Applied Ergonomics 59 (2017) 27–33

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

The identification of combat survivability tasks associated with naval vessel damage in maritime environments

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ARTICLE INFO

Article history:
Received 14 September 2015
Received in revised form
29 July 2016
Accepted 26 August 2016

Keywords:
Employment standards
Task analysis
Physically demanding occupation

ABSTRACT

Effective Navy personnel have the physical ability to perform combat survivability tasks commensurate with their unique physical requirements due to the distinctive characteristics of naval platforms. The aim of this investigation was to identify the physically demanding whole-of-ship tasks that are performed by Navy personnel while at sea. A mixed method design was used to identify tasks, inclusive of focus groups and field observations. From a series of ten focus groups, nine tasks were deemed to be physically demanding whole-of-ship tasks. A subsequent field observation of a combat survivability training course resulted in a refined and expanded 33-item list of physically demanding whole-of-ship tasks across six categories, including; replenishment at sea, emergency response, firefighting, leak stop and repair, toxic hazard and casualty evacuation. The findings from this study provide the basis for the development of physical employment standards for whole-of-ship tasks within the Royal Australian Navy.

1. Introduction

Active combat has illustrated the devastating effect weaponry such as anti-ship missiles, torpedoes and mines can have on naval vessels. To survive such attacks, it is necessary for the conduct of physically demanding and time critical firefighting, leak stopping and structural repair in order to maintain operability (Famme and Taylor, 1992; Brown et al., 2000). Even during peacetime, knowledge of- and proficiency in-damage control cannot be relaxed due to the ever present potential for fire, collision and/or grounding of maritime vessels (Zhu et al., 2002). The main aims for employing combat survivability measures include limiting the extent of damage and protecting personnel from the effects of vessel damage. These aims cannot be met if proficiencies in combat survivability are not maintained through regular training and exercise. The skill sets involved in combat survivability are perishable and any decline can be catastrophic, involving the potential for loss of resources and/or life (Report of the board of enquiry, 2003).

The physical demands of specific whole-of-ship tasks performed by Navy personnel have previously been investigated (Bilzon et al., 2001; Bilzon et al., 2002). These studies were conducted on a single Frigate of the Royal Navy and identified that many common tasks, especially those relating to combat survivability, are whole-of-ship tasks performed by the entire ship's company. In fact, many Navy personnel spend a greater proportion of their work time performing these whole-of-ship tasks than category-specific tasks (Dowrick et al., 2007). For example, shipboard firefighting is a physically demanding task that all personnel are required to perform if required, with an aerobic demand of up to 43 ± 6 ml $min^{-1} \cdot kg^{-1}$ for a manual handling task (Bilzon et al., 2001), which is similar to the 43 ml $min^{-1} \cdot kg^{-1}$ reported during civilian firefighting (Gledhill and Jamnik, 1992). Manual handling tasks during firefighting seem to be common among firefighting services with the majority of fireground work involving dragging and carrying (Phillips et al., 2012).

It is possible that combat survivability related whole-of-ship tasks are common across platforms, and the analysis conducted by Bilzon and colleagues (2001, 2002) may not necessarily cover the physical demands of the same tasks conducted on other platforms. When investigating common intra- and inter-platform tasks, a

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http://dx.doi.org/10.1016/j.apergo.2016.08.014

number of factors must be taken into account. Each ship class has its own set of unique characteristics. For example, the platforms of the Royal Australian Navy (RAN) range in size from about 35 m to 190 m in length, have two-to-six main working decks and vary in crew size from about 15 personnel to 200 personnel (Royal Australian Navy, 2015). These characteristics may dictate the physical and physiological demands of certain tasks, even those that are common across platforms. It is essential in the development of physical employment standards in maritime environments that job task analyses (Sharkey and Davis, 2008) are conducted to identify common inter- and intra-platform tasks and the characteristics of such platforms are taken into consideration. This will ensure that tests are developed that ensure personnel have the appropriate physical capacity to safely and effectively carry out those tasks (Larsen and Aisbett, 2012).

