FIT FOR DUTY:

CONTEXT AND CORRELATES OF PARAMEDIC
HEALTH STATUS AND JOB PERFORMANCE

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A PhD thesis submitted in partial fulfilment of the requirements
for the degree of Doctor of Philosophy

Faculty of Science
School of Biomedical Sciences
Paramedic Program
Charles Sturt University

DECEMBER, 2018

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CONTEXT AND CORRELATES OF PARAMEDIC HEALTH STATUS
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CERTIFICATE OF AUTHORSHIP

I hereby declare that this submission is my own work and to the best of my knowledge and belief, understand that it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at Charles Sturt University or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by colleagues with whom I have worked at Charles Sturt University or elsewhere during my candidature is fully acknowledged.

I agree that this thesis be accessible for the purpose of study and research in accordance with normal conditions established by the Executive Director, Library Services, Charles Sturt University or nominee, for the care, loan and reproduction of thesis, subject to confidentiality provisions as approved by the University.

Name: Alexander James MacQuarrie

Date: December 21, 2018

Signature:  

This thesis does not exceed 75,000 words
ACKNOWLEDGEMENTS

I am grateful for the patience and sage advice offered by my supervisors: Dr James Wickham, Dr Peter Micalos, Dr Eric Drinkwater and Dr James Crane. They kindly granted me entrance to the world of research.

Mr Ben Hinton, of NSW Police blazed a path in this field of research and offered timely advice on data analysis. Ms Sharon Nielsen provided statistical advice and Ms Gail Fuller administered the on-line survey. Mr Praneel Titheridge and Dr Rob Robergs assisted in data collection and analysis for Chapter 4. Thank you all.

To my colleagues in the School of Biomedical Sciences Paramedicine Program I wish to extend a very big thank you for lightening my teaching load at critical points and giving feedback through this journey. Discipline co-leads, Ms Sonja Maria and Mr Phil Ebbs along with Head of School Professor Rod Hill encouraged me and allowed me to stay on task. Dr Rod Pope, CSU School of Community Health provided timely feedback on the thesis.

Mr Richard High and Dr Rosemary Carney of New South Wales Ambulance, your contribution and assistance were invaluable. CEO Dominic Morgan and former CEO Ray Creen have supported this research from day 1. Thank you.

I recognise the financial contribution of Paramedics Australasia for a grant to purchase equipment. The Faculty of Science Research Office provided a seed grant to allow completion of the final study. Funds from the School of Biomedical Sciences were used to purchase analytical software and for travel to present on research findings nationally and internationally.
Chief Michael Nolan, Renfrew County Paramedic Service, Ontario, Canada, continually pushed (or pulled) me through a large part of my paramedic career and never, ever took “No” for an answer. Your guidance and friendship are woven into this thesis.

Associate Professor Lyn Angel was instrumental in my PhD journey from its most formative stage. I recognise the unique contribution to my research career path that Lyn made. You are a true friend.

To the men and women on the front line of paramedic care at New South Wales Ambulance, I thank you. You selflessly volunteered to be surveyed, measured and reported on. Thirty-two of you welcomed me into your daily practice, wearing biometric monitors while you cared for almost 1,000 patients. Your data and story are here.

I dedicate this thesis to my mother, Mary Jenkins. You instilled in me a love of learning that helped get me through this in one piece. Strong in your faith, firm in your convictions, you accomplished so much in your time. I think of you every day.

The best is saved for last. Dr Caroline Robertson is my friend, partner and wife. You navigated your own PhD while encouraging me with mine. You inspire me, support me and show me how to be better. You are my world.

A.J.M.
21.12.18
PUBLICATIONS, CONFERENCES & PRESENTATIONS

The data from this thesis have resulted in the following:

Peer reviewed journal article


Non-peer reviewed journal articles


Conference presentations


**Industry Workshop**

Research from this thesis was used in the development and delivery of Wellbeing Workshops for the 4,000 paramedics of New South Wales Ambulance. First workshop delivered May 2018.

**Wellness Programs**

Research from this thesis was used in the development of the Medic Fit on-station physical fitness program for regional paramedics of New South Wales Ambulance.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>Act</td>
<td>Actigraphy</td>
</tr>
<tr>
<td>AED</td>
<td>Automated External Defibrillator</td>
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<tr>
<td>AV</td>
<td>Ambulance Victoria</td>
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<tr>
<td>bpm</td>
<td>Beats per Minute</td>
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<td>CAD</td>
<td>Computer Aided Dispatch</td>
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<tr>
<td>CDC</td>
<td>Centre for Disease Control</td>
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<td>CI</td>
<td>Confidence Interval</td>
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<tr>
<td>CVD</td>
<td>Cardiovascular Disease</td>
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<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
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<td>ED</td>
<td>Emergency Department</td>
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<td>EE</td>
<td>Energy Expenditure</td>
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<td>EMS</td>
<td>Emergency Medical Services</td>
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<td>EMSS</td>
<td>Emergency Medical Services System</td>
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<td>EMT</td>
<td>Emergency Medical Technician</td>
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<td>EMT-P</td>
<td>Emergency Medical Technician – Paramedic</td>
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<tr>
<td>g-force</td>
<td>Gravitational force</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<td>HILDA</td>
<td>Household Income and Labour Dynamics Australia</td>
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<td>HR</td>
<td>Heart Rate</td>
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<td>HRQoL</td>
<td>Health Related Quality of Life</td>
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<td>Hz</td>
<td>Hertz</td>
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<td>ICC</td>
<td>Intraclass Correlation Coefficient</td>
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<td>Abbreviation</td>
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<tr>
<td>ICP</td>
<td>Intensive Care Paramedic</td>
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<td>IPAQ</td>
<td>International Physical Activity Questionnaire</td>
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<td>IQR</td>
<td>Interquartile Range</td>
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<td>KCal</td>
<td>Kilocalorie(s)</td>
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<td>MDT</td>
<td>Mobile Data Terminal</td>
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<td>MET</td>
<td>Metabolic Equivalent of Task</td>
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<td>mL</td>
<td>Millilitre(s)</td>
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<tr>
<td>MOS SF-36</td>
<td>Medical Outcomes Survey Short Form-36</td>
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<tr>
<td>NSW</td>
<td>New South Wales</td>
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<td>NSW Ambulance</td>
<td>New South Wales Ambulance</td>
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<td>OPA</td>
<td>Occupational Physical Activity</td>
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<td>PA</td>
<td>Physical Activity</td>
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<td>PCA</td>
<td>Principal Component Analysis</td>
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<td>PTSD</td>
<td>Post Traumatic Stress Disorder</td>
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<td>RR</td>
<td>Respiratory Rate</td>
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<td>SD</td>
<td>Standard Deviation</td>
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<tr>
<td>SPM</td>
<td>Steps per Minute</td>
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<td>SS</td>
<td>Steady State</td>
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<tr>
<td>vT</td>
<td>Tidal Volume</td>
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<tr>
<td>UHU</td>
<td>Unit Hour Utilisation</td>
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<tr>
<td>VO$_{2max}$</td>
<td>Maximal Oxygen Consumption</td>
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<tr>
<td>WtHR</td>
<td>Waist to Height Ratio</td>
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<tr>
<td>WHO</td>
<td>World Health Organisation</td>
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A career as a paramedic was not an immediate or obvious one for me. After university, a job in another field briefly occupied me. It was not until joining a volunteer fire department that my journey started. There I was mentored and introduced to the world of pre-hospital care by three senior firefighters who were also paramedics. Watching them deliver patient care in very trying circumstances ignited a desire to learn more.

I wanted to be a paramedic! My training began with Emergency Medical Technician and culminated over a decade later with Critical Care Paramedic (Flight). Along the way I met the people of Emergency Medical Services while posted to rural stations, in busy urban posts and at altitude as a flight paramedic. All were good to me, teaching me their craft with equal measures of wisdom, cynicism and humour.

Paramedics are the focus of this thesis. Many of whom I worked with are now no longer in this industry. For some, moving on was a natural progression, but for many it was the demands of the job, the working conditions, the calls, and the list goes on.

I wanted to study these people who are unique in our health care system. Paramedics as mobile health care providers who, it seems, may not be as healthy as they could or should be. We need to be better informed to understand if being a paramedic affects health status. We need to be better informed if health status affects being a paramedic.

My goal was to look at how healthy they perceived themselves to be and to follow them (literally) heart beat by heart beat as they responded to emergency calls wearing biometric monitors. Finally, there was a curiosity about whether a high(er) level of physical fitness could result in or influence a paramedic to provide better care. And I wanted to quantify all of that. At the same time, a contextualisation of the job of paramedic
needed definition. Exploring the temporal flow of a paramedic’s shift can aid in understanding why injury and illness rates are so high and perhaps why some of my friends are no longer paramedics.

This PhD journey has absolutely shown me that we don’t know enough about the health of paramedics. We need to know more about the physiological changes that occur in paramedics during emergency calls. Moreover, we need to know more about the effect of paramedic fitness on the provision of patient care.

In the end, this thesis presents information and knowledge gained in a unique way. It serves to inform paramedics, their families, their employers and all those who work to support the delivery of paramedic care.

We know that the patient, whose family has just frantically dialled the emergency telephone number, is ready for the paramedics.

The question is: Are the paramedics ready for the patient?
Professor Lyn Angel
Executive Dean (Interim)
Faculty of Science
Charles Sturt University
Burrora St
NORTH WAGGA WAGGA NSW 2650

Dear Professor Angel,

I am pleased to offer this letter of support to the research project “Fit for Duty”. The Principal Investigator is Mr Alex (Sandy) MacQuarie, a Paramedic Academic and PhD student from School of Biomedical Sciences at Charles Sturt University (CSU) in Bathurst, NSW.

Mr MacQuarie approached NSW Ambulance in 2013, proposing to study the health and wellbeing of our paramedics. A research proposal followed and the studies were undertaken between 2015 and 2017.

The research project was composed of three studies:

1. the self-reported health status of paramedics;
2. the context of paramedic job performance and variables affecting performance; and
3. the effect of paramedic cardiorespiratory fitness on self-reported health status and job performance.

NSW Ambulance has had a very productive working relationship with Sandy and CSU. There has been much to report with early outcomes allowing us insight into our staff’s health status which has informed NSW Ambulance of areas for further investigation.

Outcomes thus far have included:

- data from the project informed the Workplace Wellness workshops currently being offered to all staff;
- findings have spurred further research (also in cooperation with CSU) on the effect of an “on station” physical fitness program for regionally based paramedics; and
- the research has been presented in Australia and internationally.

Our commitment to our staff was a major factor in our participation on the Fit for Duty project. NSW Ambulance views this project as a successful partnership between NSW Ambulance and Charles Sturt University. NSW Ambulance looks forward to seeing Sandy’s completed thesis.

Yours sincerely,

Dominic Morgan ASM
Chief Executive
19/10/19
This thesis is an exploration of paramedic health status and how the demands of their job may influence their health. It begins with an overview of the role of paramedics in the health care system and, importantly, an explanation of the structure of Emergency Medical Services Systems. Their role is explored in settings both nationally and internationally.

The first study, as reported in Chapter 3, surveyed the self-reported health status and physical activity (PA) levels of paramedics working for New South Wales Ambulance (NSW Ambulance) in New South Wales, Australia. Data was collected from 747 respondents (507 male, 230 female) and included Body Mass Index (BMI), demographic data, their self-reported Health Related Quality of Life (HRQoL) using the Medical Outcome Survey Short Form 36 (SF-36) and PA levels using the International Physical Abilities Questionnaire (IPAQ). Paramedic health status was explored by gender, posting, level of certification and primary role. Their data were compared with that from the Australian population using data from Household Labour Income Dynamics in Australia (HILDA) Wave 13 survey. There was an exploration of paramedics’ perceived barriers to exercise.

There were few significant differences in reporting of HRQoL scores of paramedics by gender and posting. However, there were significantly lower paramedic HRQoL scores compared to the Australian population in six of eight domains and both summary scores. There were small but significant differences in BMI between paramedics by gender and posting (p< 0.001) and between the paramedics and the Australian population (p= 0.01).

From paramedics’ survey answers, perceived barriers to exercise most frequently reported were family commitments and lack of time. Regional
rostered paramedics reported the barrier of lack of exercise facilities significantly more often than metropolitan rostered paramedics (p<0.001).

Physical activity level, reported as median total MET-minutes were 3626 (IQR 1737 – 6537). Males reported significantly higher PA scores than females (p< 0.02) with no significant difference by posting. Median total MET-minutes reported by NSW Ambulance paramedics seem much higher than other studies. High BMI and low SF-36 scores may be related to a perceived inability to engage in regular exercise and the effects of shift work, especially in regional areas.

The second study, as reported in Chapter 4, was the validation of the Hexoskin® biometric shirt, specifically its ability to monitor physiological measures of heart rate (HR) and respiratory rate (RR). The Hexoskin® was to be used in an applied research setting, with paramedics wearing it while responding to emergency calls. Heart rate and RR of twenty cyclists wearing the Hexoskin® biometric shirt were compared to standard laboratory devices of ECG and a metabolic cart under four conditions: (1) 85% steady state (rest), (2) 85% steady state (final minute), (3) \( \dot{V}O_2 \) max (rest) and (4) \( \dot{V}O_2 \) max (final minute). Measures of HR between the Hexoskin® and the ECG were not significantly different with good Intraclass Correlation Coefficient (ICC). Bland-Altman plots revealed low bias with good agreement. Measures of RR between the Hexoskin® and the metabolic cart were not significantly different with good ICC. Bland-Altman plots revealed low bias with good agreement. Based on this study and the work of others, the Hexoskin® biometric shirt is a reliable and valid method of measuring HR and RR data in conditions including intense physical activity. The validation study allowed a familiarisation process with the Hexoskins in advance of their use in the third and fourth studies.
The third study, as reported in Chapter 5, aimed to establish and compare descriptive profiles of two distinct groups of NSW Ambulance paramedics (metropolitan and regional rostered paramedics) and the variables affecting physiological response during emergency calls. It utilised continuous biometric monitoring to measure HR, RR and occupational physical activity (OPA) combined with self-reported measures of non-invasive mean arterial pressure (MAP) and Rate of Perceived Exertion (RPE). Thirty-two paramedics (38.8 ± 8.8 yrs., males 40.6 ± 8.9 yrs., females 35.7 ± 7.4 yrs.) completed a total of 232 shifts (7.3 ± 2.1 shifts/paramedic) establishing a descriptive profile of paramedics. Paramedics completed a total transport to hospital of 3.3 ± 1.7 patients per shift (metropolitan 3.2 ± 1.7, regional 3.4 ± 1.7, p= 0.29). Time (hrs) on all calls for each shift were 4.4 ± 2.4 hrs (metropolitan 5.0 ± 2.6, regional 3.9 ± 2.0 hrs, p< 0.001, d= 0.5). Differences in the physiological parameters were examined from shift start (at rest), during emergency call outs (by call epoch and total call) and shift average. The variables of age, posting, and BMI, also significantly influenced the model. Heart rate and RR increased significantly by seriousness of call priority and by epoch (Assign and On Scene epoch). Mean arterial pressure and RPE were not significantly different by Chief Complaint, but both increased significantly from shift start to shift end (p< 0.01). Occupation physical activity levels were classed as “Low” and steps per shift were below Australian recommended steps per day. Paramedics had significant changes in HR and RR by call priority, epoch, BMI, posting and type of shift.

