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RESEARCH

Too Much Puff, Not Enough Push? Surf Lifeguard Simulated CPR Performance

Kevin Moran and Jonathon Webber

The purpose of this paper is to report on the technical competency of volunteer surf lifeguards to perform CPR on a manikin in light of their lifeguard experience, age, and gender. The CPR skills of surf lifeguards on patrol at the beginning of the 2010–11 summer season were tested on manikins by observation of CPR procedures and electronic recording of compression and ventilation skills. Almost all lifeguards (n = 252) made the appropriate initial checks for responsiveness (98%). Compression skills were generally performed accurately with few technical errors (such as incomplete release). Most lifeguards (87%) over-ventilated the lungs (> 600 ml) on each breath and, of these, one third (31%) over-ventilated to a point that may worsen gastric distension (> 1000ml). Males were significantly more likely ($\chi 2$ = 28.965, df = 14, p = .011) to over-inflate the lungs during testing. Reasons for poor performance are discussed and ways of addressing errors are suggested.

Victims of drowning are more likely to survive when effective CPR is applied immediately (Layon & Modell, 2009). In developed countries, many drowning incidents occur during aquatic recreation at supervised open water sites, and lifeguards are required to provide immediate emergency care (Branche & Stewart, 2001; Faddy, 2002; Fenner, Harrison, Williamson, & Williamson, 1995; Manolios & Mackie, 1988). Yet in spite of comprehensive reporting of lifeguard rescue activity in countries such as New Zealand (Surf Life Saving New Zealand, SLSNZ, 2010), Australia (Surf Life Saving Australia, SLSA, 2010), and the U.S. (United States Lifesaving Association, USLA, 2010), not a lot is known about the technical competency of lifeguards to perform CPR. Furthermore, little is known about the impact of changes to resuscitation guidelines in 2010 (New Zealand and Australian Resuscitation Councils, NZAUSRC, 2010) on lifeguard CPR skills. The purpose of this paper is to report on the technical competency of volunteer surf lifeguards to perform CPR on a manikin in light of their lifeguard experience, age, and gender.

Evidence of the perceptions and practice of CPR by surf lifeguards is sparse. A retrospective case survey of 171 resuscitation incidents on Queensland surf beaches from 1973 to 1992 reported a success rate of 67% for immersion victims, a success rate attributed to close proximity and short response time of lifeguards to the victims (Fenner et al., 1995). An earlier Australian study reported that of 262 immersion victims requiring resuscitation at patrolled surf beaches during

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1973–83, less than one quarter (22%) of initially pulseless and apnoeic patients survived (Manolios & Mackie, 1988). Another Australian study has suggested that lifeguards had unrealistic expectations of the chances of success for CPR in return of spontaneous circulation (ROSC) with most (80%) expecting a 36% or better chance of survival (Faddy, 2002). More recently, the authors have reported more realistic estimates of success rates of CPR use in out-of-hospital cardiac arrest (OHCA) by New Zealand surf lifeguards with almost half (48%) expecting less than 25% chance of survival (Moran & Webber, 2012).

Some studies have reported on the efficacy of preservice/in-service training of medical, paramedical, professional personnel, and laypeople (Garcia-Barbero & Caturla-Such, 1999; Fossel, Kiskaddon, & Sternbach, 1983), the effectiveness of different forms of CPR training (Adelborg, Dalgas, Grove, Jorgensen, Al-Mashhadi, & Lofgren, 2011; Brennan & Maslow, 2000; Chamberlain et al., 2002; de Vries & Bierens, 2010; Faddy, 2002; Isbye, Rasmussen, Lippert, Rudolph, & Ringsted, 2006; Lynch, Einspruch, Nichol, & Aufderheide, 2008; Lynch et al., 2005; Niles et al., 2009; Reder & Quan, 2003; Todd et al., 1998), and levels of retention after training (Chamberlain et al., 2002; De Vries & Bierens, 2010; Niles et al., 2009; Weaver, Ramirez, Dorfma, & Raizner, 1979). Other studies have explored the physiological demands of performing CPR and the effect of fatigue (Claesson, Karlsson, Thoren, & Herlitz, 2011; Odegaard, Saether, Steen, & Wik, 2006; Reilly, Wooler, &Tipton, 2006).