Therefore the aim of the current study was to identify the common intra- and inter-platform whole-of-ship tasks of the RAN. It was expected that common intra- and inter-platform whole-of-ship tasks would be identified and the potential of a ‘baseline’ physical employment standard for naval forces would be viable.

2. Methods

2.1. Experimental design

All participants gave written informed consent to all procedures approved by the Australian Defence Human Research Ethics Committee throughout all phases of this study. The experimental design of the current study followed a mixed-methodology stepwise approach and was adapted from previous models of trade and task analyses (Taylor and Groeller, 2003; Payne and Harvey, 2010), including the identification, review, confirmation and initial observation of job tasks (Fig. 1). The design incorporated a decision tree throughout the process to aid in systematic task reduction.

2.2. Sea-riding experience

To gain an initial understanding of general sea tasks and the day-to-day duties of a ship's company at sea, members of the research team were attached to a Guided Missile Frigate of the RAN for a period of five days. The Adelaide Class Guided Missile Frigate is a major warship within the RAN providing, roles such as long range escort and surface and undersea warfare. The Adelaide Class Guided Missile Frigate has a displacement of 4267 tonnes, a 13.7 m beam and a 4.5 m draught and is 138.1 m in length with six main working decks. The total complement of crew on a RAN Adelaide Class Guided Missile Frigate is 184 persons. The five days aboard the vessel coincided with the ship's work-up period, which is the period of time when training is provided to reach the required level of ship-level technical capability necessary for an operation. The RAN advised the researchers that this period would allow for the greatest concentration of tasks being performed.

2.3. Policy and research document review

After the sea-riding field observation, a review of damage control policy (Royal Australian Navy, 2015) and a 168-item RAN whole-of-ship occupational analysis (Dowrick et al., 2007) was conducted. This review was undertaken in order to construct an initial inventory of physically demanding whole-of-ship activities to be presented in subsequent focus groups (Table 1). The tasks included in the whole-of-ship task inventory were selected independently by two members of the research team. In order to limit the number initial tasks presented to participants in the focus groups and the directive to investigate whole-of-ship tasks, only those that were performed by more than 20% of the population sampled by Dowrick et al. (2007) and were subjectively deemed to require at least light-moderate physical effort were considered. Any unknown nomenclature was translated by a senior RAN Officer prior to presenting the task inventory to RAN personnel during focus groups in order to perform a detailed review of identified whole-of-ship activities.

2.4. Focus groups

2.4.1. Study location and description

A total of ten workshops were held over a two-month period (April–May 2013). Workshops were conducted at Fleet Base East (Sydney, New South Wales), Fleet Base West (Perth, Western Australia), HMAS Waterhen (Sydney, New South Wales) and HMAS Cairns (Cairns, Queensland). Subject matter experts subjectively quantified the task parameters and criteria of typical operations. Consequently, consideration was given to the overall operational roles, responsibilities and missions that may impact upon these tasks.