The fourth and final study, as reported in Chapter 6, utilised the Multi-Stage Shuttle Test to estimate the cardiorespiratory fitness (CRF) levels (V̇O₂ max and V̇O₂ max by category) and established Heart Rate maximum (HRmax) of 14 of the 32 paramedics from Study 3. Differences and associations between the HR, %HRmax, RR, MAP and RPE with CRF were examined. A self-reported measure of HRQoL (SF-36) was employed to examine correlations between those scores with BMI and
VO₂ max. Paramedics who had a higher level of CRF had a lower maximal HR on all calls and by Priority Code and exhibited a lower %HRmax. VO₂ max values varied from 23-43 mL/kg/min. CRF did not influence HR or %HRmax while performing CPR during cardiac arrest, although results may be affected by sample size. There were few significant correlations between VO₂ max and HRQoL scores except for general health domain of the SF-36 (r= .571, p= 0.03).

Through paramedic self-report and objective measures, it appears that the profession of paramedicine influences health status. This research has provided evidence that paramedic job performance is influenced by aspects of health status and other variables: CRF, BMI, Priority Code response, gender and posting. Not enough is known about the demands of paramedic job performance therefore further study should examine paramedic job demands to better understand the impact or influence of physiological changes on a) clinical performance, b) physical performance and c) resiliency. Paramedic services and the paramedics themselves should recognise, value and promote good health in paramedics.
“Modern healthcare has been called the most complex domain of work known to humans. Paramedics face these complexities and the additional factors of delivering healthcare in a mobile, volatile, unpredictable and unforgiving environment. As such, they arguably have one of the most cognitively and physically demanding jobs in healthcare”

Paul Misasi and Joseph Keebler
Human Factors and Ergonomics of Prehospital Emergency Care (2017)
1.1 Paramedics and Emergency Medical Services

1.1.1 Introduction

Paramedicine is an emerging discipline in modern healthcare systems and is establishing its place in the continuum of patient care. Paramedic care is acknowledged as being delivered primarily in the out-of-hospital setting, with providers called urgently to assess and treat illness and injury (O'Meara, 2012). The front-line staff are paramedics, defined as mobile healthcare workers who specialise in managing clinical emergencies and acute health issues in the community (NSW Ambulance, 2012).

Paramedics are the focus of this thesis with consideration given to their health and wellness. In 2017, the final year of data collection for this PhD, paramedics employed with New South Wales Ambulance (NSW Ambulance) accrued the highest average sick leave of all employees of NSW Health (an average of 85.2 hours per FTE), more than 37% higher than the state-wide average (Goodwin, 2017). As a former paramedic I felt crucial research was needed to understand why these paramedics are frequently ill or injured and seem to have lower health status than other occupations, both nationally and internationally (Maguire, O'Meara, Brightwell, O'Neill, & Fitzgerald, 2014; Sterud, Oivind, & Hem, 2006). I also believe that there were periods in my paramedic career where I was not as healthy as I could have been. Looking back, this may have impacted the care I delivered to patients.

Today, paramedic services face increasing injury and illness claims and associated costs including high WorkCover premiums (iCare, 2018; Roberts, Sim, Black, & Smith, 2015). The implication could mean paramedics working whilst ill or injured, or not providing patient care to the best possible standard (Maguire & Smith, 2013; Reichard & Jackson, 2010). These injuries or illnesses could influence paramedics’ physiological and psychological responses before, during and after
emergency calls and may affect patient care (van der Ploeg & Kleber, 2003). There is also evidence that paramedics risk developing work-related health problems such as PTSD (Halpern, Maunder, Schwartz, & Gurevich, 2012; LeBlanc et al., 2011; Sterud et al., 2006) and may not have longevity in their career compared with other health occupations (Rodgers, 1998a, 1998b). Research into these issues has never been more important and timelier.

This thesis reports on the health status and physical activity (PA) levels of NSW Ambulance paramedics. They work in locations ranging from remote country towns to the urban core of large cities. A group of paramedics were fitted with biometric monitors to measure physiological changes in heart rate (HR) and respiratory rate (RR) and to record occupational physical activity (OPA) levels as they responded to emergency calls. These calls ranged from the non-serious to the “sickest of the sick”: cardiac arrest patients. Finally, this thesis examined the link between paramedics’ level of cardiorespiratory fitness (CRF) and their self-reported health status. There was an exploration of call type, time on task, while investigating physiological responses as the paramedics provided care. With a data set of over 230 shifts and Computer Aided Dispatch (CAD) data for over 900 emergency calls by 32 paramedics, the research gives a deeper understanding of the temporal flow of their work. This has not previously been well reported.

Prior to discussing the complexities and challenges facing paramedics as healthcare providers, a brief introduction to the Emergency Medical Services System (EMSS) in which paramedic services operate is outlined. It is pertinent to frame EMSS in Australia, as the paramedic health issues outlined in Australia are common around the world. A comprehensive examination of the issue of the health of paramedics and how it may affect their job performance will be presented in Chapter 2: Review of Literature.
1.1.2 Emergency Medical Services Systems - An Overview

EMSS is a relatively new branch of health care, although its roots can be traced back to care of the grievously wounded during and after conflict. EMSS’ origins on the battlefield progressed in patient transport, sophistication of treatment methods and, over time, decreased mortality and morbidity rates for the wounded. Transportation of sick and injured civilians in peacetime settings became more common (Chilton, 2004). Countries such as Australia, Canada, and the United States formalised this with training for emergency attendants: the beginnings of paramedicine. The release of the 1966 White Paper in the United States, “Accidental Death and Disability: The Neglected Disease of Modern Society” starkly highlighted that Americans had a “better chance of surviving combat zones in Korea or Vietnam than on that nation’s highways” (National Academy of Sciences, 1966). As a result, the US Department of Transportation developed a standard curriculum forming the foundation paramedic training that is utilised in many countries today (Shrader, 2015).

1.1.3 Modern EMS Systems

Emergency Medical Services Systems in western countries have commonalities. Most include provision for citizen activation and prehospital care delivered by healthcare providers and transportation to higher care (Shah, 2006). The structure of EMSS at local, state, or national level has several predominant models:

(1) Privately run (usually on a “for profit” basis);
(2) Operated by non-government organisations (e.g. St John Ambulance in Northern Territory, Australia);
(3) “Third Service EMS”. EMS part of state government health authorities. (Overton & Gundeson, 2015)
This thesis examined paramedics who are employed by a “Third Service EMS”: NSW Ambulance Service in New South Wales, Australia.

There are issues in EMS delivery that directly impact paramedics and their health. Demand for service from an aging population has resulted in a fast-growing annual call volume (Peacock & Peacock, 2006). For instance, in a 6-year period from 2011 to 2017, there was an almost 30% overall increase in Australian ambulance call volume, from 127.1 calls/1000 people to 178.1 calls/1000 people (Australian Government Productivity Commission, 2012, 2017b). This increased call volume means paramedics are busier and under more pressure to deliver care than ever before. As well, funding has not kept pace with the real demand for service (Al-Shaqsi, 2010) and there are calls to be even more diverse in-service including community paramedicine. (O'Meara & Grbich, 2009).

1.1.4 Paramedic – Context, Roles and Responsibilities

Titles such as Ambulance Attendant or Ambulance Driver have evolved to Emergency Medical Technician (EMT), and Paramedic (Bell, 2009). In Australia, most paramedics employed by state or territory services are hired after attaining a degree in paramedicine at the university level (O'Meara, 2012).

Paramedics are expected to be ready to respond quickly to emergency calls, typically in teams of two. Geographic location can dictate the number and type of call outs within a shift, with heavily populated areas tending to have higher call volumes (Yasunaga et al., 2011). Conveyance to the call is usually in a van type truck although some settings include responding by car, motorcycle, boat, helicopter or fixed-wing airplane (O'Meara & Grbich, 2009; Shah, 2006). Once at patient side, complex clinical decisions underpin the paramedic’s treatment. As well, there are times when paramedics can face periods of high physical exertion. For instance, cardiac arrest can require long periods of cardiopulmonary
resuscitation (CPR) (Youness et al., 2016) and extricating, lifting and carrying patients (Lad, Oomen, Callaghan, & Fischer, 2018).

From sometimes chaotic scenes, a paramedic is engaged in a race against the clock to assess, intervene and transport a patient in potentially hazardous conditions, in what Campeau (2008) calls a “socially complex environment managing resources and relationships in a multi-crisis context”. As an example: a paramedic may arrive on scene after carrying heavy medical equipment and walking up many flights of stairs or across rough terrain. Paramedics can arrive out-of-breath with an elevated heart rate and must immediately assess, treat and transport the patient. This poses the question of whether these abrupt changes in paramedic physiology could influence decision making, skill execution and ultimately, patient care. The high rates of sick time and injury reported may point to paramedics working at or beyond their limits. It is critically important that research be undertaken to identify contributory factors to this problem. Not only do paramedics make life and death decisions in uncontrolled environments, but their own health may be endangered by the very practice of being a paramedic.

1.1.5 Paramedics in Australia

Australia has a well-developed EMSS that is comparable in terms of performance measures and outcomes with other industrialised countries internationally (O'Meara & Grbich, 2009). The majority of the 11,940 paramedics enumerated in the 2011 Australian National Census were employed by state and territory ambulance services (Paramedics Australasia, 2012). Other work settings for paramedics include industrial sites, training and education.

The work environment for many paramedics involves working a rotating schedule (usually 12-hour shifts) based at a paramedic station or mobile post. The percentage of shift time on calls delivering patient care can range from 0 to almost 100% and is referred to as Unit Hour Utilisation.
(UHU) (Brismar, Dahlgren, & Larsson, 1984). There has been little research examining UHU rates with level of paramedic fatigue, injury or illness. However, rotating schedules have been attributed to contributing to paramedic fatigue (Sofianopoulos, Williams, Archer, & Thompson, 2011), increased levels of Body Mass Index (BMI) and an increased incidence of cardiovascular disease (Wong, 2012).

NSW Ambulance lists commonly performed paramedic tasks which are summarised in Table 1.1.

**Table 1.1**
Physical and Clinical Tasks of Paramedics

| Physical Task                                                | Walk to the patient over rough, slippery or sloping terrain and up flights of stairs. |
|                                                             | Assemble, stabilize and utilize lifting aids such as carry chairs and stretchers.     |
|                                                             | Lift loads including equipment (up to 24 kg for dual responder, up to 36 kg for sole responder). |
|                                                             | Lift patients (using equipment and with assistance), regularly bearing weight up to 50 kg and occasionally up to 60 kg. |
|                                                             | Be able to carry equipment weighing 24 kg for dual responder and 36 kg if a solo responder for up to 10 minutes, including upstairs. |
| Clinical Task                                                | Bag/valve/mask resuscitation and endotracheal intubation.                             |
|                                                             | Intravenous and intraosseous cannulation.                                            |
|                                                             | Administration of intravenous fluids and medications.                               |
|                                                             | Performing Cardiopulmonary resuscitation (CPR).                                     |
|                                                             | Bandaging/splinting/chest decompression.                                            |
|                                                             | Cardiac monitoring and defibrillator use.                                            |
|                                                             | Oxyviva (oxygen resuscitator) use and oxygen therapy.                               |

Adapted from NSW Ambulance (2012)
The clinical decisions are usually the responsibility of the lead paramedic on the call. Being the lead paramedic can be based on clinical experience or shared on a rotating basis between partners. Clinical decision-making ranges from very routine (e.g. measuring blood pressure) to very complex (e.g. administering a clot dissolving medication for a heart attack) (O’Meara & Grbich, 2009).

1.1.6 New South Wales Ambulance

Paramedic care to the population of 7.8 million people in New South Wales is delivered by the state government organisation: NSW Ambulance. In the 2015/16 reporting period, the service responded to 1,115,635 requests for service. This is an average of 3,048 responses per day or approximately one response every 28 seconds (NSW Ambulance, 2016). The service employs over 4,500 staff, most of whom are paramedics reporting to work in either of the two distinct geographic rostering areas: metropolitan and regional (see Figure 1.1). The call volume, scale and complexity of service operations makes NSW Ambulance the third largest paramedic service in the world (NSW Ambulance, 2011).
At 809,444 km², the state of New South Wales could fit the entire United Kingdom three times, with room left over. One of the biggest challenges to overcome in such a large state is the distance travelled to deliver the patient to higher levels of care. This can take many hours and can contribute to paramedic fatigue (Courtney, Francis, & Paxton, 2010; Sofianopoulos et al., 2011).
1.1.7 The Anatomy of a Paramedic Call

In Australia, a paramedic call begins with a request, through the 0-0-0 emergency telephone number to a dispatcher who gathers information on the emergency. Aided by software prompts, they will ask questions to categorise the call by urgency. This is known as Computer Aided Dispatch (CAD) (Sporer & Johnson, 2011). Dispatchers will relay information to the paramedics, document times and prioritise calls. In New South Wales, priority of response determines the number of paramedic units to send and the use of ambulance warning lights and sirens. The most severe or urgent cases are assigned a Priority 1 response. See Table 1.2.
### Table 1.2
NSW Ambulance Response Grid

<table>
<thead>
<tr>
<th>Priority Code</th>
<th>Response Code</th>
<th>Category</th>
<th>Mode</th>
<th>Response Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>1A</td>
<td>Emergency Immediate Response</td>
<td>Hot</td>
<td>Closest and most timely approved Ambulance resource Minimum of 3 officers Highest Clinical Skill</td>
</tr>
<tr>
<td>P1</td>
<td>1B</td>
<td>Emergency Immediate Response</td>
<td>Hot</td>
<td>Most timely Ambulance response Highest Clinical Skill available</td>
</tr>
<tr>
<td>P1</td>
<td>1C</td>
<td>Emergency Immediate Response</td>
<td>Hot</td>
<td>Most timely Ambulance response</td>
</tr>
<tr>
<td>P2</td>
<td>2A</td>
<td>Emergency 30 minute Response</td>
<td>Cold</td>
<td>Ambulance to be at patient location within 30 minutes of call</td>
</tr>
<tr>
<td>P2</td>
<td>2B</td>
<td>Emergency 60 minute Response</td>
<td>Cold</td>
<td>Ambulance to be at patient location within 60 minutes of call</td>
</tr>
<tr>
<td>P2</td>
<td>2C</td>
<td>Emergency 90 minute Response</td>
<td>Cold</td>
<td>Ambulance to be at patient location within 90 minutes of call</td>
</tr>
<tr>
<td></td>
<td>2Ah 2Bh 2Ch</td>
<td>Emergency</td>
<td>Cold</td>
<td>Must arrive in accordance with 2A, 2B or 2C guidelines Consider ECP</td>
</tr>
<tr>
<td>P3</td>
<td>R3</td>
<td>Priority Medical</td>
<td>Cold</td>
<td>Medical calls to transport a patient to a health facility within an agreed time</td>
</tr>
<tr>
<td>P4</td>
<td>R4</td>
<td>Priority Aeromedical</td>
<td>Cold</td>
<td>Time critical prearranged response to or from airport/helipad</td>
</tr>
<tr>
<td>P5</td>
<td>R5</td>
<td>Routine Appointments</td>
<td>Cold</td>
<td>Medical/treatment appointments</td>
</tr>
<tr>
<td>P6</td>
<td>R6</td>
<td>Post appointments</td>
<td>Cold</td>
<td>Post Medical/treatment appointments</td>
</tr>
<tr>
<td>P7</td>
<td>R7</td>
<td>Convalescent</td>
<td>Cold</td>
<td>Discharge/Inter-facility/Palliative care</td>
</tr>
<tr>
<td>P8</td>
<td>R8</td>
<td>Sports/Special Events</td>
<td>Cold</td>
<td>Event Standby</td>
</tr>
<tr>
<td>P9</td>
<td>R9</td>
<td>Major Incidents</td>
<td>Hot/Cold</td>
<td>Major incidents as per service policy</td>
</tr>
</tbody>
</table>

**Note:** “Hot” refers to proceeding with the use of warning lights and siren. “Cold” refers to proceeding without warning lights and siren.
The dispatcher will make voice contact with a paramedic crew to relay (1) the Priority Code, (2) the nature/problem (Chief Complaint), and (3) the location of the incident. It is then relayed to a Mobile Data Terminal (MDT) in the ambulance. These data can be updated in the MDT as more information is acquired (NSW Ambulance, 2017b).