A study on the quality of lay person CPR performance indicated some deterioration in quality of chest compressions over time when different compression to ventilation ratios were used (Odegaard et al., 2006). A study on British surf lifeguards reported that they possessed the necessary fitness to perform CPR after a strenuous rescue (Reilly et al., 2006), while another study found similar capacities among 42 Swedish surf lifeguards whose performance of CPR was unaffected by a 100 m rescue and tow/carry (Claesson et al., 2011). In the Swedish study, the proportion of adequate compressions was identical at 8–10 min of CPR for both rested and fatigued lifeguards. It was anticipated that the current study would provide a comprehensive analysis of the technical competency of surf lifeguards to perform CPR in simulated manikin practice, and it was hypothesized that skill levels would vary with age, gender, and lifeguard experience.

Method

Study Design

A cross-sectional design was used to ascertain CPR competencies of volunteer surf lifeguards in relation to age, gender, and length of service. The first phase of data collection consisted of a self-complete questionnaire containing 14 questions that elicited information on demographics (e.g., age, gender, length of lifeguard service) and information on CPR training, previous use, and perceptions of CPR efficacy. The results of this phase of the study have been reported previously (Moran & Webber, 2012). The second phase of data collection consisted of a practical test of CPR skills on a manikin.

The study took place during early season patrols on 10 weekends between November 2010 and January 2011. Before the commencement of the study, ethics approval was obtained from the University of Auckland Human Participants Ethics

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Committee (Project number 2010/400). Informed consent in writing was obtained from each participant after written and verbal explanations of the study were provided to club administrators, patrol captains, and surf lifeguards who had agreed to take part in the study.

Participants

The participants in the study were volunteer surf lifeguards in the Auckland region. Lifeguards with a health-professional background or who were employed as professional lifeguards in the summer season (requires additional CPR training) were excluded from the study. At the beginning of each season, surf lifeguards in New Zealand are trained/retrained in rescue competency, CPR, and other first aid procedures as a prerequisite to participation in patrol activity. This training takes place on designated refresher days and during initial patrols and requires lifeguards to demonstrate CPR competency on a manikin as well as answer questions on CPR protocols. Using mastery learning strategies to promote successful completion, training/retraining is conducted by qualified instructors within each surf club/region using SLSNZ standard BLS/CPR formatted theory and practical tests with designated required levels of competency.

Research Instruments

The practical CPR skill test was conducted using two Laerdal ResusciAnne® SkillReporter manikins, electronically calibrated to measure a range of resuscitation parameters (for example, compression depth and rate per minute, respiratory tidal volume, and rate per minute). While not able to represent all possible conditions for CPR application, it was assumed that the manikins provided an accurate opportunity to assess simulated CPR on an adult (Adelborg et al., 2011; Berden et al., 1994). The practical test was based on the New Zealand Resuscitation Council (NZRC) guidelines (NZRC, 2006) and adult collapse algorithm (NZRC, 2007) current at the time of the study and adopted by SLSNZ in their training of lifeguards. Correct execution of compression and ventilations skills was assessed over a 2-min period of CPR, commencing from the delivery of the first chest compression.

"Correct compressions" were recorded on the manikin as 4–5 cm in depth with no incomplete release or incorrect hand placement and "correct ventilations" as 500–600 ml in volume, with each ventilation delivered over a minimum of one second (NZRC, 2007). Note: authors recognize that the most recent Guidelines (NZAUSRC, 2010) based on the 2010 ILCOR recommendations suggest delivery of chest compressions at a depth of at least 5 cm. It was estimated that in 2 min of CPR at a compression/ventilation ratio of 30:2 the lifeguard would perform 5 cycles, comprised of 150 compressions and 10 ventilations.