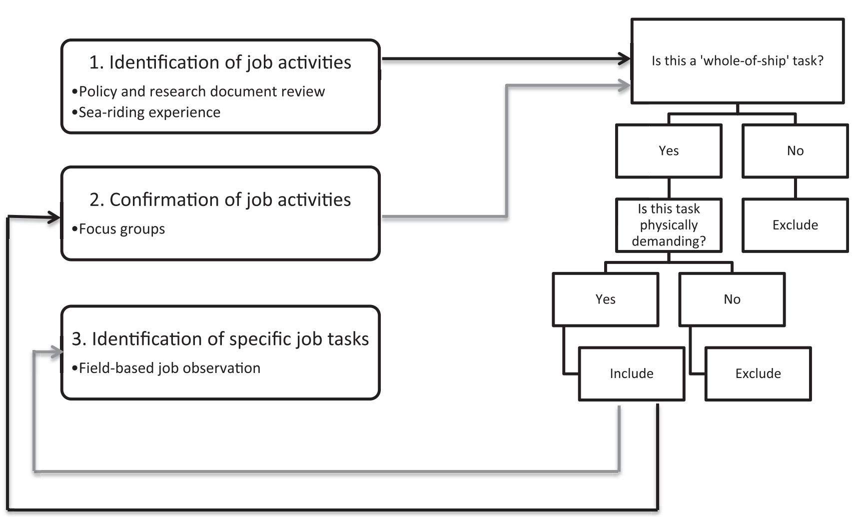

Fig. 1. Overview of the stepwise process to identify job tasks in the development of physical employment standards and assessments for the Royal Australian Navy.

Table 1
Initial task inventory developed from the Royal Australian Navy Occupational Analysis (Dowrick et al., 2007).

Task no.	Task description
01	Ascending and descending ladders
02	Manoeuvring through hatches
03	Turn hatch cover handle and lift hatch
04	Firefighting
05	Shoring
06	Casualty evacuation
07	Jackstay and line transfer
08	Break down pallets of stores
09	Participate in gash removal
10	Securing for Sea
11	Seamanship evolutions (line handling/man overboard)
12	Participate in bomb threat exercises
13	Participate in stores parties
14	Ammunition/de-ammunition evolution
15	Ship preservation (chipping, painting, wash down)
16	Participate in Force Protection
17	Transfer of equipment (ship to shore)
18	Participate in ship reconstitution
19	Participate and rigging/de-rigging
20	Participate in re-fuelling alongside
21	Participate in towing evolutions
22	Participate in Boarding Party Operations
23	Participate in hazardous materials (HAZMAT) evolutions
24	Participate in Safety of Life at Sea (SOLAS)
25	Participate in Special Sea Dutymen (SSD)
26	Participate in de-storing ship prior to refit/Reduced Activity Period (RAP)
27	Participate in the loading and discharge of heavy cargo

2.4.2. Participants

Eighty-nine incumbent RAN personnel who were posted to a vessel at the time of the focus group volunteered for this phase of the study. One of the ship classes was due to be decommissioned shortly after the focus groups and was therefore not included. Each focus group consisted of a homogenous convenience sample of participants who were posted to each vessel and represented a wide distribution of age, experience, ship class, and rank (Table 2 & Table 3).

2.4.3. Procedures

At all workshops, at least two research team members and a military liaison officer were in attendance. A member of the research team acted as the focus group moderator while another was a note taker. A portable video camera (HC-V700, Panasonic, Japan) and audio recorder (ICD-UX533F, Sony, Japan) were used to record the focus group for reference. Given the current study was set in a military environment, participants were asked to *'leave their rank at the door'* in order to facilitate an open and candid discussion. Input from all participants was welcomed and open dialogue was fostered.

An introduction was provided to participants outlining the aims of the project and the importance of the identification of whole-of-ship rather than category specific tasks. Participants were asked to provide a brief description of the whole-of-ship tasks required on their specific vessel. The whole-of-ship task inventory was then presented to the participants to facilitate discussion among the focus group participants. For each task identified, specific questions were raised in order to identify details such as whether the task was a physically demanding whole-of-ship task, based on cues given by the research team in relation to considerations such as task frequency, load and ambulation. Task reduction was then performed using a decision tree (see Fig. 1) whereby tasks that were deemed to be category specific were removed followed by the removal of tasks that were deemed not to be physically demanding. For those tasks that were deemed to be physically demanding whole-of-ship tasks, the research team asked additional questions in order to ascertain details such as the number of personnel required to complete the task, the distance covered when completing the task and the duration required to complete the task. Once all of the tasks of the task-inventory were presented, the participants were asked to identify any physically demanding whole-of-ship tasks that had not

Table 2
Demographic data of focus group participants (n = 89) stratified by ship class. Data for age, service and experience are Mean (SD).