For documenting times for quality assurance and other purposes, there are five distinct epochs (or phases) of a paramedic call. The first epoch begins when dispatch contacts the paramedic will be termed “Assigned.” This may be the first instance of an elevated paramedic physiological response, for two reasons: (1) paramedics may have to move quickly to the ambulance and (2) this is the first instance of the nature/severity of the problem. It can elicit an elevated physiological response in the paramedics. Research on paramedics in Sweden reported a significant rise of heart rate unrelated to physical effort during the alarm phase (p <0.05) and remained high during all phases of an emergency call. Further, the authors stated that workload (physical effort) on calls did not involve major physical efforts except for moving the patient, equipment and other equipment, although these efforts were not well quantified. (Karlsson, Niemela, & Jonsson, 2009). See Figure 1.2.
Figure 1.2 A paramedic receiving a call in the **Assign** epoch. Call is received by radio, pager, phone or MDT. Paramedics usually have a maximum “chute” time (time from dispatch until ambulance begins continuous travel) to respond within (Eddy, 2018).

As the vehicle leaves the station or post, it is “**Enroute**” to the call and is the second epoch. Paramedics must multi-task while proceeding, often utilising warning lights and siren, monitoring radio communications and the mobile data terminal. They may also be discussing the approach to the call in advance. Coupled with these tasks, navigating busy streets during peak hour can be very challenging. Safe Work Australia data for the period 2000-2010 reveal that the ambulance vehicle accidents contributed to 62% of paramedic fatalities. This is a rate of 5.8 fatalities per 100,000 workers for paramedics compared to 0.5 fatalities per 100,000 for all workers. (Maguire et al., 2014). The cause or causes of ambulance vehicle accidents resulting in fatalities has not been described in the literature. See Figure 1.3.
Figure 1.3 A paramedic driving to the call in the Enroute epoch. One paramedic will drive, and the second paramedic may navigate, receive additional call information or begin preparing for the call (Simcoe Paramedic Service, 2018).

With arrival at patient side, the “On Scene” epoch of the call begins. After physically carrying or conveying equipment (see Table 1.1) such as stretcher, cardiac monitor, airway bag, medication bag, and/or trauma bag, the patient assessment begins. A decision is made whether the patient a) is ill enough to require a higher level of care, b) wants, or will seek that care, or c) can be referred to a lower acuity pathway. In the case of (a) or (b) the patient will be further assessed and treated, with extrication to the ambulance. Patient assessment and treatment can induce high levels of stress for the paramedic, for example, affecting accuracy in medication administration calculations (LeBlanc, MacDonald, McArthur, & King, 2005). The movement and extrication of a patient is a significant contributor to paramedic injury (Studnek, Mac Crawford, & Fernandez, 2012), most specifically stretcher operations (Crill & Hostler, 2005). This has been attributed to the weight of handling a loaded stretcher that can be associated with moving across uneven surfaces (Barnekow-Bergkvist, Aasa, Ängquist, & Johansson, 2004). See Figure 1.4.
Figure 1.4 A paramedic On Scene epoch initiating patient contact. The paramedic will carry necessary equipment to the patient, meet and assess the patient and determine appropriate treatment (LAS, 2018).

Once the patient is moved to the ambulance the “To Hospital” epoch begins. Assessment and treatment continue during this epoch, usually
with one paramedic giving care and the other driving to the hospital. See Figure 1.5.

![Figure 1.5](image)

**Figure 1.5** A paramedic in the ambulance with a patient in the **To Hospital** epoch. The paramedic will continue treatments, reassess the patient, and contact the hospital with updates when necessary (BCEHS, 2018).

The fifth epoch of a paramedic call is termed “**At Hospital**”. Here, paramedics physically move the patient from the ambulance to the hospital (usually Emergency Department) and begin transfer of care to nurses and/or physicians. This takes the form of an oral handover and moving the patient from their stretcher to a hospital bed. The lead paramedic will begin documenting the call. Paramedics will then ready the ambulance: restocking and cleaning for the next call. Dispatch will then be notified that they are ready for the next call. Post call, quality assurance managers will analyse the patient care data to measure patient outcome, patient satisfaction as well as other indicators of performance (El Sayed, 2012). See Figure 1.6.
Figure 1.6 Paramedics delivering a patient to the Emergency Department in the At Hospital epoch. Here, the patient is handed over to hospital staff at which point care is transferred. Paramedics will complete a patient care record and prepare the ambulance for the next call (Simcoe Paramedic Service, 2018).

1.2 Aims – Context and Correlates of Paramedic Health Status and Job Performance

The execution of an emergency call involves making clinical decisions based on available information with emergency care relying on critical decision making and peak cognitive functioning (Courtney et al., 2010). The demands of a paramedic’s job are multifactorial. This means that a paramedic can experience physical and mental challenges of the occupation (Chapman, Peiffer, Abbiss, & Laursen, 2012; Gamble et al., 1991; Hammer, Mathews, Lyons, & Johnson, 1986; Paterson, Sofianopoulos, & Williams, 2014). How clinical decision making, and the physical challenges of the paramedic job performance relate warrants further examination. There is a paucity of literature on the effect of health status on job performance.
As this profession evolves, issues such as paramedic health status, the demands of occupational performance, clinical decision-making and how these may influence patient care is gaining attention. However, paramedic care, specifically the occupational tasks are not well defined, nor measured. For this thesis, it meant developing new approaches to researching paramedics to more fully define the context of their work. This includes continuous physiological monitoring in situ to understand how heart rate, respiratory rate and g-force production are influenced by their job. The last measure, g-force, is derived from tri-axial accelerometers recording raw accelerometer signal in x, y and z planes of movement worn by the paramedics (Barker & Mercer, 2017; Speckhard, Knous, & Coughlin, 2017). There is a necessity in establishing the context as it can help to identify trends and new information on how the job may affect health status. In a novel approach to researching these issues, this thesis examined the factors that influence physiological demands during the performance of emergency calls. It is important that these factors be examined to ensure that paramedic care can be delivered well and consistently, to all who need it. It seems paramedic injury statistics are well reported, but the work that paramedics do is not. Therefore, this research will focus on paramedics of NSW Ambulance and comprises four studies, each with specific aims.

1.2.1 Aims and Hypotheses: Study One

Study 1, as described in Chapter 3, had primary and secondary aims. The first primary aim was to determine if differences or relationships are apparent in the health status using a previously validated survey instrument (SF-36) and self-reported BMI of paramedics by gender, posting, age and years of service. The second primary aim was to compare health status (SF-36 and BMI) of paramedics with that of the Australian general population. Study 1 had a secondary aim of exploring paramedics’ perceived barriers to exercise. As well, it examined PA levels using a survey instrument, the IPAQ which estimates total MET-
minutes to determine if differences or relationships are apparent by gender, posting, age and years of service.

Hypotheses

1. Health status of paramedics (SF-36 and BMI) will differ by gender and posting and be negatively correlated with age and years of service.

2. The paramedic population of NSW Ambulance will have a lower health status (SF-36 and BMI) when compared to the Australian population.

3. Paramedics reported barriers to exercise will differ by posting.

4. Physical activity levels (IPAQ) of paramedics will differ by gender and posting and be negatively correlated with age and years of service.

1.2.2 Aims and Hypotheses: Study Two

Study 2, as described in Chapter 4, was a validation of the Hexoskin® biometric shirt and associated hardware and software for HR and RR measurement. Biometric monitors (also known as “smart wearables) are relatively new to applied research and hold promise in the collection of human physiological data. These devices were used to collect data for two studies in this thesis. The ability to monitor HR, RR, steps, occupational physical activity (OPA) and energy expenditure (EE) during paramedic calls can give additional insight into the demands of paramedic job performance. The aims were to validate the Hexoskin® biometric shirt compared to standard laboratory equipment for measurement of HR and RR.
Hypotheses

1. The Hexoskin® biometric shirt will be validated for heart rate monitoring when compared with a standard ECG monitoring machine.

2. The Hexoskin® biometric shirt will be validated for respiratory rate monitoring when compared with the metabolic cart.

1.2.3 Aims and Hypotheses: Study Three

Study 3, as described in Chapter 5, was an examination of the demands of paramedic job performance and to establish a descriptive profile of occupational task performance. Paramedics were monitored through the measurement of HR and RR before, during and after emergency calls. Self-reported measures of mean arterial blood pressure (MAP) and Rate of Perceived Exertion (RPE) were also recorded. In this novel approach to researching paramedics, a tri-axial accelerometer recorded of levels of OPA (expressed as g-force) during emergency calls and throughout shifts. All these data were correlated with calls attended to establish trends and examine linkages to variables (e.g. age, gender, level of certification, BMI, shift type, Priority Code, Chief Complaint).

The first aim was to establish and compare the descriptive profiles of two distinct groups of NSW Ambulance paramedics: Paramedic posted in urban areas (Metropolitan) and those posted in regional and rural areas (Regional). Research used objective and self-reported measures of (1) demographic characteristics, (2) OPA (3) emergency call response characteristics, and (4) physiological responses. The second aim was to examine if BMI by WHO category (Underweight, Normal Weight, Overweight and Obese) affects physiological responses of paramedics, specifically: HR at shift start, shift average, call average, %HR_{max} and MAP. The third aim was to examine how variables of emergency call
response (Priority Code, time on calls, time on all calls, calls per shift, transports per shift, and RPE) affected physiological responses of paramedics (HR, RR, and MAP). The fourth aim was to examine how variables of OPA (g-force: shift start, shift average, call average, call maximum and steps per shift) affected physiological responses of paramedics (HR, RR and MAP).

Hypotheses

1. Demographic characteristics, occupational physical activity, emergency call response characteristics and physiological responses will differ by posting (Metropolitan and Regional).

2. BMI in the WHO categories of Overweight and Obese will elicit a stronger physiological response of paramedics compared to Normal and Underweight categories (HR: at shift start, shift average, call average, %HR\textsubscript{max} and MAP).

3. Variables of emergency call responses (higher call priority, chief complaint, time on calls, increasing calls/shift, transports/shift, and increasing RPE) will elicit stronger physiological responses in paramedics (HR and RR).

4. Variables of OPA (higher g-forces at: shift start, shift average, call average, call maximum, and steps/shift) will elicit stronger physiological responses of paramedics (HR and RR).

1.2.4 Aims and Hypotheses: Study Four

Study 4, as described in Chapter 6, examined the effect of cardiorespiratory fitness (CRF) levels on paramedic response during emergency calls including cardiac arrest calls. Fitness levels were
established using a field-based physical conditioning test which measured aerobic capacity and established HR\text{max}, the Multi-stage Shuttle test (Paradisis et al., 2014; Ramsbottom, Brewer, & Williams, 1988). Participants also completed the SF-36 and IPAQ. The aims were to examine how CRF (\( \dot{V}O_2 \) \text{max} and \( \dot{V}O_2 \) \text{max by category}) and health status (BMI) influences physiological response (HR, %HR\text{max} and RR,) during emergency call responses (by epoch and Priority Code), including while performing CPR during cardiac arrest calls. A second aim was to explore relationships between measures of health status (BMI, SF-36 and IPAQ), CRF and physiological response (HR, %HR\text{max} and RR).

Hypotheses

1. Paramedics with higher levels of CRF and better measures of health status (BMI) will have lower HR, %HR\text{max} and RR) on emergency call responses than those with lower CRF and lower measures of health status including while performing CPR during cardiac arrest calls.

2. Lower measures of health status (increased BMI, decreased SF-36 and IPAQ scores) will be negatively correlated with higher levels of CRF.

Summary

It is the intention that the knowledge gained from this research will contribute to paramedic service strategies to support paramedics. These are paramedics who may presently be at risk of decrements in skill performance (e.g. CPR) or at risk of musculoskeletal injury due to occupational physical demands. These may be linked to fitness level. Further, they may be at increased risk of illness impacting their health status. This thesis intends to provide an examination of the paramedic
health status, physical activity levels (self-reported and objectively measured) and the effect of the physical and physiological demands of the job of paramedics.

In 2017, the same year NSW Ambulance paramedics accrued record levels of sick time, there were 1,087 students enrolled in NSW university paramedic programs preparing for graduation and to enter the profession (Sher, 2018).

*Without an examination of how to create, measure and maintain healthy work practices, we are perpetuating the need for more and more paramedics to replace the “broken” ones. And our customer, the patient, is demanding a skilled practitioner who makes complex clinical decisions and executes skills without mistake, a paramedic who is “Fit for Duty”.*
CHAPTER 2: REVIEW OF LITERATURE

“The delivery of emergency medical services….is a complex enterprise that exists at the confluence of medicine, public safety, public health and transportation”

Dave Shrader
2.1 Overview

The challenge facing paramedics is that of reported poor health status and how their occupation may be affecting that health status. The research aims, and hypotheses presented in Chapter 1 outline an investigation into the health of paramedics and an establishment of a descriptive profile of the nature of their work. Furthermore, how paramedics’ health status may influence physiological responses during emergency calls and the effect of cardiorespiratory fitness and health status will be examined.

The literature review will describe paramedic care including describing the physical demands of occupational task performance. How the paramedics are assessed to meet these physical demands (1) as student paramedics, (2) at hiring and (3) post-hiring, will be detailed. Additionally, how these physical demands influence physiological response from a cardio-respiratory, musculoskeletal, and energy expenditure perspective will be examined.

Current health status of paramedics is the focus of this thesis, therefore there will be a discussion on measures of paramedic health status, and specifically describing injury rates and patterns and incidence of illness. The impact of paramedic health status on job performance will be described. This will include how clinical performance is impacted and its effect on the longevity of a paramedic’s career. How this compares to the health status of the Australian general population and other public safety providers is also presented.

2.2 Describing Paramedic Care

2.2.1 Paramedics

Paramedics must adapt and fit the delivery of care into the unpredictable out-of-hospital environment, something that makes them unique in the world of health care. Paramedic care evolved from rapid treatment and
transport of the sick or injured, originating in the battlefield setting (Bell, 2009). The physical dangers and mental stressors of early war-time paramedicine are now changing, being replaced with the tensions and issues of delivering patient care in civilian settings.

The term “paramedic” as defined by Paramedics Australasia in a report prepared in 2016:

“A paramedic is a health professional who provides rapid response, emergency medical assessment and care in the out of hospital environment…the paramedic is often required to make complex and critical clinical judgements without direct supervision. A paramedic may be engaged by a statutory ambulance service, a private paramedic service, academic/teaching institution or defence force. They may operate in community, resource sector, education, defence or event/public gathering settings.” (Paramedics Australasia, 2016).

