obtained from each subject.

(i) Ninety-one BLGs (10 female) from every region in the South West of the UK operated by the Royal National Lifeboat Institution (RNLI) were given an individual, structured interview.

(ii) A casualty face down in water will begin to aspirate sea water immediately and death will usually ensue in $\sim 2$ min [3–5]. Should the casualty be observed experiencing difficulties, aspiration may be absent initially, thereby increasing the potential rescue time. However, panic and fatigue will limit the length of time available to affect a rescue, before aspiration commences. It is concluded that in this scenario there is a 3–4 min rescue window. Thus, the distance a BLG is responsible for covering (patrolled area) should be accessible in 3.5 min. Once the victim has been reached, his/her airway secured and the threat of drowning removed, the return to the beach for the majority of casualties is less critical and should be conducted in a way that ensures the safe return of both the casualty and the BLGs. The aim should be to prevent, at most, 10 min of acute cerebral hypoxia. This time represents the maximum duration of hypoxia before the occurrence of irreversible brain damage [5].

(iii) Testing was carried out on three beaches, identified as being representative of the different types of beaches (sea states) supervised by the RNLI. The prevailing sea conditions of each were calm, moderate surf and large surf by UK standards, with wave heights of $<0.5$, $0.5–1$ and $0.5–2$ m, respectively. Twenty-eight BLGs (22 male, 6 female) between the ages of 18 and 45 years were tested [calm ($n = 9$), moderate surf ($n = 10$) and large surf ($n = 9$)]. A series of maximum-effort and self-paced tasks were undertaken on the beach, in the sea and in a swimming pool.

The following sea-based tests were performed twice at maximum effort (confirmed by post-test blood lactate measurement); subjects were permitted to wear standard issue swimming costumes or suits.

(i) Time to run 200 m on the beach parallel to the sea, immediately followed by an offshore swim in the sea to a buoy secured at 200 m.

(ii) Time to run 200 m on the beach parallel to the sea, immediately followed by a 400-m prone paddle on a rescue board (Gainsborough).

Two self-paced tasks were performed continuously for a minimum of 4 min at sea.

(i) Cross-chest tow: The subjects towed a 50-kg marine anthropometric manikin (designed to float in the sea as an unconscious 50th percentile male) using a rescue tube secured around the chest of the manikin.

(ii) Paddle (prone): The manikin was placed on the rescue board and the subject paddled the rescue board. The manikin and subject were prone.

In both tests the subjects were asked to work at the pace they would choose if they were with a casualty, had secured the airway and were returning to shore. The tests were undertaken parallel to the shore beyond the break to minimize the influence of waves and tide. Sea temperature was 17–18°C. Subjects wore lifeguard issue swimming costumes or suits and a nose clip, and breathed through a mouthpiece. The mouthpiece was connected to a respiratory tubing of sufficient length (5 m) to reach a support boat. The boat remained far enough away from the subject to ensure that it did not interfere with the tests. During the last minute of each test, expired gases were collected in a Douglas bag and analysed immediately on return to the beach.

Each subject was required to approach a 41-kg head and torso manikin from the rear, grasp it under the arms, lift it and carry it backwards for 10 m across the beach. This task was used to simulate the individual contribution to a two-man casualty lift. Forty-one kilograms represents 60% of the 50th percentile body mass of the combined male and female British adult aged 19–65 years [6]. On average, the individual at the head end of a casualty carries 60% of the mass of the casualty [7]. The chest circumference of the manikin was 91 cm to match the mean of the 50th percentile British male and female [6].

Each subject undertook the following tests at maximum effort twice in a 25-m heated indoor pool. At least 30 min elapsed between successive tests and blood lactate was measured after each test.
(i) A 200-m front crawl swim.
(ii) A 25-m underwater swim + 25-m surface swim.

Height (cm) and mass (kg) were measured. Percentage body fat was estimated from the measurement of skinfold thickness at four sites as described by Durnin and Womersley [8]. Surface area and body mass index were calculated from height and mass [9]. All timings were taken in duplicate. Handgrip strength was measured (Grip ATKK 5001, Takei Scientific Instruments, Japan) in duplicate in the dominant and non-dominant hands of each subject with the shoulder adducted and arm straight in the neutral position. A maximum contraction for each side was recorded. Blood lactate was measured from a finger or ear prick blood sample taken 3 min after cessation of each maximum activity (ProTest meter, Arkray Inc., Japan). Exhaled gas (Douglas bags) was analysed for oxygen and carbon dioxide concentration (Servomex, Japan). Volumes were corrected to standard temperature pressure dry (STPD) for the calculation of oxygen consumption (VO\textsubscript{2}).

Data were analysed using simple descriptive statistics with Minitab® 13 software.