Ship class	N	% of total N	Age (Years)	RAN service (Years)	Sea-going experience (Years)
Gascoyne	8	9.0	24.4 (3.2)	4.2 (2.7)	2.8 (2.3)
Tobruk	10	11.2	31.4 (12.5)	10.7 (11.0)	4.9 (4.8)
Choules	10	11.2	36.7 (11.2)	12.3 (8.4)	4.5 (3.1)
Darwin	9	10.1	27.4 (5.1)	8.3 (5.8)	5.3 (3.9)
Success	11	12.4	33.6 (8.5)	14.4 (8.7)	7.3 (6.4)
Canberra	11	12.4	33.8 (9.5)	11.4 (9.8)	5.4 (5.5)
Sheean	7	7.9	32.1 (8.9)	9.6 (9.2)	4.8 (4.8)
Perth	10	11.2	30.1 (9.0)	8.1 (7.4)	4.7 (4.0)
Launceston	6	6.7	30.7 (8.1)	10.2 (8.0)	7.7 (5.5)
Benalla	2	2.2	25.5 (3.5)	5.0 (2.1)	2.8 (0.4)
Melville	5	5.7	36.6 (12.0)	7.6 (4.0)	5.4 (2.0)
Weighted Mean			**31.6 (9.4)**	**9.9 (8.2)**	**5.2 (4.4)**

Table 3
Demographic data of focus group participants stratified by rank. Data for age, service and experience are Mean (SD).

Rank[a]	N	% of total N	Age (Years)	RAN service (Years)	Sea-going experience (Years)
LCDR	3	3.4	45.3 (9.6)	16.0 (11.5)	12.3 (8.5)
LEUT	10	11.2	27.8 (6.3)	7.9 (2.1)	4.0 (2.4)
SBLT	5	5.6	30.2 (6.3)	5.9 (3.8)	2.7 (2.3)
WO	1	1.1	47.0 (n/a)	29.0 (n/a)	7.5 (n/a)
CPO	8	9.0	43.9 (4.3)	23.8 (5.4)	12.1 (5.5)
PO	15	16.9	36.3 (8.5)	16.6 (7.7)	7.9 (3.4)
LS	18	20.2	32.3 (8.3)	9.0 (3.8)	5.4 (2.0)
AB	26	29.2	25.3 (5.6)	3.4 (1.7)	1.8 (1.1)
SMN	3	3.4	20.7 (0.6)	1.3 (0.6)	0.7 (0.3)

[a] LCDR: Lieutenant Commander; LEUT: Lieutenant; SBLT: Sub Lieutenant; WO: Warrant Officer; CPO: Chief Petty Officer; PO: Petty Officer; LS: Leading Seaman; AB: Able Seaman; SMN: Seaman.

been presented. Each focus group was completed in approximately 1–2 h, and an important outcome of the focus group was the collation of the amended whole-of-ship task inventory. The tasks and their associated descriptions were used to inform the subsequent initial field observations, and to specify the tasks that would be performed by personnel in those observations, in order to expand the task descriptions and identify different roles personnel assume during these tasks.

2.5. Field observation

To complement and expand on the list of physically demanding activities identified during the focus groups, an observation of the RAN's Advanced Combat Survivability Course was undertaken. This study was conducted in November 2013 during the Advanced Combat Survivability Course at the RAN's School of Survivability and Ship Safety, HMAS Stirling, Garden Island, Australia. The course was run over a two-week period with practical classes covering combat survivability activities. Seventeen sailors (15 male, 2 female; age 27.0 ± 4.4 years; height 177.2 ± 8.6 cm; mass 83.0 ± 12.7 kg; RAN service 6.2 ± 2.9 years; sea-going experience 3.1 ± 2.0 years) volunteered to participate in this study.