Paramedic care, as summarised by Canadian researchers is care rendered by an advanced medical provider responding by ambulance to a patient’s side in an emergency to assess and treat urgent medical and trauma conditions then transport the patient for further medical care. (Bowles, van Beek, & Anderson, 2017). Thus, for the purposes of this thesis, paramedics working for NSW Ambulance delivering care in the out-of-hospital environment will be the focus of the research. The context of their work (how they do their job) will be examined to better understand why they have high rates of injuries and sick time.

2.2.2 Paramedic Calls: Nature and Volume

In Australia, in 2016, there were 3.4 million paramedic call incidents or 145.1 incidents per 1,000 people. Of these incidents, 40.3% were classed as emergency incidents, 33.9% classed as urgent and 25.9% as non-emergency. That equates to over 13 million urgent incidents. These calls are a subset of the 4.3 million responses or 178.1 responses per 1,000 people where multiple responses deployed to a single incident, or
incidents where no patients were treated and/or transported (Australian Government Productivity Commission, 2017a). Exploring how paramedics cope with the type and amount of these responses and their effect on paramedic health needs research, especially considering the frequency of paramedic injury and illness.

2.2.3 Paramedic Physical Demands

While paramedic work can be very unpredictable, the following demands could be expected in carrying out the occupational tasks: standing/walking, sitting, lifting and carrying, bending, crouching/kneeling, climbing, reaching, pushing/pulling and handling/grasping (Bureau of Labor Statistics, 2018). These demands have not been well quantified in the literature. However, NSW Ambulance developed the Paramedic Health Standard “to define the level of health and fitness required to perform these inherent requirements and physical demands of the position of Paramedic” (NSW Ambulance, 2012). The standard defines three areas of physical performance: (1) Ambulance operation where the paramedic must have sufficient musculoskeletal strength, endurance, range of movement, coordination and dexterity to operate the vehicle safely. (2) Access/extrication of patients where paramedics must be able to carry defibrillators, oxyvivas and equipment packs weighing up to 12 kg each for a total of 36 kg. The ability to lift patient loads with a scoop stretcher, individually lift up to 40 kg or in teams of two, up to 60 kg using a stair chair, and (3) Perform clinical tasks such as gain access to patient for treatment. Access to patients’ homes or apartments is often through normal points of entry. However, in calls involving trapped patients (for example motor vehicle collisions), access may be delayed and require the assistance of the fire department. Once access in gained, paramedics would position equipment weighing up to 15 kg (NSW Ambulance, 2012).

The Queensland Ambulance Service (QAS) also details critical job demands that include: sitting and driving, frequent and sustained
squatting and kneeling, frequent manual handling of patients, lifting and handling patients (<180 kg), manual handling of equipment (<20 kg) between ground and should level (QAS, 2016). QAS appears to be the only paramedic service in Australia to define job demands by geographic posting (metropolitan and regional). The additional job demand for QAS regional paramedics is “some sustained sitting or lying down at station when on standby waiting for calls on night shift” (QAS, 2016). This does not infer that metropolitan crews cannot have periods of sustained sitting or lying down, rather the call volumes in some regional areas are significantly lower. This has been researched in England, with researchers finding a significant difference in calls based on population density (Peacock & Peacock, 2006).

In a national study, Fischer (2014) cross-trained Canadian paramedics to evaluate occupational tasks from an ergonomist viewpoint in 7 paramedic services. This aided in identifying high demand and frequently occurring tasks, and factors that affect those demands. Dividing respondents into high populous (HP) and low populous services (LP), they found the frequency of routine physical demands were lifting, lowering, carrying, pushing and pulling with stretcher loading (25.6% of respondents) carrying equipment (19.5 % of respondents), and pushing and pulling the stretcher (13.4% of respondents), as the most physically demanding tasks. In HP services the empty stretcher was loaded and unloaded more often than the LP (10.0 ± 4.1 vs 5.6 ± 3.4) each 12-hour shift (Coffey, MacPhee, Socha, & Fischer, 2016). The authors noted that paramedic work consisted of periods of sedentary activity interspersed with periods of higher physical activity. Lavender, Conrad, Reichelt, Johnson, and Meyer (2000) described the most frequently performed physically demanding tasks as transferring a patient from bed to stretcher, lifting and transporting patients down stairs either on a backboard or using a stair chair. The physical occupational tasks as outlined above, can be further demanding by environment. Barnekow-Bergkvist, Aasa, Ångquist, and Johansson (2004) report that lifting and
carrying patients and equipment up and down stairs. This agrees with (Corbeil et al., 2018), who interviewed 101 paramedics in Quebec, Canada. Researchers noted that paramedics reported a perception of increased physical demand for these tasks if the call was deemed “urgent” and time sensitive.

2.3 Physiological Demands during Paramedic Job Performance

Research on the physiological demands of paramedic job performance takes place in several settings including laboratory, simulation and in the workplace. The literature reports most of the research in the laboratory and simulation settings. A previous lack of reliable and validated biometric measurement devices that could function in that environment may have contributed to the lack of research. Other factors that may have contributed include no agenda to study paramedic health, lack of funding, lack of researchers and support for researchers to conduct this research.

2.3.1 Cardiorespiratory

Cardiorespiratory fitness is the ability of the circulatory and respiratory systems to supply and utilise oxygen during sustained physical activity (Caspersen, Powell, & Christenson, 1985). Thus, cardiorespiratory fitness (CRF), expressed as $\dot{V}O_2\text{max}$, is the best marker for functional capacity. The measure of $\dot{V}O_2\text{max}$ can be used to describe maximal oxygen uptake and is often used in conjunction with the term aerobic power (Rankovic et al., 2010). Where $\dot{V}O_2\text{max}$ is used in this thesis, it is being used to describe aerobic power. This measure can be expressed relative to body weight in millilitres of oxygen consumed per kilogram per minute (mL/kg/min) and is influenced by physical activity and exercise, age, gender and genotype. Specifically, $\dot{V}O_2\text{max}$ can improve with increasing physical activity and exercise and will decease with age. Males can have higher $\dot{V}O_2\text{max}$ than females and the rate of heritability suggests that $\dot{V}O_2\text{max}$ capacity is under strong genetic control (Alonso,
Research indicates that $\dot{V}O_2$ max is quite variable in paramedics. Buzga, Jirak, and Buzgova (2015) report the mean oxygen consumption $\dot{V}O_2$ max of 42 professional paramedics from the EMS Regional Center of Ostrava City, Czech Republic was 36 mL/kg/min in the group <30 years of age; 39.8 mL/kg/min in the group 31 to 35 years of age; and 31.1 ml/kg/min in the group >36 years of age. English paramedics (n=6) in special operations roles (ambulance responders trained to deal with hazardous or difficult situations, particularly incidents such as situations involving firearms and mass casualties) appear to have higher $\dot{V}O_2$ max, recording a mean $\dot{V}O_2$ max value of 46.5 ± 1.6 mL/kg/min (Gallagher et al., 2017) consistent with special operations paramedics in Western Australia (n=11) who reported $\dot{V}O_2$ max value of 45.8 ± 5.2 mL/kg/min. Estimating the CRF of paramedics based on the available literature is imprecise as there is a variety of methodologies employed in the small number of studies of paramedic $\dot{V}O_2$ max values. However, when comparing the $\dot{V}O_2$ max values of paramedics to studies of other occupations, one can note that values of 39-43 mL/kg/min were reported in one study of healthy and full-time employed adults (n=303) (Mundwiler et al., 2017). The implication is that paramedics may not have higher $\dot{V}O_2$ max values than the general population except in a) pre or early career, or b) where job requirements (for example special operations) establish a higher level.

One of the first studies of the cardiorespiratory physiological demands of paramedics was in Northern Ireland. Gamble et al. (1991), in a study of 8 paramedics, monitored HR over a total of 21 shifts. The data showed periods of high activity including during CPR and carrying patients resulting in HR above anaerobic threshold (the highest sustained intensity of exercise for which measurement of oxygen uptake can account for the entire energy requirement (Svedahl & Maclntosh, 2003)) for periods of up to 11 minutes. Gamble et al. (1991) also had paramedics
respond to a simulated emergency. Participants, divided into pairs were
tasked to run up five flights of stairs to a simulated emergency, assess
the patient, return down stairs to retrieve equipment and then carry a
patient (body weight 70 kg) down the stairs. Mean heart rates of 150 bpm
were reached (range 129-162 bpm) in all 8 personnel representing 60% of
their calculated \( \dot{V}O_2 \) max. A submaximal test of physical working
capacity was performed on a cycle ergometer and converted to predicted
\( \dot{V}O_2 \) max. The study was one of the first to call for standards of physical
fitness for ambulance personnel. Given the scant research on the
physical capacities and health of paramedics at the time of this
publication (1991), this is the first recommendation based on applied
research involving paramedics. It also highlights that the examination of
aerobic power in paramedics must continue to be studied.

Heart rate in paramedics working 24-hour shifts (n= 30) recorded a mean
HR of 78.1 ± 8.1, slightly lower (and non-significant) compared to HR on
non-work days (83.2 ± 10.9). This difference was attributed to more
instances of standing and different types of work activity undertaken at
home compared to while on shift (Goldstein, Jamner, & Shapiro, 1992).
In examining HR during shifts only, it appears affected by occupational
stressors. Karlsson et al. (2009) noted that paramedics (n= 20) exhibited
significant increases in HR not related to physical exertion of an
emergency call and postulated that this was due to other occupational
stressors (for instance responding to a report of an ill child). Similarly,
level of care influenced HR response. Paramedics (n= 24) wore heart
rate monitors and were observed to have significantly higher heart rate
changes (in beats per minute) on the intensive care unit as opposed to
the patient transport unit (ICU 30 ± 17 bpm versus PTU 7 ± 8 BPM, p<
0.001) compared to shift start at rest (Backe et al., 2009).

The data and research studying the cardio-respiratory response of
paramedics illustrates a variability in results and an overall need for more
research in this area. Some of the studies are now over 10 years old and
given the advances in physiological monitoring technology, a more comprehensive approach to the effect of the occupation on the physiology of paramedics is possible.

2.3.2 Musculoskeletal

The physiological demands of paramedic occupational task performance from a musculoskeletal perspective seem not well reported. While research can report types and frequencies of injuries, the quantification of the role is not clear. The two Australian paramedic services who quantify physical demands are described earlier. Paramedics perform job tasks that cross the primary components of fitness as described by others (Chapman et al., 2008; Merrill, 2013; Pollock et al., 1998) examples of which can be summarised in the following table:

<table>
<thead>
<tr>
<th>Component of Fitness</th>
<th>Associated Job Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic Endurance</td>
<td>Extended periods of CPR</td>
</tr>
<tr>
<td>Anaerobic Endurance</td>
<td>Carrying equipment and/or patients over extended periods</td>
</tr>
<tr>
<td>Muscular Strength</td>
<td>Lifting and carrying patients from the floor to a higher position</td>
</tr>
<tr>
<td>Muscular Endurance</td>
<td>Extended periods of CPR</td>
</tr>
<tr>
<td>Mobility</td>
<td>Bending to pick up equipment, manoeuvring in tight or awkward areas to access patients.</td>
</tr>
</tbody>
</table>

This thesis will conduct research to examine these components of paramedic fitness to better understand physical demands of the role.

Swedish researchers studying paramedics in simulation (n= 65, 48 males and 17 females) showed a strong correlation between maximum aerobic capacity (\( \text{VO}_2 \text{ max} \)), isometric back endurance and acute fatigue while carrying a loaded stretcher with a total load of 920 N in simulation (Barnekow-Bergkvist et al., 2004). In the Swedish study, subjects’ isometric lifting strength was measured. The compressive forces of patient movement were quantified in work by Lavender et al (2000). They
describe that lifting and carrying of patients elicited a heightened risk of musculoskeletal injury whilst under load. (Lavender et al., 2000), suggesting that paramedics may not have sufficient strength to cope with job-related physical stressors. In the Lavender study, paramedics qualified that they felt the most physical demanding tasks were horizontal transfer from bed to stretcher and descending stairs with a patient on a stretcher. The authors state that the lack of muscular strength in paramedics was concerning given the relatively light weight of the test dummy.

The ergonomics of paramedic task performance can lend itself to paramedics adopting sustained and awkward postures involving variable levels of force (Broniecki, Esterman, May, & Grantham, 2010). In a study of paramedics who were transferring a simulated patient from a bed to the stretcher evidenced median compressive forces on the paramedics’ spine (L4/L5) of between 3,700 and 7,600 N (mean 5476 N). All values exceeded US National Institute of Occupational Safety and Health action limit of 3434 N, with some values exceeding maximum allowable limit (6,377 N) (Lavender et al., 2000).

Musculoskeletal strength as part of physical fitness testing has been measured in paramedics. Chapman et al. (2012) evaluated 29 Western Australian paramedics finding above normal levels of local muscular endurance (measured with sit-ups, push-ups and chin-ups) and muscular strength (measured with 5 stage abdominal and grip strength). However, 11 of the paramedics were special operations paramedics which may suggest that they may have higher levels of overall fitness as part of their role. Of note is that all paramedics were either serving special operations paramedics or undergoing fitness evaluation as part of the selection process for special operations positions. These findings were in contrast in a study of 139 regional NSW Ambulance paramedics who demonstrated insufficient core strength (as measured by the prone plank hold) and lower body strength (as measured by the wall squat test) compared to adult norms (Hunter et al., 2018).
With evidence that occupational activities can contribute to musculoskeletal strain, and some evidence of current fitness levels of paramedics, there is a need to further examine both. Specifically, monitoring paramedics’ response to occupational physical activity in situ becomes even more important.

2.3.3 Physical Activity and Energy Expenditure

Physical activity (PA) is defined as any bodily movement produced by skeletal muscles that require energy expenditure (Caspersen et al., 1985). Consequently, PA is classed as either modes (referring to different specific activities) or domains (walking, running, carrying loads) (Welk, 2002). Further, these vary along three dimensions: frequency (number of bouts of PA), duration (length of time) and intensity (how strenuously the activity is performed) (Hansen & Ekelund, 2017).

Occupational physical activity has been measured objectively and subjectively. From the National Health and Nutrition Examination Survey (NHANES) research in the United States, objectively measured occupational activity using accelerometers and placed paramedics in the Low Occupational Activity category (Steeves et al., 2005). Although there are physical demands of paramedic work, over the entire shift, these demands may be infrequent or interposed with long periods of relatively sedentary activity, for example, driving or waiting at station for the next call. This has been reported in Canadian paramedics participating in a study of physical demands (Coffey, MacPhee, Socha, & Fischer, 2016). Paramedic self-reported physical activity has been measured. The International Physical Abilities Questionnaire (IPAQ) measures estimates total MET-minutes per week (Craig et al., 2003). Paramedics using the IPAQ, have quite variable results from 2088 MET-minutes/week (Courtney et al., 2010) to 4,000 MET-minutes in paramedic students (Micalos, MacQuarrie, Haskins, Barry, & Anderson, 2017). Current Australian guidelines for weekly Met-minutes are between 500-1000 MET-minutes. This difference between reported paramedic MET-minutes
and the guidelines seems to indicate that the paramedics and paramedic students accrue more than the weekly recommendation. This seems at odds to published reports of high BMI in paramedics. Further study of paramedic activity with accelerometers is warranted as part of this thesis.