Procedures

Standardized test procedures were developed and their efficacy evaluated on lifeguards in a pilot study one month before the commencement of the data collection, using a group of 12 lifeguards who did not take part in the main study. Results from each observer were compared and procedures amended to minimize observer bias during testing in the main study. All participants were tested individually in a designated room away from the surf patrol area. Lifeguards undertook a practical test of CPR skills using resuscitation manikins while being observed by the examiners who were assessing procedures using a standardized checklist of Danger, Response, Send for help, Airway, Breathing, Chest compressions (DRSABC). They were read a standard scenario briefing card that suggested they had arrived for patrol but no other lifeguards or bystanders were present when an adult collapsed on the beach in front of them. They were informed that gloves (optional) and face shields (compulsory) were available for them to use. The gloves were presented as an option to test whether the lifeguard considered them important to safety.

Data Analysis

Data from the completed questionnaires and manikin printouts were downloaded into SPSS Version 17 for statistical analysis. Descriptive statistics described or characterized all numeric variables using frequency and percentages. Continuous variables, including 10 observed skills during simulated CPR over 2 min (Table 1), 9 compression skills via electronic recording (Table 2), and 7 ventilation skills via electronic recording (Table 3), are reported using measures of central tendency and dispersion (mean, standard deviation and range).

Chi-square statistics were used to test associations between the independent sociodemographic variables of age (subsequently dichotomized into lifeguards aged 30 years or less years and lifeguards aged > 30 years), gender, and length of lifeguard service against CPR competencies. Logistic regression analysis was used to examine how well the sociodemographic variables predicted the performance of the various CPR skills tested. After confirming there were no violations of the classical linear model, the goodness-of-fit of each bivariate model was examined using an ANOVA F test of significance, with the proportion of variance in the dependent variable explained by the predictor variable/s assessed using the adjusted R-square statistic.

Results

Of the 280 volunteer surf lifeguards invited to participate in the study, a sample of 260 lifeguards from 16 clubs in the greater Auckland region completed the survey and practical skills test, representing a response rate of 93%. Of these, 8 cases were excluded from the final analysis because of equipment malfunction during one test leaving a sample of 252 lifeguards. The sample included more males than female participants (male 57%, female 43%), 63% of lifeguards were less than 20 years of age, and 77% had less than 6 years of lifeguard experience. Almost two-thirds (65%) of participants had received lifeguard CPR training in the 3 months before the study, a further 27% had received training in the previous 4–12 months.

Observed CPR Skills

Table 1 shows that most lifeguards (72%) did an immediate check for danger to themselves, their patient, and others, but many who failed this aspect of the emergency response did so because they failed to don the protective gloves. Almost all lifeguards made the appropriate checks for responsiveness (98%), establishing the airway (92%), checking for breathing (94%), commencing chest compressions

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Table 1 Observed CPR Skills of Lifeguards

Observed Skill	Correct Response	
	n	%
Danger (checks safe to approach, dons gloves)	180	72.0
Responsiveness (checks using voice and touch)	244	97.6
Send for help (activates EMS/summons assistance)	178	71.2
Airway (opens airway using head-tilt/chin-lift)	231	92.4
Breathing (checks breathing ≤ 10 seconds)	236	94.4
Upon being told "not breathing" goes for help (or indicates they would do so)	70	28.0
Chest compressions (commences CPR)	245	98.0
Correct ratio (30:2)	225	90.0
Maintains airway between sets of compressions	214	85.6
Correct sequence (DRSABC)	120	48.0

(98%), establishing a correct compression/ventilation ratio of 30:2 (90%), and maintaining an open airway between sets of compressions (86%).

More than one quarter (29%) did not send for help after determining that the patient was unresponsive, and only 28% indicated that they would go for help after determining that the patient was not breathing. As a consequence of these lapses, we deemed that slightly less than half of the participants (48%) performed the emergency response in the correct sequence.