2.5.1. Course components

Each course component was carried out according to standard operating procedures and run by qualified instructors at all times. All course components have been developed by content experts in the area of combat survivability. All course equipment was weighed using platform scales (PM150, Wedderburn, New South Wales, Australia). The components of the round robin exercise were conducted in various locations around the fire ground. Each course component was conducted on separate days as dictated by the course schedule.

2.5.1.1. Toxic hazard. The toxic hazard exercises were conducted in a fire unit and was comprised of two ground floor compartments — one replicating a ‘galley’ and the other replicating a machinery compartment — connected by a corridor. The machinery compartment contained a ladder and hatch leading to a third compartment on the first floor. During the toxic hazard exercise, six sailors performed a search and rescue of a 6.7 kg manikin in a fire unit. The six sailors were divided into three teams of two (Team 1; Team 2; Team 3) with each individual within each team conducting identical tasks. Each sailor wore intermediate rig of coveralls, anti-flash, gum boots, Open Circuit Compressed Air Breathing Apparatus (OCCABA) and two Emergency Life Support Respiratory Devices (ELSRD). The combined mass of clothing and equipment equated to 23.8 kg. Each member of Team 2 also carried two gas monitors (~1 kg additional mass per sailor). Team 1 entered the fire unit from the ground floor and proceeded directly to the suspected source of the hazard then commenced their search for casualties along the connecting corridor and up and out of the other ground floor compartment. Team 2 entered the fire unit from the first floor and commenced their search for casualties down from the first floor compartment into the ground floor compartment, along the connecting corridor and into the other ground floor compartment. Teams 1 and 2 continued to search for casualties until they met, signifying that all compartments had been searched. Team 3 entered the fire unit and proceeded to the ‘casualty’ (6.7 kg; Oscar — water-rescue training dummy, Emerald Marine, Washington, USA) that was found in the ‘galley’. Once an Emergency Life Support Respiratory Device was donned on the casualty, Team 3 performed a RAN safety lift-and-carry of approximately 10 m to the bottom of a ladder in the machinery compartment, secured a fire hose around the casualty and then performed a fire hose lift through the hatch and out of the compartment.

2.5.1.2. Leak step and repair 1. Participants took part in a number of activities that were set up in a round robin format. Activities included the use of a Broco Underwater Cutting System (Broco, Inc., California, USA), a SalvageMaster Underwater Marine Tool (211HD, Ramset, Victoria, Australia) and a Bauer Air Compressor (C-D/DV/NAVY, Bauer Compressors, Inc., Virginia, USA). These activities were deemed to be instructional rather than practical and were not included in subsequent analyses. The practical components of the circuit training included a leak stop and repair (LS&R) exercise where participants were required to cover a leak with rubber and sheet metal then secure with ‘bulldog’ clips. Participants also conducted a door entry whilst carrying a fire extinguisher (approximately 14 kg) and proceeded to simulate the extinguishment of a fire.

2.5.1.3. Firefighting. The firefighting exercises were conducted in a fire unit and was comprised of two ground floor compartments — one replicating a ‘galley’ and the other replicating a machinery compartment — connected by a corridor. The machinery compartment contained a ladder and hatch leading to a third compartment on the first floor. Firefighting exercises involved teams of six participants entering a compartment in an attempt to extinguish a fire. Each participant was delegated to roles including Nozzleman, Hose Handler, Support Party in-charge or Hydrants. All participants entered the fire compartment with the exception of the Hydrants who remained outside to man the hydrant and assist in holding both hoses. This activity was conducted under three conditions: dry, wet and hot. The dry condition was performed without the discharge of water or the presence of fire. The wet condition was performed with the discharge of water but not in the presence of fire. The hot condition was performed with the discharge of water and the presence of fire. During the hot condition a participant also conducted boundary cooling whereby they continuously opened and closed the nozzle of a hose for five and 10 s respectively to cool the bulkhead adjacent to the deck above the source of a fire.