Energy expenditure, expressed as Total Energy Expenditure (TEE) represents the basal metabolic rate (BMR) and the thermic effect of food and activity thermogenesis (also referred to as Active Energy Expenditure (Hansen & Ekelund, 2017). There appears to be a paucity of research examining EE in paramedics. Its usefulness can extend to providing further background on paramedic activity patterns in the workplace.

Researchers examined EE in paramedics in Quebec, Canada (n= 22) estimating 24-hour EE in situ during scheduled work days of between 2,500 and 2,700 kcal. Energy expenditure on those days was estimated based on the relationship between energy expenditure (estimated through indirect calorimetry measured during a laboratory session) and HR. The methodology appears unclear of how HR was measured and how the calorimetry was carried out (Hegg-Deloye, Prairie, Larouche, & Corbeil, 2018). A simulated call lasting a total of 60.3 minutes, utilising one paramedic from the same study provided an estimated EE of 5.0 kcal/minute (Corbeil et al., 2018).

In other emergency services, Affeldt (2010) monitored firefighters (n= 9) using an Actiheart monitor (Mini Mitter Co., Inc, Bend, OR) to estimate EE found that it was significantly higher during shift activities (station duties) compared to emergency response. This was attributed to the greater amount of time spent on shift activities than on responses. Canadian wildland firefighters (n= 21) wore activity trackers and heart rate monitors during firefighting, project-planning and base duties to calculate their EE. Hourly EE was significantly higher during firefighting (250 ± 61.9 kcal/hr) compared to project planning (202 ± 79.4 kcal/hr) and base duties (137 ± 51.1 kcal/hr) (p< 0.001) (Robertson et al., 2017).
This suggests that emergency response in firefighting can elicit a higher energy expenditure than other duties associated with the role of a firefighter.

The paucity of data on energy expenditure during work activities for paramedics meant that an examination of other emergency responders was necessary. The data in this section in terms of hourly energy expenditure by firefighters was used in Chapter 5 of the thesis as a comparator with newly collected EE data for the paramedics. It was important to illustrate, through a variety of measures that paramedics may not be as physically active in the workplace as once thought.

2.4 Fit for Duty: Assessing for the Physical Demands of Paramedicine

2.4.1 During Training

Prior to employment as a paramedic, most candidates complete an undergraduate degree in paramedicine. The professional body representing paramedic services in Australia is the Council of Ambulance Authorities (CAA, 2018). They have established the Professional Competency Standards which form the basis of accreditation of Australian universities teaching paramedic programs (Council of Ambulance Authorities, 2013). There is language in the Standards addressing the requisite fitness level of paramedics, specifically stating: “Develops and maintains personal health and wellbeing strategies - practices safe manual handling techniques within the scope of paramedic duties - maintains physical health, fitness and nutrition” (Council of Ambulance Authorities, 2013). Universities training paramedics would then incorporate this competency within their curricula.

Assessing physical suitability for the occupation by universities is variable. Several universities stipulate successful completion of a physical fitness test either before entry to university or prior to ambulance placements. Two universities in Australia measure fitness components through a step test, double leg hold, supine neck hold, plank hold, static
push and pull and grip strength based on the Ambulance Victoria Physical Capacity Testing Protocol (Monash University, 2017; Victoria University, 2017). No reference is made as to the criterion validity of this set of tests. Flinders University states that an assessment of paramedic students’ muscle strength and endurance, fitness, flexibility, and the student’s ability to lift, push, pull, bend, stoop, squat, kneel and reach is performed (Flinders University, 2017) utilising the guidelines of South Australia Ambulance Service. Charles Sturt University does not indicate health and fitness requirements for entry to the paramedic degree, nor specify a requisite level for placement or upon graduation. (Charles Sturt University, 2018).

Curtin University in Western Australia is a post-employment educator who states that St John Ambulance, the provider, carry out a functional capacity and medical assessment of students prior to beginning the training (St. John Ambulance, 2018). Australian Catholic University, with campuses across Australia follow the guidelines for the ambulance service of their respective states. For example, in Queensland, students specifically indicate the components of their physical testing (Australian Catholic University, 2017).

There is evidence that paramedics receive education on health, nutrition, physical activity and injury prevention in at least one university (Norton, 2018), however, it does not seem to be present as a stand-alone subject at all universities. Preparation during undergraduate training for the physical nature of the profession, appears inconsistent. This may be evidencing itself in the current reporting of paramedic injuries (Roberts et al., 2015). It is, therefore, difficult to ascertain if paramedic students are fit for duty. The issue is that the physical demands of paramedicine are not well quantified, therefore, the preparation to meet them will remain unclear. Whether new paramedic graduates are physically capable of the work is one question. The second question is what happens in the later years of the paramedic career, given little information on the job and how
to prepare for it. High rates of injury could be attenuated by early targeted education and deserves further research.

Where paramedic students in training have undergone fitness testing, the results were comparable. Male Finnish paramedics students (n=40, 26 female and 14 male) had greater strength and VO₂ max in male than female students (p< 0.05). BMI for all participants was in the WHO category of normal with both strength and cardio-respiratory fitness within norms for age and gender (Paakkonen, Ring, & Kettunen, 2018). Student paramedics in Czechoslovakia (n= 32) had a mean VO₂ max of 47.0 ± 6.1 mL/kg/min (Buzga et al., 2015). Male paramedic students (n= 20) in South Africa had a significantly higher VO₂ max of 47.0 ± 7.8 mL/kg/min compared to 37.3 ± 6.9 mL/kg/min for females (n= 18) (p= 0.01). The implication is that there is a rapidly changing paramedic workforce demographic. In a once male dominated profession, females in many services now represent a significant proportion of the workforce. How female paramedics perform the physical aspects of the job needs to be studied.

More research on the fitness levels of paramedic students could better inform universities of strategies to prepare students for the physical nature of the profession. Specifically, testing paramedic students on the components of fitness as described by the paramedic service (see Table 2.3) would serve to make students aware of the physical nature of the profession. Given the relatively young paramedic workforce in Australia and high injury rates, this may not be taking place presently.

2.4.2 Upon Hiring

All Australian states and territory services state that fitness testing is a component of the initial employment process: Ambulance Victoria, New South Wales Ambulance, South Australia Ambulance Service, Queensland Ambulance Service, Tasmanian Ambulance Service, ACT Ambulance Service, St John Ambulance Western Australia and Northern
Territory. Information from each service, describing the physical demands and pre-employment health and fitness testing is summarised in Table 2.3.

It appears that the physical fitness testing both varies by service and may not be uniformly based on a validated physical demands analysis. This latter point is illustrated in a study of undergraduate paramedic students (n=251, mean 24.9 ± 1.9 yrs.) in an Australian university utilising the physical pre-employment test for the Queensland Ambulance Service. Researchers concluded the scoring system did not exclude participants with poor fitness levels. There was no gender adjusted scores, therefore male participants had a decided advantage with males scoring significantly higher (p< 0.005) in strength tests than females. (Thornton & Sayers, 2013).

There is an identified need to evaluate the efficacy of paramedic service pre-employment physical capacity testing. A systematic review of paramedic physical capacity testing as a predictor of musculoskeletal injuries noted no studies in this area specific to paramedics (Jenkins, Smith, Stewart, & Kamphius, 2016). The authors did note that decreased level of physical fitness and the physical nature of the job could contribute to injuries. Gender was also a key factor, with female paramedics having a disproportionate number of injuries. As well, the use of powered stretchers was associated with a decrease in injuries, although this was not the only contributing factor in the reported high rates of paramedic injury. So, while paramedic injuries are well reported (Maguire, 2011; Maguire et al., 2014; Maguire & Smith, 2013; Roberts et al., 2015; Sterud et al., 2006), the physical demands of paramedic job performance are not well quantified.
<table>
<thead>
<tr>
<th>Paramedic Service</th>
<th>Position description Physical Demands</th>
<th>Assessment items</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW Ambulance</td>
<td>Operate ambulance medical equipment and implement medical procedures to provide patient care and treatment in an out of hospital environment consistent with the Paramedic scope of practice.</td>
<td>1. Hover test – support body weight between toes and elbow, with back and legs held straight for at least 60 seconds. 2. Carry load test – demonstrate can safely lift and carry two weighted bags (total weighted maximum of 36 kg) and ascend and descend one storey of stairs twice in less than 90 seconds. 3. Shoulder lift test – reach and lift a 12 kg weighted bag near shoulder height and carry with the same arm.</td>
</tr>
<tr>
<td>Queensland Ambulance Service</td>
<td>Present fit for duty by being physically healthy, illness and fatigue free, and psychologically healthy; and utilise staff support and counselling services when required. Assess the most appropriate method of conveying patients using the relevant equipment and moving and handling techniques where necessary.</td>
<td>Manual Dexterity: Purdue Peg Board Test This component assesses dexterity a. gross movements of the fingers, hands and arms; and b. fine fingertip dexterity necessary in assembly tasks. Grip Strength: Unilateral Grip Strength Dynamometer Test This component assesses grip strength Back Strength: Back Strength Dynamometer Test Leg Strength: Leg Strength Dynamometer Test Abdominal Strength: 7 Stage Sit Up Test This component measures abdominal strength Abdominal Endurance: 60 Second Sit Up Test. Cardiovascular Fitness: 3 Minute Step Test This component measures submaximal aerobic capacity via continuous stepping up and down on a step of specific height (12 inches) at a specific speed (24 steps per minute). Trunk Flexibility: Sit and Reach Test This component measures low back and hamstring flexibility. Trunk Rotational Flexibility Test</td>
</tr>
<tr>
<td>South Australia Ambulance Service</td>
<td>No mention</td>
<td>The dynamic lift of a weighted box is primarily based on the force required to lift the head end of a laden stretcher from half height to full height. The static push and pull demands are based on the forces required to load and unload laden stretchers. They also reflect the forces involved in lateral transfers.</td>
</tr>
</tbody>
</table>
Note the data are adapted from Ambulance Tasmania (2015); Jansz (2016); NSW Ambulance (2017a); SAAS (2018); St. John Ambulance (2018).

2.4.3 Post-Hire

In terms of post-employment recurring fitness training or testing for physical demands, it is evident Australian paramedic services have an

<table>
<thead>
<tr>
<th>Ambulance Service</th>
<th>Functional Capacity and Medical Assessment</th>
<th>Physical Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. John Ambulance Western Australia</td>
<td>The Functional Capacity and Medical Assessment is designed to assess your physical capability to undertake the requirements of the role. Work as an Ambulance Officer with St John requires a good level of physical fitness.</td>
<td>Manoeuvring stretchers, and sliding patients on the blue slide sheets or on spinal boards. The grip strength minimum requirements are based on the force required to operate the stretcher levers. The Jamar measuring equipment is positioned at the same grip width and angle to mimic the hand position of an Ambulance Officer loading a stretcher.</td>
</tr>
<tr>
<td>Ambulance Tasmania</td>
<td>Ambulance staff are required to carry out a range of physically demanding tasks whilst performing patient care duties. These tasks often require a combination of both physical fitness and functional attributes.</td>
<td>The physical assessment is designed to assess the physical capacity and ability to perform physical tasks specific to the ambulance role. This includes aerobic fitness level and strength requirements to suitability undertake the work such as carrying a patient and performing cardio pulmonary resuscitation.</td>
</tr>
<tr>
<td>ACT Ambulance Service</td>
<td>Applicants who are being considered for appointment may be required to undertake a medical examination and fitness assessment. This will be performed at the expense of the ACTAS. Following review of the medical examination, a work related functional (physical) test may be scheduled for those who are deemed medically suitable for the position. Full details of this test will be provided with the medical examination documentation.</td>
<td>1. Aerobic Treadmill Test 2. Double Leg Hold 3. Neck Hold 4. Core Strength A - Timed Prone Hold 5. Core Strength B - Dynamic Prone Hold 6. Static Lift - 245mm 7. Static Lift - 600mm 8. Static Lift - 950mm 9. Static Push - 950mm 10. Static Pull - 950mm 11. Grip Strength</td>
</tr>
<tr>
<td>St. John Ambulance Northern Territory</td>
<td>Using patient lifting devices, stretchers, carry chairs, treating patients who may have infectious or communicable diseases. Working for extended periods during the day or night in ambulance vehicles. Driving a range of ambulance vehicles in all kinds of weather conditions. Working in confined spaces such as under vehicles, trains and buildings. Working a hazardous material scene such as a chemical spill, industrial fire or accident.</td>
<td>To be eligible you must have an Authority to Practice, a current manual drivers licence, physical fitness, medical suitability and psychological characteristics appropriate to the duties of a paramedic.</td>
</tr>
</tbody>
</table>
inconsistent approach. For members of Ambulance Victoria paramedic special teams (for example flight paramedics) there is a fitness standard that must be met regularly (Jansz, 2016). However, general duties paramedics don’t have a requirement for health screening or fitness testing once employed across services, although there may be specific return to work testing that paramedics returning from injury must successfully complete. It is unclear if fitness testing is any more prevalent or consistent in other countries. What has been reported is that paramedic injuries are high and appear to be so in many countries around the world (Jenkins, Smith, Stewart, & Kamphius, 2016; Maguire, O'Meara, Brightwell, O'Neill, & Fitzgerald, 2014; Maguire & Smith, 2013; Merrill, 2013; Roberts, Sim, Black, & Smith, 2015; Suyama, Rittenberger, Patterson, & Hostler, 2009).

Readiness for the demands of paramedic job performance remains an unclear construct. From initial training, to the hiring process, to the post hire period, there is not a validated physical employment standard at the paramedic service level across Australia. This is a concern given the literature on paramedic health status (Sheridan, 2019; Sterud, Oivind, & Hem, 2006; Studnek, Bentley, MacCrawford, & Fernandez, 2010).

The clear message is that without a careful examination of the role of paramedic, including the quantification of the demands of the role, there will only be a continuing of the reporting of high injury rates along with the economic and human costs of not addressing the issue.

2.5 The Health of Paramedics

2.5.1 Health Status, Illness and Injury

Health has been defined as a state of being free from illness and injury (Brüssow, 2013). Further, health assessment can include the evaluation of health status through physical, diagnostic tests and health history and measures such as health surveys (Bergner, 1987). Aspects of paramedic
health status have been well reported in the literature. Research has yielded findings on health status from surveys of paramedic personnel (Alenazi, Al Otaibi, Alenaz, & Alrashidi, 2016), interviews and focus groups (Blau, Bentley, & Eggerichs-Purcell, 2012), and direct observation (Boreham, Gamble, Wallace, Cran, & Stevens, 1994).

Body Mass Index

Studnek, Bentley, MacCrawford, and Fernandez (2010) reported on the health of US EMTs and paramedics (n= 30,560) in the Longitudinal EMT Attributes and Demographics Study (LEADS). The researchers examined indicators of personal health including BMI through questionnaires. This was one of the few large studies of the baseline health status of EMS professionals. Results showed that mean BMI was 27.7 kg/m² (classed as “overweight” by World Health Organisation (WHO), 23.5% had at least one existing health condition and 75% did not meet Centre for Disease Control (CDC) recommendations for physical activity (Studnek et al., 2010). High BMI levels in European paramedics (n= 42) also appears in research by Buzga et al. (2015) with a mean BMI of 26.8 kg/m², Canada (n= 295 with 79% either overweight or obese) and Australia (n= 139 with a mean BMI of 28.5 kg/m²) (Hegg-Deloye et al., 2015; Hegg-Deloye et al., 2014; Hunter et al., 2017). In Ireland, 52% of paramedics (n= 105) fell outside the WHO category of normal weight, with 10% being greater than 30 kg/m². These results contrast with the findings of Gallagher et al. (2017) for specialist paramedics (n= 6) presenting with a mean BMI of 24.2 kg/m² and Chapman et al. (2012) presenting a mean BMI of 26.9 ± 3.2 kg/m². Specialist paramedics generally have a clearly defined physical employment standard that would result in BMI in the healthy range (Jansz, 2016).