No significant differences were evident when observed skills were analyzed by length of service or gender. Significant differences were reported when observed skills were analyzed by age group with regard to the preliminary checking phase. Younger lifeguards (< 30 years old) were more likely ($\chi 2 = 19.543$, df = 3, p = < 0.001) than older lifeguards (> 30 years old) to check for danger at the outset of an emergency response (< 30 years old, 78%: >30 years old, 46%). Younger lifeguards were more likely to correctly check for an initial response ($\chi 2 = 13.021$, df = 3, p = .005), although most lifeguards, irrespective of age were observed making the appropriate checks for responsiveness (< 30 years old, 99%: > 30 years old, 94%). Younger lifeguards also were more accurate in their initial call for help ($\chi 2 = 10.458$, df = 3, p = .015), with more young lifeguards having been observed initiating the appropriate call for help (< 30 years old, 75%: > 30 years old, 54%). No significant differences were observed by age with regards to the ensuing application of compression and ventilation skills.

Compression Skills

Table 2 shows that compression rates (127 ± 17.7 min-1) tended to exceed the recommended compression rate of 100 per minute, although the total number of compressions delivered (142 ± 13.6) was slightly less than the recommended total of 150 compressions in the 5 cycles that should occur in 2 min. Participants were accurate in the depth of chest compressions (M = 40.63mm ± 8.684, range

Table 2 Compression Skills of Lifeguards

Compression Skills	Mean	SD	Range
Mean compression rate (100 per minute)*	127	17.7	52–172
Mean compression depth (4-5 cm)*	40.63 mm	8.7	14–58 mm
Total number of compressions (150 in 2 minutes)*	141.9	32.5	28–242
Technical Errors			
Compressions "too deep" (> 5cm)*	25.4	44.2	0–173
Compressions "too shallow" (< 4cm)*	49.6	55.6	0–212
Hand positions "too low"	12.5	32.4	0–145
Other wrong hand positions	35.4	47.6	0–195
Incomplete releases	5.4	18.9	0–118

*Recommended in NZRC Guidelines 2007.

14–58mm), the recommended depth at the time of testing being from 40 to 50mm (NZRC, 2007).

In terms of technical errors, 4% of lifeguards performed incomplete releases, 9% placed their hands too low, 18% compressed the chest too deeply, 25% at some stage compressed the chest using a wrong hand position, and 35% were too shallow during the 2 min test duration, although male lifeguards tended to compress to a greater depth and at a slightly faster rate than female lifeguards.

Ventilation Skills

Table 3 shows that lifeguards provided slightly fewer ventilations than the recommended 10 in 2 min of manikin practice, but many over-inflated the lungs resulting in an excess minute volume. Most lifeguards (87%) over-ventilated the lungs (> 600ml) on each rescue breath and, of these, 31% over-ventilated to a point that might worsen gastric distension (> 1000 ml; Wenzel et al., 1998). A small proportion (3%) under-ventilated the lungs (< 500ml) and only 9% consistently remained within the normal range (500–600 ml). No significant differences were found when ventilation skills were analyzed by age group or length of lifeguard experience.

Figure 1 shows that males were significantly more likely than females ($\chi 2 = 28.965$, df = 14, $p = .011$) to over-inflate the lungs during testing on the manikin.

Regression analysis was conducted to investigate how well the gender of the lifeguard predicted the volume of ventilation that was used during CPR. The regression analysis showed that results were statistically significant $F(1,243) = 10.49$, $p < .001$. The adjusted R squared value ($R = .04$) showed that 4% of the variability in the volume of ventilation used is explained by the gender of the lifeguard.