During the wet and hot conditions the Nozzleman was required to hold the nozzle (4.6 kg) and direct a water stream in an appropriate pattern and flow rate. The Hose Handler was positioned behind each Nozzleman and was required to assist in pushing the hose forward to compensate for the nozzle reaction force, partially hold the weight of the hose, move the hose as required and assist the Nozzleman in directing the stream. The Support Party in-charge was required to search the compartment using a thermal imaging camera and physically (push and/or pull) direct the hose team to the source of any fire.

2.5.1.4. Leak stop and repair 2. The second leak stop and repair exercise was conducted in a flood unit that was comprised of a ground floor compartment containing a ladder and hatch and a first floor compartment. The flood unit was constructed on a static 7° incline to replicate the roll or pitch of a vessel at sea. Participants were required to cut an arbitrary length of 0.1 × 0.1 m Oregon timber using a hand saw. They then carried a larger piece of timber (ranging from approximately 0.5 m and 3 kg to 2.0 m and 12 kg) a distance of 10 m and then ascended an external staircase (vertical height of 4 m) into a compartment where they passed the timber to a team member. The second task included team members erecting the timber vertically from the bottom deck and hammering wedges in place between the top of the timber and the top deck. A similar task was performed with breast pieces (timber placed in horizontal orientation) that were hammered between the bulkhead and a vertical piece of timber.

3. Results

3.1. Focus groups

Using the decision tree, participants identified that eight of the 27 activities in the initial inventory were physically demanding whole-of-ship activities. Additionally, participants representing the Collins Class submarine identified the ‘stowage of oxygen candles’ as a physically demanding whole-of-ship activity. Therefore, a total of nine physically demanding whole-of-ship activities and associated intra-task platform differences were identified (Table 4). The 19 activities that were eliminated from the list were deemed to either be not physically demanding or were not whole-of-ship activities for the purpose of this analysis. Although these activities may have been an evolution that the entire ship's company would be involved in, the individual tasks performed by each crew member would be employment category dependant.

After synthesising the list of nine whole-of-ship activities and discussions with senior RAN officers, it was evident that number of activities as described in the list were an amalgamation of multiple individual tasks. This has previously been illustrated by Taylor et al. (2015), who found that urban fire fighters perform 29 essential tasks. Firefighting, shoring and casualty evacuation were highlighted as having a number of sub-tasks. It was therefore confirmed that a field observation of these activities was required and the observation of a training course would be suitable to observe all tasks within these activities.

3.2. Field observations

During the combat survivability course observation, it was found that there were distinct tasks that were performed during each practical component of the course. Together with all of the information gathered thus far throughout the process, individual task descriptions were formulated and collated to form a comprehensive whole-of-ship task list. Review and refinement of task descriptions was undertaken in consultation with course staff. Each identified task generally remained in one of six categories: replenishment at sea; emergency response; firefighting; leak stop and repair; toxic hazard and casualty evacuation (Table 5). The ascent and descent of ladders was shown to be performed during the execution of many other tasks and was therefore removed from the inventory as an independent task. Firefighting was expanded to include nine individual tasks whilst leak stop and repair was expanded to eight individual tasks. The full process of evacuating a casualty included the initial search of the casualty and the eventual extraction of the casualty and was therefore separated into the response to a toxic hazard (four individual tasks) and casualty evacuation (four individual tasks). Replenishment at sea remained unchanged (two individual tasks) whilst the movement of stores was merged into a single task. Four ‘emergency situation’ tasks were also added to the task inventory based on observations of the course.

4. Discussion

This is the first investigation to identify the common whole-of-ship tasks that are conducted by RAN personnel. The current study builds upon previous research investigating physical demands across a military service (Rayson, 2000) and previous investigations of the physical requirements of Navy personnel when performing tasks unique to the maritime environment (Bilzon et al., 2002). Experienced incumbent RAN personnel identified nine whole-of-ship activities as physically demanding. These tasks had subtle but very important cross-platform differences that may alter the physical and physiological demand of these tasks. After the observation of a combat survivability course, the nine activities were broken down into 33 single tasks across six categories of replenishment at sea, emergency response, firefighting, leak stop and repair, toxic hazard and casualty evacuation. As predicted, the majority of tasks were associated with combat survivability.