It must be noted that BMI is only one measure of health status and when employed as a single measure of health must be interpreted with caution. A high BMI does not necessarily indicate a level of an individual’s fatness (Nuttall, 2015). For instance, in tactical populations, operators may have 70
a BMI in the overweight range, but have a lower body fat percentage due to more lean muscle mass (Maupin, Wills, Orr, & Schram, 2018).

Cardiovascular disease

Early research in paramedic health status in Ireland has been reported by Boreham et al. (1994) studying male ambulance personnel in Belfast, comparing them to normative data from the Northern Ireland general population. The 93 ambulance personnel studied had significantly higher blood pressure than the population (p< 0.05), similar cholesterol levels but significantly lower high-density lipoproteins (HDL). Elevated Low-Density Lipoprotein (LDL) levels were also noted in 60% of participants in a health study of Czech paramedics (n= 42). Elevated LDL levels are associated with an increased risk of cardiovascular disease and the development of acute coronary syndromes (Nelson, 2013).

Hypertension has been noted in paramedics. In one study it was noted that up to 75% of emergency responders have hypertension (Kales, Tsismenakis, Zhang, & Soteriades, 2009). Hegg-Deloye et al. (2013) reviewed 25 studies on paramedic health and found high rates of cardiovascular disease and obesity, both risk factors for hypertension. Barrett et al. (2000) noted self-reported levels of hypertension of 13% in a sample of 85 paramedics. In a study of 109 regional Australian paramedics, Hunter et al. (2017) found mean resting blood pressure in the pre-hypertensive range for both males and females. It seems like ambulance services the world over are challenged to have frontline staff fit enough to be able to do the job. This challenge can begin even before hiring. In a sample of 370 emergency responder candidates for fire and ambulance services in the US, those in overweight and obese BMI categories (n=284) had significantly higher prehypertensive and hypertensive blood pressures than those with healthy BMI (n=83).

A systematic review examined risk factors for work-related cardiovascular and musculoskeletal diseases in paramedics. Sedrez,
Kasten, Chaise, and Candotti (2017) conducted a review of the literature into risk factors for cardiovascular disease (CVD), specifically, and identified that increased BMI and those reporting a sedentary lifestyle in paramedics were at increased risk for CVD (Sedrez et al., 2017). In research on paramedics in British Columbia, Canada, Wong (2012), did not find significant associations between their shift work and hypertension, chronic or acute coronary syndrome. Hegg-Deloye et al. (2013) reviewed 25 studies on paramedic health and found high rates of cardiovascular disease and obesity. Ambulance services the world over are challenged to keep their frontline staff fit enough to be able to do the job.

Injuries

Maguire looked at the reporting of paramedic injuries in the United States and Australia. In the US, EMS call volume is estimated at 22 million patients per year. For the period 2003 - 2007, paramedics reported 21,749 injuries. Sixty-seven percent (14,470) involved sprains or strains, 43% (9,290) involved back injuries. This translated to an injury rate of 349.9 injuries per 10,000 workers compared to an average of 122.2 injuries per 10,000 workers for all private industry occupations (relative risk = 2.9, CI: 2.7-3.0) (Maguire & Smith, 2013). In Australia where call volume is just over 3 million calls was paramedic injury rates were examined. They found an average reported injury of 80 serious cases per 1,000 workers annually (a serious case was defined as at least a week of lost work time). There appears to be an increasing rate of injury, with 560 cases reported in 2000 and 825 cases reported in 2008. In the latter data point, this yields an injury rate of 94.6 serious cases per 1,000, while the national rate for all occupations was 13/1,000 (Maguire et al., 2014).

The insurance provider for NSW Ambulance is iCare, a new organisation created to deliver the state’s insurance and care schemes. In their 2017 report, workers in the ambulance service averaged 51 days off work per claim compared to 47 days off for all other occupations. Further, 83%
were for injuries and 17% for illness. The distribution of claims by gender was approximately 60% for males and 40% for females which is similar to the gender composition for NSW Ambulance. The majority of claims are lodged by ambulance service workers in the 46-60-year-old category (42%) and 33-45-year-old (33%). Both age groups present more claims than comparable age groups for other occupations.

In other countries, researchers report that non-fatal injury types for US paramedics are predominately strains and sprains, with involvement of the back in almost 50% of injuries (Gentzler & Stader, 2010). Another US study looked at injured paramedics who attended Emergency Departments (n= 89,100). Reichard, Marsh, Tonozzi, Konda, and Gormley (2017) reported that for the period 2010 – 2014 the calculated paramedic injury rate was 8.6 per 100 full time equivalent workers. The majority were sprains and strains (40%) due to body motion injuries resulting in 24,400 injuries. This trend of stressing injuries due to strains and sprains was also reported in Polish paramedics who, in a 10-year period, had 5.34/100 paramedic injury rate (Garus-Pakowski, Szatko, & Ulrichs, 2017).

In a systematic review over a multiyear reporting period of four United States data sets (Census of Fatal Occupational Injuries, Survey of Occupational Injuries and Illnesses, Firefighter Fatalities and Statistics and the EMC Voluntary Event Notification Tool, (n= 65,275) it was reported that the biggest mortal threat to paramedics was vehicular accidents and heart attacks. Not-fatal injuries were violence, slips, trips, falls and overexertion (Miller, 2018).

Lifting and carrying are reported as leading causes of injury. In an American study by Crill and Hostler (2005), a group of 90 subjects (53 male with a BMI of 30.7 ± 7.2 kg/m² and 37 females with a BMI of 28 ± 5.7 kg/m² found 47.8% reported back pain in the past 6 months, and of those, 13% reported missing work due to that injury although more than half reported it interfered with daily activities. In Japan, a survey of 2,017
predominantly EMT's saw a response of 1,551 (76.9%). They reported lower back injuries (25.8%), neck (9.9%) and shoulder injuries (9.9%) in the previous 12 months (Okada, Ishii, Nakata, & Nakayama, 2005).

Worker’s compensation and sick time

In Australia, a national study of compensation claims for paramedics were examined. Gray and Collie (2016) reported on ambulance officers claims during the period 2008-2014. Their accepted claims ranged from 131/1,000 in 2009 to a peak of 172/1,000 in 2012 (Figure 2.1). The corresponding rate in nurses over the same period were significantly lower at 26/1,000 in 2009 rising to 32/1,000 in 2012. The majority of the paramedic claims (59%) were for body stressing injuries. This represents a rate of claim between 4 to 7 times that of all other non-healthcare workers. The highest rate of claims was in New South Wales at 199.9/1,000 workers (Gray & Collie, 2016).

![Figure 2.1 National data for rates of injuries to paramedics compared to nurses and all other occupations (Gray & Collie, 2016).](image-url)
The rate of paramedic sick time, specifically sick time that incurs time away from work is not widely reported in the literature. A significant finding of the NSW Auditor General 2017 report was that NSW Ambulance paramedics have the highest average sick leave rate in NSW Health of 85.2 hours per FTE, up from 78.7 hours the year before. To put this in perspective, the state-wide average is 62.1 hours per FTE (Goodwin, 2017).

The insurance provider for NSW Ambulance is iCare, created to deliver the state’s insurance and care schemes. In their 2017 report, workers in the ambulance service averaged 51 days off work per claim compared to 47 days off for all other occupations. Further, the majority, 83% were for injuries and 17% for illness. The distribution of claims by gender was approximately 60% for males and 40% for females. This distribution of injuries by gender matches the approximate gender distribution in NSW Ambulance. The majority of claims are lodged by ambulance service workers in the 46-60-year-old category (42%) and 33-45 year old (33%). Both age groups present more claims than comparable age groups for other occupations (iCare, 2018). Australian workers in protective services (police, border security, correctional services) lodged an average of 4,080 serious claims per year for injury, comprised, in order of frequency, of falls on the same level, muscular stress while handling objects and muscular stress while lifting, carrying or putting down objects (Safe Work Australia, 2018).

Comparing public safety personnel from one area, a US study examined injuries in one city. From a workforce of 850 firefighters, 194 paramedics and 850 police officers, there were 1,295 injuries occurring in just over a two-year period. Compared to firefighters and police officers, paramedics had higher rates of missed time and an injury rate per person significantly higher than fire or police (p< 0.004) (Suyama, Rittenberger, Patterson, & Hostler, 2009). This higher rate was attributed to the high number of injuries to paramedics due to exposure to blood borne pathogens.
In summary, the data indicates that paramedics can have higher levels of BMI including overweight and obese categorisation. This may be linked to cardiovascular disease and metabolic syndromes. In terms of musculoskeletal injuries, body stressing injuries are much more prevalent than many other occupations. Higher BMI can be associated with increased rates of injury. Research needs to focus on the interaction of obesity, illness and injury prevalence in paramedics as their sick time and injury rates are high.

2.5.2 Fitness and Impact on Job Performance

Although there are data reporting the positive health effects of aerobic and resistance training programs in the general population including reduced coronary heart disease, obesity, and Type II diabetes (Kravitz, 2007; O'Donovan et al., 2010; O'Donovan, Hillsdon, Ukoumunne, Stamatakis, & Hamer, 2013), there has been little attention directed in terms of these same effect(s) on the paramedic population. This is particularly relevant as to whether this type of intervention would improve job performance and reduce injury incidence. Other responders, for instance firefighters, have benefited from on station supervised exercise programs, with outcomes of positive changes in strength, body fat and blood pressure. (Roberts, O'Dea, Boyce, & Mannix, 2002; Throne, Bartholomew, Craig, & Farrar, 2000). In a study examining the introduction of a physical fitness program for Swedish paramedics, Aasa, et al (2008) showed inconclusive results, perhaps limited by participant engagement in the fitness program. Conversely, another study noted an association in paramedics with a higher VO$_2$ max which correlated with a decrease in blood lactate concentrations in paramedics simulating a lifting/carrying task. The authors noted that this was positively associated with paramedics who completed strength training 1-2 times per week (Barnekow-Bergkvist et al., 2004) highlighting the benefits of a strength training program. More investigation needs to be done on the effects of an exercise program on paramedic performance, especially considering data on paramedic health status as reported in the literature.
Hungarian paramedics (n= 364) were surveyed and found that the respondents who did not exercise appeared to have a lower level of fitness. They stated it was due to time or financial reasons and they also reported lower levels of self-rated health. However, those who reported the ability to play sports or exercise led a reporting of fewer limitations in daily activities (Betlehem et al., 2013). This finding is further strengthened by the work of Hansen, et al. (2012) who found that Danish paramedics had high emotional demands of the job and these were associated with higher levels of poor mental health, poor sleep quality and increased levels of musculoskeletal pain.

In tactical or special operations paramedicine (work environments considered austere), research has been done in paramedic physiological responses. A study of tactical paramedics in Western Australia revealed that compared to conventional male paramedics (n=18), a cohort of special operations paramedics (n=11) showed the latter group completed significantly more pushups, performed better on fatigue tests and had a lower percentage body fat. Both groups had an aerobic capacity comparable to the general population, however the authors noted that the fitness profile for both groups highlighted a potential deficiency in anaerobic capacity (Chapman et al., 2012). Gallagher et al. (2017) measured physiological strain in six specialist ambulance responders to a simulated firearms incident. From measurements of core temperature during and after the scenario, there was no significant rise, despite responders having to wear ballistic personal protective equipment (19 ± 1 kg) over a 120-minute scenario. (Jansz, 2016). Tactical or special operations paramedics are expected to maintain a requisite level of fitness for these positions and therefore may not be a good direct comparator for general duties paramedics.
2.5.3 Stress, Physiological Response and Clinical Performance

Clinical performance encompasses the gathering and integration of a constellation of signs, symptoms, results of diagnostic tests and history of present illness from patient, bystander or family member. Jensen (2010) likens the process to one similarly used to describe emergency medicine noting high levels of diagnostic uncertainty, decisions made in a short time period, often with inexperienced team members, time restrictions, shift work and lack of feedback to providers. When this integration of information has an untoward or poor outcome it can be termed a clinical adverse event. These adverse events or circumstances where clinical care could have impacted negatively are called “near misses” (Fairbanks et al., 2008).

Elevated physiological response to calls (for example increased HR, RR or BP), due to the occupational demands of a paramedic’s job may not only lead to physical injuries but clinical errors as well. Medication errors have been flagged as a major issue with health care providers (Lane, Stanton, & Harrison, 2006) and for paramedics in particular (Crossman, 2012; Zachary, Stephen, & Jon, 2008). Errors could be linked to physiological responses during an emergency call and resultant stress. In one simulation study, medical students showed significant self-reported stress as well as elevated cortisol during a cardiac arrest scenario (Hunziker et al., 2012). Research on paramedic stress levels using salivary cortisol as a marker have been conducted and points to strong sympathetic nervous system responses during simulated ambulance tasks (LeBlanc et al., 2005). In that study, the high cortisol levels were linked to a significantly decreased performance in medication calculations. In a follow up study of 22 Advanced Care Paramedics, Leblanc et al. (2012) found that paramedics demonstrated greater increases in anxiety (p< 0.05) (based on measures collected in an anxiety questionnaire), and salivary cortisol levels (p< 0.05) in response to high stress simulations compared to low stress simulations. There were more
errors of commission (reporting information not present in the scenario) in patient care documentation following the high stress simulation than the low stress simulation (p<0.05).

Clinical judgment has been identified as a contributor to patient harm events (O’Connor, Slovis, Hunt, Pirrallo, & Sayre, 2002; Price, Bendall, Patterson, & Middleton, 2012). Literature on occupations such as nursing (Barker & Nussbaum, 2011), military (Perry, Sheik-Nainar, Segall, Ma, & Kaber, 2007) as well as athletic research shows that acute exercise can influence cognitive performance illustrated by either decrements or no change in performance (Davey, 1973). Findings of decrements have been observed in concert musicians (Drinkwater & Klopper, 2010). Stressing firefighters with an acute bout of exercise followed by a fire ground tactics drill resulted in substantially higher heart rates and catecholamine levels than exercise alone compared to exercise alone, suggesting the addition of a mental challenge influences physiologic response (Huang et al., 2010). This was confirmed by Morley et al. (2012) who conducted cognitive testing on firefighters using the tests of Paced Auditory Serial Addition and Random Episodic Memory. This testing did not show immediate neurocognitive changes until 120 minutes post-testing, suggesting that there may be a “washout” effect in cognition at points after exercise. From this limited research, if subjects are acutely exerted, adverse patient events could occur due to impaired clinical judgment and this is deserving of further study.

SjÖberg (1980) examined two groups of healthy young adults who differed in physical fitness (n= 24 for each group) examining mental performance before and after physical work. Each group took part in physical work as a percentage of maximal work capacity (0, 25, 50 and 75%). Two mental tasks were performed during the work and a third thereafter. Heart rate was not significantly different between groups; however, heart rate recovery was faster and post work mental task was significantly better in the fit group than the unfit group. This could indicate
the fitter subjects were more able to cope with the negative effects of physical effort.