Discussion

The single most important finding of the study was the marked tendency for lifeguards to over-inflate the lungs during rescue breathing (935.55 ml ± 293 ml). Excessive ventilation volumes were reported for both rested (1174 ml ± 324 ml) and exercised surf lifeguards (1203 ml ± 377 ml) after 8 min of CPR by Claesson

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Table 3 Ventilation Skills of Lifeguards

Ventilation Skills	Mean	SD	Range
Average number of ventilations per minute	4.0	1.0	2–9
Average tidal volume of ventilations	935.6	292.9	400–1790
Minute volume ventilations in 2 minutes	3709.8	1481.9	500–8950
Total number of ventilations	8.8	2.6	2-19
Technical Errors			
Ventilations "too fast" in 2 minutes	5.5	3.7	0–16
Ventilations "too little" in 2 minutes	2.4	2.9	0–19
Ventilations "too much" in 2 minutes	3.7	3.7	0–16

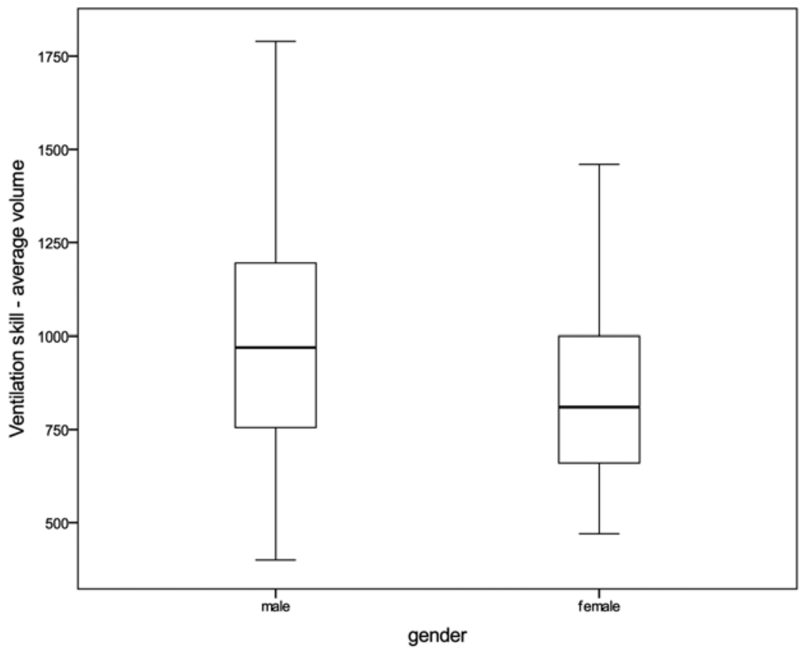

Figure 1 — Comparison of average tidal volumes (ml) by gender. The boxes represent the interquartile range and median values. The protruding whisper lines show the smallest and largest values. The boxes show that male lifeguards rescue breaths are of greater average volume than females as well as greater range.

and colleagues (2011). This is potentially harmful since hyperventilation causes increased intrathoracic pressure, thereby decreasing venous return to the heart and reducing cardiac output (Aufderheide et al., 2004). Wenzel and colleagues (1998) suggested that when the airway is unprotected as in an unconscious patient, a tidal volume of 1000 ml produces significantly more gastric distension than a tidal volume of 500 ml. Low minute-ventilation (e.g., lower than normal tidal volume and respiratory rate) can maintain effective oxygenation and ventilation during CPR (Idris, Gabrielli, & Caruso, 1999).

The reasons why lifeguards in this study and other studies (Adelborg et al., 2011; Claesson et al., 2011) tend to over-inflate the lungs are unknown. One possible explanation is that the surf lifeguards in this study were predominantly young and aerobically fit (since they are required to perform swimming-related tests during their training/retraining). They may thus have possessed healthy lung capacities and strong forced expiratory musculature that may have caused over-inflation of the manikin lungs, but further research is required to corroborate or refute this speculation. Another possible explanation is that lifeguards may simply not have been exposed to the accurate recording of ventilation volumes during their initial training or annual retraining. Further study is required to determine if this is the case, but given the extent of over-ventilation reported here, it is recommended that instructors emphasize caution when teaching expired air breathing, especially among male lifeguards. Strict adherence to the current guidelines for rescuers to give each rescue breath extended over 1 s, with enough volume to make the victim's chest rise, but to avoid rapid or forceful breaths is recommended (NZAUSRC, 2010). We also recommend that manikins that can accurately record over-ventilation be a part of normal training/retraining practice.