In a previous investigation documenting the physical demands of British Navy personnel (Bilzon et al., 2002), a comprehensive and detailed approach to field observations was conducted. However

Table 4
Abridged whole of ship task inventory after the conduct of focus groups.

Task number	Task description	Sources of platform differences
01	Ascending and descending ladders	Hatch type, number of decks
04	Firefighting (including standing sea fire brigade or silent hours emergency response)	Equipment and methods used
05	Shoring	
06	Casualty evacuation	Space availability, number of personnel
07	Jackstay and line transfer	Requirement to conduct
08	Break down pallets of stores	
13	Participate in stores parties	Item type, personnel numbers
14	Ammunition/de-ammunition evolution	
28	Stowage of oxygen candles	

Table 5
Task inventory of physically demanding whole-of-ship Royal Australian Navy tasks.

Task Category	Task #	Task description
Replenishment at Sea	01	Perform line handling
	02	Break down a pallet of stores
	03	Participate in stores party
Emergency Response	04	Closing up to Action Stations
	05	Closing up to Emergency Stations
	06	Closing up to Leaving Ship Stations
	07	Conduct a single emergency cable run in 5 min
Firefighting	08	While wearing basic rig, lift and carry fire extinguisher a distance of x metres and enter affected compartment within 1 min of the alarm being raised (FAA)
	09	While wearing intermediate rig and OCCABA, lift and carry fire extinguisher a distance of x metres and enter affected compartment within 3 min (BA-P)
	10	While wearing full firefighting ensemble and OCCABA lift and carry fire hose a distance of x metres, attach to water main and enter affected compartment in 7 min (BA-H)
	11	While wearing full firefighting ensemble and OCCABA and acting as a nozzleman, participate in sustained use of charged fire hose
	12	While wearing full firefighting ensemble and OCCABA and acting as IC, move and support nozzlemen
	13	While wearing full firefighting ensemble and OCCABA and acting as a hose handler, move with and support nozzleman's charged hose
	14	While wearing full firefighting ensemble and OCCABA and acting as a Hose Handler/Inductor/Hydrants, hold hoses for an extended period of time.
	15	Conduct boundary cooling
	16	Lift and carry as a team of two, a de-smoking fan a distance of x metres
	17	While wearing full firefighting ensemble and OCCABA conduct fire overhaul
Leak Stop and Repair	18	Enter affected compartment within 3 min of the alarm being raised in search of casualties
	19	Lift and carry as a team of three, a de-watering pump a distance of x metres in 3 min
	20	Cut 4 × 4 Oregon timber to size using a hand saw
	21	As a team of two, carry timber piece from storage area to required site
	22	As a team of two, carry acro shoring from storage area to required site and erect by twisting
	23	Hammer wedges into place in order to secure vertical and breast pieces
	24	Hammer plugs into place in order to maintain hull integrity
	25	Carry a tool bag and conduct a permanent pipe repair
Toxic Hazard	26	Wearing intermediate rig and OCCABA while carrying two spare ELSRDs and as a member of Team One (Search), enter affected compartment and spiral upwards to meet Team Two placing ELSRD on first casualty within 4 min
	27	Wearing intermediate rig and OCCABA while carrying two spare ELSRDs and as a member of Team Two (Search), enter gas boundary and spiral downwards to meet Team One placing ELSRD on first casualty within 4 min
	28	Wearing intermediate rig and OCCABA while carrying two spare ELSRDs and as a member of Team Three (Casualty Evacuation), enter gas boundary and evacuate casualty
	29	As a member of Team Four (Repair Team) and wearing intermediate rig and OCCABA, carry a kit bag with tools and repair and clean up toxic hazard
Casualty Evacuation	30	While wearing OCCABA individually or in a team of two, perform a fire hose lift as a member of Team One (upper) or Team Two (lower)
	31	While wearing OCCABA individually or in a team of two, perform a Res-Q-Mate stretcher lift as a member of Team One (above) or Team Two (below)
	32	In a team of 6–8, lift and carry a casualty on a Res-Q-mate stretcher from site of injury x metres to first aid post/sick bay
	33	While wearing OCCABA and in a team of two, lift and carry a casualty using a fore-aft carry from site of injury x metres to first aid post/sick bay