Lucia et al. (1999) studied two groups of paramedic rescuers: sedentary (n=14) and physically active (n=14) who had to perform 18 minutes of uninterrupted CPR. CPR performance was similar in both groups but 4 of the sedentary groups could not complete the trial and there were also indicators of significantly higher maximum oxygen uptake (p<0.05) and HR at the end of the trial (p<0.01) in the sedentary group. A contrasting study found no difference in quality over a 10-minute period of CPR despite physiological changes in the rescuers, although these were first aid providers, and not paramedics (Bridgewater, Bridgewater, & Zeitz, 2000). There is limited evidence of the efficacy of CPR performance in the out of hospital environment. While it stands to reason that a rescuer with a higher fitness level could maintain a higher quality of CPR for longer periods, and thus have better patient outcomes, this contention has yet to be empirically demonstrated.

2.5.4 Effect of Shiftwork and Fatigue

Many paramedic services are staffed following a rotating (shift work) schedule to best provide care 24 hours a day. The effects of working a rotating schedule can affect, specifically high levels of fatigue, depression, anxiety and stress that were attributed to shift work in a sample of Victoria, Australia paramedic (n=342) (Courtney, Francis, & Paxton, 2010). Fatigue is a complex phenomenon that has effects on physical characteristics, cognition behaviours and physical and mental health (Ramey et al., 2019). These findings on the effect of shift work agree with the work of Dropkin, Moline, Power, and Kim (2015) who found shift work was associated with injuries.

Shift work may contribute to sleep disorders among paramedics (Ramey et al., 2019). Sleep interruption or deprivation by paramedics can contribute to performance decrements. Empathy levels were significantly
lower in a group of paramedics (n=16) compared to a non-paramedic control group (n=16) which was attributed to paramedic shift work (Guadagni, Cook, Hart, Burles, & Iaria, 2018). The work of Patterson, Suffoletto, Kupas, Weaver, and Hostler (2010) indicates in paramedics reporting fatigue or poor sleep quality were more likely to report an error or adverse event in practice.

2.5.5 Career Longevity

With aging comes a decline in performance and the need to meet standards of physical employment standards (Kenny, Groeller, McGinn, & Flouris, 2016). With reporting of injury and illness rates of emergency services providers comes an understanding that the aging paramedic can experience decline in CRF and musculoskeletal strength. Paramedicine is characterised as a physically demanding occupation and that is unlikely to change in the near future. For those in the paramedic workforce it is possible to have a full and productive career as a paramedic. However, statistically, the chance of working to an expected retirement date is not as common in paramedicine as compared to other branches of emergency services or health services (Rodgers, 1998a, 1998b).

Workforce composition by age - Workforce composition statistics offers insight into age distribution of paramedics in Australia. Overall, 77.3% (n=11,048) of the paramedic workforce is under 50 years of age (range 73.8% in South Australia to 84.5% in Northern Territory). In New South Wales this figure is 74.5% with 21% between the ages of 50-59 and just 3% over the age of 60 (Australian Government Productivity Commission, 2017a). A high percentage of a younger workforce could indicate that paramedics are not staying in front line positions through to retirement age. Nursing (including midwives) in public hospitals in the same report illustrate a markedly different staffing profile with 61.8% under the age of 50, 26.5% between ages 50 and 59 and 11.6% over the age of 60 (Australian Government Productivity Commission, 2017b). Given the
attrition rate of some services, there needs to be further research as to why paramedics may be exiting the industry early, and why the age distribution in the paramedic workforce differs from other healthcare providers.

Early work by Rodgers (1998a) on paramedics working in Northern Ireland found that in the reporting period of 1988 to 1992, early retirement on medical grounds (EROMG) was 55.9 per 1,000 per annum compared to nursing staff (5.9/1000 per annum), non-manual staff, such as administrative (2.6/1,000 per annum) and manual staff, such as maintenance (24.8/1,000 per annum). Early retirement was defined as “permanently incapable of discharging efficiently...by reason of physical or mental infirmity”. (Rodgers, 1998a). Ambulance staff have the highest Standardised Early Retirement Ratio (derived by dividing the observed EROMG by the expected and multiplying by 100). It was significantly higher than that calculated for administrative and manual staff in the same workplace.

In a subsequent study by the same researcher, the causes of these early retirements were examined. The largest proportion of EROMG was due to musculoskeletal injury, circulatory and mental disorder (combined). Ambulance personnel comprised the highest number of retirements in two of those groups (42% because of musculoskeletal injury and 31% for circulatory disorder). Nursing had a slightly higher EROMG rate for mental disorders (23% versus 22% for ambulance personnel (Rodgers, 1998b). Interestingly, aside from the widely cited Rodgers studies, there is a paucity of literature on retirement rates of paramedics.

If injury or illness are causing paramedics in Australia to exit the profession early, it is not immediately apparent from paramedic service data. NSW Ambulance, in 2016, reported a 4.3% turnover due to resignations (higher than the 3.3% paramedic turnover nationally) (NSW Ambulance, 2016). Nationally, in 2015-16 operational workforce attrition
ranged from a low of 1.7% in South Australia to a high of 13.5% in Northern Territories (Australian Government Productivity Commission, 2017a). Both New South Wales and Australian national statistics appear lower than the reported annual turnover of 10.7% of paramedics in a national study of 40 EMS agencies across the US (Patterson et al., 2010).

2.6 Comparators

2.6.1 The Australian General Population

There are two reasons to report on the health status of the Australian population: (1) the burden of caring for those with decreasing health status in the Australian population can and does fall, in part to paramedic services, and (2) paramedics are drawn from the general population. The implications for both (1) and (2) are that an aging and unwell population may be receiving care from an unwell group of healthcare providers – paramedics.

Australia’s population of approximately 23 million people have had their health studied. As reported in “Australia’s Health 2016”, Australia has one of the highest life expectancies in the world, however more than 11 million Australians had at least one of eight selected chronic diseases, with cancer, cardiovascular diseases, mental and substance abuse disorders, musculoskeletal disorders and injuries accounting for approximately two-thirds of that burden. (Australian Institute of Health and Welfare, 2016). The AIHW lists five risk factors that caused the most burden to be high body mass, tobacco, high alcohol use, lack of physical activity and high blood pressure.

The population exhibits a trend towards having a large percentage in the obese or overweight WHO categories according to two studies (Cameron et al., 2003; Knox, Harrison, Britt, & Henderson, 2008). In the results from the 2014-15 Australian Health Survey, 63.4% of Australians aged 18 and
over were overweight or obese and this prevalence of overweight and obesity has increased in Australia over time, from 56.2% in 1995 to 61.2% in 2007-9 (Australian Bureau of Statistics, 2015). This is consistent with the incidence of BMI by WHO categories of ‘overweight’ and ‘obese’ reported by NSW Ministry of Health as 40% and 21% for adults (NSW Ministry of Health, 2016). High BMI and associated measures (for example weight-to-height ratio and conicity) can be indicative of an increased risk of developing cardiovascular disease, hypertension and Type 2 diabetes (da Silva et al., 2014; Di Angelantonio et al., 2016; Huxley, Mendis, Zheleznyakov, Reddy, & Chan, 2010).

The prevalence of morbidities according to Knox et al. (2008) reporting on a sample of 9,156 patients under the care of a physician state that 30% had at least one cardiovascular problem (uncomplicated hypertension, ischemic heart disease), 25% had psychological problems, 23% had arthritis, 11% had asthma and 8% had diabetes (predominately Type 2). Hypertension was examined in the national health survey and (excluding those currently medicated for hypertension), 21.5% (n=32,000) of those respondents had a measured high blood pressure compared to a higher 28.4% (n=12,979) hypertensive adults reported in NSW (Centre for Epidemiology and Evidence, 2018).

2.6.2 Firefighters:

Firefighters are public safety personnel who are responsible for a multitude of fire prevention and suppression activities in settings ranging from rural to urban locations. They also can provide patient-centred care and are often tasked with first response capacity where they co-respond with paramedics to calls. The work of firefighters is characterised by danger, urgency, and a unique work environment and by its considerable physical requirements. They also face exposure to increasingly complex psychological, physical, chemical and biological hazards (Kim, 2010). They deserve attention as they can report similarities in aspects of health status.
Firefighters appear to have similar issues in terms of the prevalence of heart disease when compared to paramedics. In a review article published in the New England Journal of Medicine, Kales, Soteriades, Christoudias, and Christiani (2007) found that 45% of the deaths of career on duty US firefighters occurred from heart disease with 32% of those deaths occurring during fire suppression duties. They reported this may be linked to a lack of adequate fitness.

The occupational demands of firefighters seem to be better defined in the literature compared to paramedics. Kiss et al. (2014) measured VO₂ max through a maximal exercise test on a treadmill and dual-energy X-ray to determine body fat in a sample of 1,225 Belgian career firefighters. They established a mean VO₂ max of 46.5 mL/kg/min comparing it to the criteria for cardiorespiratory fitness for firefighters in Belgium of 45 mL/kg/min (at recruitment), 38 mL/kg/min for SCBA trained firefighters and 45 mL/kg/min for those using chemical protective suits. Unlike paramedicine, the fire service has developed physical employment standards which include criteria tests for selection and for in-service fire and rescue personnel. The selection tests for paramedics in Australia (previously described) vary widely. Physical employment standards based on a validated model of paramedic occupational tasks is needed.

The ability to demonstrate a physical standard including level of fitness seems to vary in the fire service. In Australia, it has been reported by Walker, Driller, Argus, Cooke, and Rattray (2014) that there is no enforcement of physical standards within Australian career fire services post-recruitment. Their study looked at 73 firefighters from three different age groups: 25-34 years, (n=27), (35-44) years (n= 27) and 45-54 years (n= 19) using dual x-ray analysis and existing fitness tests that are used for recruit testing. They found the 45-54-year-old participants demonstrated significantly poorer physical standards compared to younger participants including cardiovascular fitness (p< 0.05) strength (p< 0.001) and simulated operational power testing tasks (p< 0.001).
Researchers in the United States surveyed career firefighters (n=249) to assess occupational injuries with almost a third reporting an occupational injury in the previous 12 months. Although work patterns differ from paramedics in terms of fire scene environment, the majority of this group’s injury occurred on non-fire call scenes (for example first response patient care) performing activities that involved lifting, pushing or pulling. Back injuries were the most frequently reported and those reporting were more likely to be older and experiencing occupational stress (Phelps et al., 2018).

There has also been investigation into the risk of injuries in relation to fitness using a retrospective occupational cohort of career firefighters in the US using results of annual physical examination to assess fitness levels and department injury surveillance reports. The intention was to compare all injuries and fitness levels between injured and non-injured employees (Poplin, Roe, Peate, Harris, & Burgess, 2014). Persons in the lowest fitness category ($\text{VO}_2\text{max} < 43 \text{mL/kg/min}$) were 2.2 times more likely to sustain an injury than those in the highest fitness category ($\text{VO}_2\text{max} > 48 \text{mL/kg/min}$) (95% CI: 2.06, 2.78). Those in the middle category (43 – 48 mL/kg/min) were 1.38 times as likely (CI: 1.06, 1.78). The authors further postulated that improving relative aerobic capacity by 1 metabolic equivalent of task (3.5 mL/kg/min) reduces the rate of injury by 14% (Poplin et al., 2014).

2.6.3 Police Officers

Police officers are public safety personnel. Along with paramedics and firefighters, police officers serve in law enforcement capacities and frequently will co-respond with EMS and the fire department to calls involving the sick and injured. In some instances, police officers contribute to patient care, for instance utilising AED’s in instances of cardiac arrest (van Alem, Vrenken, de Vos, Tijssen, & Koster, 2003). There appears in the literature, evidence that police officers have similar issues in terms of health status like firefighters.
They report high levels of stress, both physical and psycho-social (Anderson, Litzenberger, & Plecas, 2002). As well, there are objective measures of physical activity during shifts that indicate police work is a sedentary occupation with lower measures of energy expenditure, activity intensity and step count per hour in at least one study. (Ramey et al., 2014). Australian research suggests that police officers’ have a primarily sedentary occupation, and similar to paramedics, must respond rapidly to unpredictable situations (Decker, Orr, Pope, & Hinton, 2016). In another study, da Silva et al. (2014) noted characteristics of military police officers (n= 165) that risk factors for cardiovascular disease (increased waist-to-height ratio, fat mass and low reported levels of PA).

Paramedics in Australia are drawn from the general population. Aside from pre-employment testing, general duties paramedics do not have to evidence a requisite level of fitness or health status. Therefore, the Australian general population serves as a very good comparator (and in fact, will be employed in Chapter 3). Comparisons to other uniformed public service professions (police and firefighters) in Australia would be most useful and international sources would be helpful, keeping in mind that the general populations of other countries differ in health and health outcomes in comparison Australia.

2.7 Summary

Paramedicine is emerging from a background of “you call, we haul, that’s all” that was oriented to quick and efficient patient transport to health care facilities to a sophisticated system of assessment, diagnosis and health care. From short duration training programs of the past to present day university education for paramedics in Australia, the scope of practice and evidence-based practice are now reflecting a more developed health care profession.

However, the physical and mental challenges of paramedic job performance are ill defined although the downstream effects in terms of
injuries and illness are becoming more widely surveyed and reported. Paramedic education may not adequately prepare or estimate the health and overall fitness qualities needed for their graduates. Paramedic services are in a growth period, from a call volume point of view, a trend unlikely to change in the immediate future. Services’ approach both the physical employment standards and requisite fitness reflect a need for screening programs. Demographically, paramedics in Australia are the benefactors of a relatively large number of hirings that now presents as a very young workforce. Here and internationally, this workforce is showing markers of injury and illness that, while in some respects, mirrors the general population, is different in that there is high emotional and physical labour involved in paramedic care.

The well-reported rates and prevalence of indicators of poor(er) health status in paramedics are evident with high BMI, increased cardiovascular disease (including hypertension), psycho-behavioural issues being one side of the health surveillance that is alarming in paramedics. The other side are the injury statistics, both nationally and internationally that are a) increasing, b) higher than other health occupations, and c) concomitant with sick time here and internationally that appear to be increasing. Applied research, especially in the physical demands of paramedic job performance is limited but lends credence to the claim that the complex out-of-hospital environment taxes paramedics and can contribute to higher levels of injuries than other health care providers.

Physiological and other measures of cardio-metabolic strain are more readily available and should be employed to examine demands of paramedicine. As well, validated survey instruments can measure with a large degree of reliability, self-reported health status. What is missing in all of this until now is the ability to translate this into targeted research on paramedics. There is an absence of validated paramedic health standards (including measures of job specific tasks) and established fitness levels for prospective paramedics. Finally, cardio-respiratory fitness, Health Related Quality of Life (HRQoL) scores and how other
health demographics (i.e. BMI) affect paramedic job performance should be quantified as the research in this area appears limited.