### Results

The most demanding strength-related tasks reported were casualty handling onto a rescue boat, board or beach; setting up the beach and boat/jet ski launch. The most demanding endurance-related tasks reported were sea swimming while towing a casualty, board paddling with a casualty and beach running (primarily required during training only).

In the regions studied, BLGs were required to paddle a median distance of 400 m in order to cover the patrolled area. The BLGs reported that they would rarely swim more than a maximum of 200 m, and seldom needed to run as they stationed themselves at the water’s edge. They may run 170 m (median) over the sand and into the sea; setting up the beach and boat/jet ski launch. The physical characteristics of the subjects undertaking the beach and pool testing are presented in Table 1.

With regard to grip strength, both the male and female subjects were categorized as ‘Average’ (combined right and left hand-grip strength) according to the norms established in Canadian Standardized Fitness Tests, 1981 [10]. All subjects (n = 28) were able to pick up the 41-kg manikin from the rear, grasp it under the arms, lift it and carry it backwards for 10 m.

Mean 200-m swim time in the sea was 3.1 min or 188 s (SD = 46 s) (Table 2). Mean 400-m paddle time was 3.9 min or 235 s (SD = 37).

The total mean time to attend a casualty at the limit of the area patrolled by swimming (200 m) after 200 m running was 36 s (run) + 188 s (swim) = 3.7 min or 224 s. Normally BLGs patrol the water’s edge, and there is no demand for running. Ninety-five percent of BLGs were able to swim 200 m in 3.5 min or 211 s (n = 22) (Figure 1). Post-exercise lactate level [mean (SD)] was 12.3 (2.2) mmol/l.

The total mean time to attend a casualty at the limit of the area patrolled by paddling (400 m) after 200 m running was 38 s (run) + 235 s (paddle) = 4.6 min or 273 s. Again, BLGs patrol the water’s edge, which negates the time required to run. Thirty percent of the BLGs were able to paddle 400 m in 3.5 min (n = 23) (Figure 2). The 5th percentile paddling speed was 1.38 m/s; therefore, 95% of the BLGs tested had the ability to paddle 289 m in 3.5 min. Mean (SD) blood lactate following running and paddling was 10.4 (2.4) mmol/l.

The self-paced casualty towing and paddling results are presented in Table 3.

The mean time for the pool-based 200-m swim was 2.95 min or 177 s (SD = 26 s). The mean (SD) time for the 25-m underwater swim was 22 (3) s, and 41 (5) s for the total 25-m underwater and 25-m surface swim.

### Table 1. Physical characteristics of UK BLG sample

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male (n = 22)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>24.4 (5.6)</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>80.9 (10.8)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>181.9 (7.7)</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>15.2 (4.3)</td>
</tr>
<tr>
<td>Maximum grip (kg) left</td>
<td>53.2 (7.8)</td>
</tr>
<tr>
<td>Maximum grip (kg) right</td>
<td>54.3 (7.9)</td>
</tr>
</tbody>
</table>

### Table 2. BLG performance on a 200-m beach run followed by either a 200-m swim out to sea (n = 26) or a 400-m paddle (n = 23)

<table>
<thead>
<tr>
<th>Mean of two trials</th>
<th>Run and swim</th>
<th>Run and paddle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Run time (s)</td>
<td>Swim time (s)</td>
</tr>
<tr>
<td>200 m</td>
<td>36</td>
<td>188</td>
</tr>
<tr>
<td>200 m</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>5th percentile</td>
<td>28</td>
<td>138</td>
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<tr>
<td>95th percentile</td>
<td>44</td>
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<td>Minimum</td>
<td>27</td>
<td>107</td>
</tr>
<tr>
<td>Maximum</td>
<td>45</td>
<td>295</td>
</tr>
</tbody>
</table>

*Potential interference with shipping lanes prevented a 400-m paddle offshore, so subjects paddled 200 m out to a buoy and returned to the shore; turning time was subtracted from total time. The time to paddle 400 m straight out to sea was then estimated by dividing the time for the total paddle by 2, and adding this to the time taken to paddle out the initial 200 m to sea (into the surf).*
Ninety-five percent of BLGs could swim 25 m underwater in 26 s and swim 25 m underwater and 25 m on the surface in 49 s (\(n=20\)).

**Discussion**

This study was designed to identify the most physically demanding generic tasks associated with beach lifeguarding in the South West of the UK, an area that contains a wide variety of beaches with regard to sea state (surf conditions). The findings were considered in the context of a theoretical assessment of the performance required to rescue a casualty from the sea in order to prevent drowning, and the minimum aerobic and strength standards required to become a BLG. The paddle and swim times recorded during the present study suggest that we sampled a range of abilities, and our subjects were not restricted to the most capable BLG. No consideration was given to surveillance capabilities and the time taken to observe a casualty in difficulties.