there were again differences to the current investigation, primarily due to the emphasis in the current investigation on the use of multiple methodologies to develop the initial list of physically demanding tasks. Our experimental design is similar to a study of the physical demands of firefighting (Gledhill and Jamnik, 1992) and correctional officers (Jamnik et al., 2010), in that the list of physically demanding tasks was subjectively and objectively based on a combination of a task analysis, collaboration with subject matter experts and input from incumbent personnel.

In one of the only investigations reporting task requirements across a whole service, Bilzon et al. (2002) focused on the anthropometric requirements associated with moving through hatches within a Naval vessel, the physiological demands of shipboard firefighting, and the anaerobic and strength-based requirements of carrying a casualty in an emergency situation. While the aforementioned investigation is the culmination of a series of three separate studies, the results of the current study are somewhat consistent, in that within the broad categories of physically demanding tasks within the RAN, firefighting, carrying a casualty and movement around a ship have been identified. The results of our investigation provide additional detail in the identification of the physical demands of Naval personnel, having itemised ten specific firefighting tasks, and four casualty evacuation tasks, therefore building on the results of previously conducted job task analyses.

The very real risk of fire, flood and toxic hazards was highlighted with all focus groups identifying firefighting, shoring and casualty evacuations as physically demanding tasks, in addition to the extensive training observed for these activities during the combat survivability training course. The demand of shipborne firefighting was reported by Bilzon et al. (2001) with the most arduous firefighting task conducted being a drum carry requiring a peak metabolic demand of 43 ml $min^{-1} \cdot kg^{-1}$ and a heart rate in excess of 90% of maximum. As mentioned previously, fire, flood and toxic hazards are possibilities on all platforms and require personnel to be physically able to perform in casualty extraction. This is not only physically demanding (Bilzon et al., 2002) but essential and critical for the preservation of life of the casualty.

With the exception of firefighting (Bilzon et al., 2001), the physical demands of naval whole-of-ship tasks have not previously been examined. Previous investigations using a combination of interview techniques and objective task observations have reported that physical demands often relate to the requirement to lift and carry equipment (e.g., tools and air tanks), dragging fire hoses, as well as using charged fire hoses for extended periods of time (Gledhill and Jamnik, 1992). Furthermore, the use of hand tools has been reported to be an important contributor to the physical demand of firefighting duties (Phillips et al., 2012). Collectively, these previous studies suggest that firefighting tasks are similar to those required of RAN personnel when performing tasks specific to both shipboard firefighting and casualty evacuation. Important future research will focus on quantifying the physical demands of RAN tasks, comparing results to previously published results that have characterised the parameters of different tasks (Phillips et al., 2012) as well as physical and physiological demands (Gledhill and Jamnik, 1992).

Further investigation is required to collect detailed task characteristics across each platform of the RAN fleet in order to quantify differences in tasks across these platforms. Furthermore, the quantification of the physical and physiological demands of whole-of-ship tasks is required before naval forces can make decisions on physical employment standards. In conclusion, the findings of the current investigation demonstrate the commonality of tasks across each platform, and suggest that a baseline physical employment standard may be viable for naval forces.

Acknowledgements

The authors would like to thank CMDR Teresa Blackman, CMDR John Merton, Dr Timothy Doyle and SQLDR Andrew Miller for their assistance during data collection.

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