Most lifeguards appeared well trained in the primary survey (DRSABC), the exceptions being in the timing of the call for assistance and the donning of gloves. Why most lifeguards (72%) failed to send for assistance is difficult to explain. One possible explanation is that the scenario described an event on the beach before patrol; lifeguards may have assumed that fellow patrol members would have initiated the standard "assistance required" response. The failure to don gloves for self and patient protection is difficult to explain, and since it is standard clinical practice in emergency medicine, it needs to be emphasized in future BLS/CPR lifeguard training.

No significant differences were evident when observed skills were analyzed by gender or length of service, but significant differences were reported when we analyzed observed skills by age group with regard to the preliminary checking phase. Younger lifeguards (< 30 years old) were more likely than older lifeguards (> 30 years old) to check for danger at the outset of an emergency response, correctly check for an initial response, and summon initial help. Similar age-related differences in BLS initial response skills were reported in a Dutch study of 139 lifeguards with younger lifeguards performing significantly better than older lifeguards (deVries & Bierens, 2010). One possible reason for these age-related differences is that older lifeguards may be more habituated in their responses and more resistant to periodic changes in protocols. Alternatively, de Vries and Bierens (2010) suggested that younger lifeguards may retain and retrieve new information and skills more readily because they cannot rely on previous knowledge or experience.

Compression skills were generally performed accurately with relatively few technical errors (such as incomplete release), and we found no significant differences when analyzed by age, length of lifeguard experience, or gender. One aspect that needs to be addressed as a consequence of the recent changes to the recommended guidelines in 2010 is the delivery of chest compressions to a depth of at least 5 cm (NZAUSRC, 2010). Lifeguards tended to compress the chest 1cm less than the new recommended depth, an inaccuracy that reflects the timing of new guideline release and upskilling of lifeguards at the start of the 2010–2011 summer season.

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Limitations of the Study

While the results of this study offer sound evidence to guide future training and use of CPR in drowning prevention, several limitations should be borne in mind.

First, the study was limited to the study of CPR using manikins rather than real-life situations. Second, it was confined to volunteer surf lifeguards patrolling the greater Auckland region at the beginning of the summer season, so the influence of local recent training may influence the results and limit generalization of results to others. In addition, because the testing took place over 10 weekends at the start of the season, lifeguards tested later in the study might have been disadvantaged by memory decay while others might have been alerted to the possibility of being tested and undertaken self-testing. Third, all subjects were rested so the effect of fatigue associated with rescue before the accurate performance of CPR is not known. Fourth, participants only completed a primary survey (DRSABC) and 2 min of CPR in the practical test (i.e., the time recommended when feasible in current guidelines, 2010), so the influence of fatigue was not tested. Recent consensus recommendations from the United States Lifeguard Standards Coalition (2011) suggest that lifeguards routinely should be assessed for a period of 9 min of CPR use, the average U.S. emergency medical services response time. Fifth and finally, the practical skill test confined respondents to a nondrowning related, adult cardiac arrest scenario requiring a single person response, whereas most surf rescue and drowning emergencies are conducted by teams of lifeguards.

Conclusion

Results suggest that surf lifeguards taking part in the study were generally proficient in the skills of CPR, except for a tendency to strongly over-ventilate the lungs and slightly under-compress the heart during simulated manikin practice. Younger lifeguards performed better than older lifeguards at the preliminary checking of a patient and females were more accurate than males in their ventilation skills, especially with regard to correct tidal volumes. More opportunity for practice on manikins capable of accurately reporting errors such as over-ventilation and under-compression is recommended.

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