The similarity of the times taken to swim 200 m in the sea and in a pool initially seemed surprising. However, given that running is faster than swimming, the factor that brought these times together was the amount of running that could be done in the sea. Thus, although swimming may have been slower in the sea than a pool, this was compensated for by the fact that BLGs could run a proportion of the 200 m in the sea. This also helps to explain why there were no differences between beaches with and without surf; more running could be done at the shallower surf beaches.

In a Royal Life Saving Society report of 503 drownings in 2002 [11], the distance offshore was recorded for 230 incidents. Of them, 181 occurred within 50 m of shore. Circumstances in the UK correspond to those in Australia, where the majority of rescues undertaken by BLGs also occur within 50 m of the shore [1]. However, if an organization has accepted the responsibility of providing cover over a designated ‘patrolled area’, they should be able to provide a ‘reasonable prospect of survival’ within this area. On the basis of a theoretical assessment, we have decided upon 3.5 min as the performance criterion for reaching a drowning casualty. This time period can, at best, only be an approximation, but in the absence of any definitive data, appears reasonable. Thus, our definition of ‘a reasonable prospect of survival’ translates into a delay of no > 3.5 min before a drowning victim is reached by a BLG.

With a little training, in excess of 95% of BLGs should be able to swim 200 m in the sea in < 3.5 min. However, only 30% would be able to cover 400 m by paddling in this time. In order to increase this percentage to > 95%, the patrolled area for rescue boards would have to be reduced. At the average paddling speed of 1.7 m/s a BLG would cover 357 m in 3.5 min. At the 5th percentile paddling speed of 1.38 m/s, a BLG would cover 289 m in 3.5 min. Thus, 95% of BLGs tested could cover 289 m in 3.5 min. As a consequence it is recommended that on beaches with rescue boards, but no inshore rescue boat or rescue water craft, the patrolled area be reduced from 400 to 300 m.

The 25-m underwater swim followed by a 25-m return freestyle in under 50 s was employed to ensure that BLGs were effective and efficient swimmers, confident under the water and had good swimming power in anaerobic conditions. Ninety-five percent of BLGs tested in this study achieved this standard. The results of the BLGs tested in the present study were similar to those obtained from lifesavers in Australia [1]. For example, the mean (SD) time taken to swim 25 m underwater, followed by 25 m on the surface was 41 s in the present study compared with 39 (6),
35 (2) and 31 (3) s for Australian life savers, lifeguards and iron men, respectively. The mean (SD) 200-m pool swim in the present study was 177 (26) s compared to 200 (46), 162 (14) and 136 (9) s for Australian life savers, lifeguards and iron men, respectively [1].

The cardiovascular demands of towing a casualty in the sea and paddling a casualty in the sea have been quantified. The mean aerobic demands are approximately equivalent to those seen during walking at 7.5 km/h and running at 11 km/h. It has been concluded that a BLG must be capable of returning the casualty to the beach in 6.5 min (3.5 min to casualty, 6.5 min back to beach to prevent, at most, 10 min of acute cerebral hypoxia). Given that a BLG should not reach the beach exhausted, and should be able to assist in casualty handling and resuscitation, the demands of towing or paddling should not exceed 70% of BLG maximum oxygen consumption (VO_{2\text{max}}). In fit, trained but non-elite athletes, this is as high a percentage as is recommended to work to avoid excessive anaerobic metabolism and fatigue [12–15].

One of the potential job demands of a BLG is the performance of cardiopulmonary resuscitation (CPR). Miles et al. [16] reported that the provision of one-man CPR under non-stressful conditions represents only a moderate physiological demand requiring a heart rate of 50% of maximum, and an oxygen consumption of 1.24 l/min (18 ml/kg/min). Similar metabolic demands while performing CPR have been reported by other authors [17–19]. A BLG who has sufficient fitness to satisfactorily swim and tow/paddle with a casualty, should possess the necessary fitness to undertake CPR, even after a rescue.

Finally, the strength requirement to perform casualty handling was assessed as the ability to lift and move 41 kg. This did not appear to present undue problems to any of the BLGs tested. It is concluded that BLGs should be able to reach a drowning casualty within 3.5 min by the means at their disposal, and over the agreed distance of the patrolled area. The casualty should be returned to the shore within a total of 10 min. With regard to swimming or board paddling, the two ways of achieving these standards are to improve the performance of BLGs or shorten the patrolled area. On the basis of the BLGs tested in the present study, all BLGs should be able to swim/run 200 m out to sea within 3.5 min. However, it has been demonstrated that a similar level of success will not be achieved when attempting to paddle 400 m in 3.5 min. Consequently, we recommend that the patrolled area should be reduced from 400 to 300 m.

The next phase of the project (following paper) assessed the relative effort required by BLGs to achieve the necessary standards for towing and paddling with a casualty. The possibility of developing predictive pool-based assessments was investigated with the aim of producing an easy-to-administer, task-based, fitness standard.

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Conflicts of interest
None declared.

References