In terms of the health of paramedics, this research project essentially posed two questions: (a) How does health status affect doing the work of a paramedic and (b) How does doing the work of a paramedic affect health status? The first question is linked to the health of the population from which paramedics come from and the second is the work and the demands of job performance. Further, the impact that the job, the environment, the calls, and how the paramedic reacts to them requires exploration to better understand the issues: including injury and illness. Finally, the demands of paramedic job performance appear not well quantified nor qualified, therefore the development of a descriptive profile for paramedics is important to better understand the stressors of the occupation and inform paramedic services.
CHAPTER 3: THE HEALTH STATUS AND PHYSICAL ACTIVITY LEVELS OF NSW AMBULANCE PARAMEDICS

The health of paramedics should be prized as highly as their work as clinicians. Paramedics are our front line providers and we must do our utmost to support them.

Chief Michael Nolan, Renfrew County Paramedic Services
Renfrew County, Ontario, Canada
ABSTRACT

Introduction

Paramedics are mobile health care workers, responding to medical emergencies. They commonly exhibit markers of poor health such as obesity and hypertension and experience high rates of musculoskeletal injury. The primary aims of this study were to explore if differences or relationships are apparent in the health status (SF-36 and BMI) of paramedics by gender, posting (metropolitan versus regional), age, and years of service and to compare their health status with that of the Australian population. The secondary aims were to examine paramedics’ attitudes about perceived barriers to exercise and to determine if differences or relationships are apparent in the physical activity (PA) levels of paramedics by gender, posting, age and years of service.

Methods

Paramedics employed by NSW Ambulance were invited to complete a web-based survey with instruments measuring health status and PA level: the Medical Outcomes Survey Short Form 36 (SF-36) and the International Physical Activities Questionnaire (IPAQ) short form. The SF-36 produces a health-related quality of life (HRQoL) score and IPAQ estimates levels of PA over a 7-day period in total MET-minutes. The survey also included questions about attitudes towards exercise. Normative comparator data for the Australian general population (SF-36 and BMI) were sourced from the Household Income Labour Dynamics in Australia (HILDA) 2015 survey.

Results

Approximately 3,300 paramedics were invited to participate, and 747 completed the survey (507 male, 240 female) with mean age and years of service being 41.5 ± 9.5 yrs. and 13.6 ± 9.0 yrs. respectively. By
gender, there were no significant differences in SF-36 scores except for the vitality domain where males scored higher than females (p< 0.001). Regional paramedics had a higher general health domain score than metropolitan paramedics (p< 0.05). Regional male paramedics had higher BMIs than metropolitan male paramedics (28.0 ± 4.0 kg/m² vs. 26.8 ± 4.7 kg/m², p= 0.001).

In comparison with Australian normative data (n= 12,373), paramedics scored significantly lower in 6 of the 8 SF-36 health domains (p< 0.001) and summary scores for mental and physical health (p< 0.001). Paramedics scored significantly higher than the Australian population in the physical function domain (p< 0.001). Paramedics' BMI were higher than the general population (27.1 ± 4.7 kg/m² vs. 26.6 ± 5.7 kg/m², p< 0.01), with significantly more (67% vs. 55%, p< 0.001) being either overweight (BMI 25 to 30 kg/m²) or obese (BMI>30 kg/m²). Paramedics most frequently reported a lack of time and motivation and family commitment as perceived barriers to exercise. In regional postings, significantly more paramedics reported distance to fitness facilities as barriers to exercise than metropolitan paramedics.

Median total MET-minutes were 3626 (IQR 1737 – 6537). Males reported significantly higher scores than females (p< 0.02) with no significant difference by posting. Median total MET-minutes reported by NSW Ambulance paramedics seem much higher than other studies.

Conclusions

There were few differences within NSW Ambulance paramedics SF-36 scores, but significantly lower scores compared to the Australian population. This could indicate a lower health related quality of life and this should be monitored longitudinally. Regional-rostered males had the highest calculated BMI of all paramedics and should represent a demographic to target health promotion programs toward. High BMI and low SF-36 scores may be related to a perceived inability to engage in regular exercise and the effects of shift work, especially in regional areas.
Paramedics had higher BMIs and were more likely to be overweight or obese than the population and these levels may contribute to illness and injury. Given the relatively young age of the workforce this is a concern. Physical activity levels indicate that paramedics see themselves as very active, reporting higher 7-day PA than other studies.

Attention is needed to ensure that these essential health care providers are “fit for duty”. Ambulance management should foster innovative health promotion programs and paramedics themselves need to recognise and value good health.

Part of this chapter is as published:

INTRODUCTION

Paramedics work in a profession that is physically and psychosocially demanding. Their work often involves sedentary periods waiting for a call, followed by periods of high or intense occupational physical activity. Physically demanding occupational tasks include lifting and carrying patients (Barnekow-Bergkvist et al., 2004; Lavender et al., 2000; Leyk et al., 2007), loading and unloading stretchers (Fischer, 2014) and performing cardiopulmonary resuscitation (Ashton, McCluskey, Gwinnutt, & Keenan, 2002; Havel et al., 2008; Ko, Wang, Chiang, Yang, & Ma, 2008). While carrying out these tasks, paramedics need to make complex clinical decisions, often in complex uncontrolled social environments (Campeau, 2008; Courtney et al., 2010). During a paramedic’s career, fatigue, lack of fitness, and injury may contribute to a significant decline in health status over time (Bennett, Williams, Page, Hood, & Woolard, 2004; Boreham et al., 1994; Buzga et al., 2015; Courtney et al., 2010; Gamble et al., 1991). It is not known if a decline in paramedic health status could affect the care they give their patients. Health status as evidenced by fatigue, level of fitness and resiliency to injury of paramedics should therefore be measured and monitored.

Health status can be estimated from several measures. A Hungarian study reported that paramedics have lower Health Related Quality of Life (HRQoL) than the general population. HRQoL is derived from assessing perceived health status and overall physical and emotional well-being that is not specific to any disease (Busija et al., 2011) This finding is coupled with a reported high BMI and evidence that their health status deteriorates with increasing length of employment (Pek et al., 2015). This is concerning because high BMI is linked to lower PA, higher mortality rates and metabolic diseases and cardiovascular disease (Berrington de Gonzalez et al., 2010). In the United States, 19,960 paramedics were surveyed in a nationwide study of health status. The average BMI as reported by Studnek et al. (2010) was in the overweight range, with
25.8% of subjects meeting the criteria for obesity. In addition, 23.5% reported at least one existing health condition. The overwhelming majority (75.3%) did not meet the Centres for Disease Control and Prevention (CDC) recommendations for PA (defined as 150 minutes a week of moderate intensity or 75 minutes a week of vigorous intensity aerobic activity) (Studnek et al., 2010). An assessment of health status has not yet been undertaken with a paramedic service in Australia to validate the findings from other countries.

Health related quality of life can be estimated by self-report. The validated survey instrument, the SF-36 is widely used in monitoring population health and reporting HRQoL in more than 4,000 published studies (Ware, 2000). It offers a readily deployable and useful tool in measurement of health status and determining HRQoL and can, therefore, be important when examining paramedics’ well-being. In researching Hungarian paramedics (n= 810) by Pek et al., (2015) upon utilising the SF-36, found decreased health scores in physical function, body pain and general health in older personnel and those with higher BMI. Part of the issue of the health surveillance of paramedics is the ability to select a tool that is a) easy to use and well validated and b) relatively quick to complete while awaiting emergency calls.

Physical activity has been shown to be important for good physical and mental health-related quality of life (Caspersen et al., 1985). A Turkish study of 120 hospital workers in two groups (high versus low PA) found that the high PA group enjoyed greater quality of life than the low PA group (Kurklu, Babayigit, Oysul, & Aktas, 2015). The potential benefits of PA and exercise for paramedics has not been specifically examined. However, Rice, Glass, Ogle, and Parsian (2014) examined physical health perceptions of health care professionals in Australia. Although limited by a small number of participants, nurses and allied health workers (n= 24) and paramedics (n= 4), the authors reported that subjects had a desire to increase PA levels and viewed physical health
as important to job satisfaction. More research needs to be undertaken to examine the attitudes of paramedics towards PA and exercise.

Quantification of PA can also be estimated and could be useful for examining paramedic activity levels. In a study of Ambulance Victoria paramedics in Australia, Courtney et al. (2010), using the IPAQ, found that paramedics reported a median score of 2,088 total MET-minutes/week. This represented 14% less PA than participants from the general populations in a 12-country study (Craig et al., 2003) and 11% less than a local community sample (Courtney et al., 2010). This lower level of PA could be detrimental to paramedic health status. Courtney suggests the reasons for lower reported levels of PA in the paramedic population could be attributed to shift work rostering which limited opportunities for regular exercise which could be a factor in injury prevalence in paramedics.

Illness and injury rates are well-reported in paramedics. Current reporting on injury and illness rates in ambulance services offers insight into the issue. Hypertension (Kales et al., 2009), obesity (Tsismenakis et al., 2009) and musculoskeletal injury (Betlehem et al., 2013; Broniecki et al., 2010; Maguire et al., 2014; Maguire & Smith, 2013) are higher than other occupations and these high rates of illness can translate into increasing rates of Workers Compensation (Workcover) claims. For example, when examining healthcare workers in Victoria, Australia, Roberts et al. (2002) reported higher rates of musculoskeletal injury and mental illness in paramedics when compared with other healthcare workers. Paramedics’ risk of lower back musculoskeletal injury and mental illness was approximately 13 times higher than nurses, the next most often injured health professional. Injury and illness can also influence how long a paramedic can work in the industry. Early exit from the industry by Irish paramedics due to circulatory or musculoskeletal disorders were higher than other healthcare groups (Rodgers, 1998a, 1998b). Given the high rates of illness and injury and potential for early retirement, more work
needs to be undertaken in measuring health status of paramedics to identify and mitigate contributing factors to injury, illness and early retirement.

The representation of females in paramedic services are increasing in what was once a male dominated profession. Females now represent 38% of NSW Ambulance staff (High, 2015). Information on their injury rates reveals that they constitute 40% of all iCare insurance claims for injuries and illness (iCare, 2018). In contrast, Maguire (2011) reports that female paramedics were shown to have a disproportionately high risk of occupational injury in the US paramedic services. Fire service research indicates that female career firefighters had the highest prevalence of on-duty injury (Kaipust, 2018). Female police officers in one study had a significant association between job stress and several metabolic syndromes (i.e. obesity, hypertension and glucose intolerance) (Hartley et al., 2011). The injury and illness rates and health status of female paramedics have not been well explored in Australia and require further study.

The geographic location of where people live and work can influence their wellbeing. In Australia, people in regional areas typically experience poorer health than urban dwellers, with 68.4% being above a healthy weight regionally compared with 61.6% in major cities (National Rural Health Alliance, 2013). If the 50% of the paramedic staff employed by NSW Ambulance whom are rostered and work regionally follow this trend, their personal health and the quality of care they provide for patients may be suboptimal. Rural and regional paramedics are not well studied, however, one survey examining Australian personnel (n= 134) found participants reported high levels of fatigue resulting in committing medication errors and falling asleep while driving (Pyper & Paterson, 2016).
In other branches of emergency services, research investigating the health status, PA and injury patterns of workers has examined firefighters and police officers. Sorensen, Smolander, Louhevaara, Korhonen, and Oja (2000) found strong correlation between PA over a 15-year period, where the physical fitness of middle-aged police officers with PA in early adulthood. In the US, police officers who engage in higher levels of PA and are more physically fit have a lower prevalence of musculoskeletal injuries and chronic pain (Nabeel, Baker, McGrail, & Flottemesch, 2007). In the fire service, Smith (2011) reported firefighters required high levels of aerobic fitness, anaerobic capacity and muscular strength and endurance to perform their duties and that exercise contributes to improved performance. Paramedic research in these areas has not been well established.

Based on the national and international reporting of illness and injury amongst paramedics, there is an identified need to investigate their health status including their level of PA. Not enough is known about the effect of being a paramedic on their health status.

Aims

Primary Aims

- To explore if differences or relationships are apparent in the health status (SF-36 and BMI) of paramedics by gender, posting (metropolitan versus regional), age, and years of service.

- To compare the health status (SF-36 and BMI) of NSW Ambulance paramedics with the Australian population.

Secondary Aims

- To examine paramedics’ attitudes about perceived barriers to exercise.
• To determine if differences or relationships are apparent in the PA levels (total MET-minutes) of paramedics by gender, posting, age, and years of service.

Hypotheses

1. Health status of paramedics (SF-36 and BMI) will differ by gender and posting and be negatively correlated with age and years of service.

2. The paramedic population of NSW Ambulance will have a lower health status (SF-36 and BMI) when compared to the Australian population.

3. Paramedic reported barriers to exercise will differ by posting.

4. Physical activity levels of paramedics will differ by gender and posting and be negatively correlated with age and years of service.

METHODOLOGY

Study Design

Utilising a cross-sectional methodology, a web-based survey was conducted with paramedics from NSW Ambulance. The survey comprised the SF-36 (Gandek, Sinclair, Kosinski, & Ware, 2004) and the IPAQ (Hagstromer, Oja, & Sjostrom, 2006) supplemented with demographic questions (age, gender, height, weight, years of service, level of certification, geographic area rostered, and primary role). The survey also included 7 questions about exercise, fitness and smoking habits (See Appendix 1).
Participants

All paramedics and trainee paramedics employed by NSW Ambulance as of May 1, 2015 (n = 3,302) were invited to participate in the survey regardless of age, gender, years of service, level of certification or geographic rostering or primary role. Paramedics working in management, education, Control Centre (dispatch) and information technology services were also invited to participate. Participants were informed that completion of the survey would indicate consent to participate in the study and consent could be withdrawn at any time by not completing the survey. Ethical approval was obtained from the South Eastern Sydney Local Health District Human Research Ethics Committee (HREC Reference number: 15/031, LNR/15/POWH/68) and Charles Sturt University Human Research Ethics Committee (HREC Protocol number 2015/011).

Procedure

The survey was created and hosted online by Charles Sturt University, Bathurst, NSW, Australia. Paramedics were invited to participate via an email sent to their corporate email account. The survey was open for 30 days from 11 May 2015 to 9 June, 2015. At day 15, a follow-up email was sent reminding paramedics they could still participate in the survey. Potential participants were informed that no explicitly identifying information would be collected. It was estimated that it would take approximately 10 minutes to complete the survey. All data were stored on a secure server at Charles Sturt University and then exported as an Excel spread sheet to a password protected computer hard drive.

Instrumentation

The SF-36 Health Survey is widely used in reporting health related quality of life (Ware, Snow, Kosinski, & Gandek, 1993). It consists of 36 questions that yields 8 health domains and two summary scores. All
domains and summary scores are scored on a scale from 0 to 100, with
100 representing the best possible health state. See Figure 3.1.

1. **Physical Functioning (PF)** assesses limitations in physical
activities, such as walking and climbing stairs (10 questions).
2. **Role Limitations due to Physical Health Problems (RLP)**
measures problems with work or other daily activities because of
physical health or emotional problems (4 questions).
3. **Role Limitations due to Personal or Emotional Problems
(RLEP)** measure problems with work or other daily activities
because of emotional problems (3 questions).
4. **Bodily Pain (BP)** assesses limitations due to pain (2 questions).
5. **Vitality (V)** measures energy and tiredness (4 questions).
6. **Social Functioning (SF)** examines the effect of physical and
emotional health on normal social activities (2 questions).
7. **Mental Health (MH)** assesses happiness, nervousness and
depression (5 questions).
8. **General Health Perceptions (GH)** evaluates personal health
and the expectation of changes in health (5 questions).

The 8 domain scores contribute to the construction of two summary
measures:

1. **Physical Health Summary (PHS)** is an average of Physical
Functioning, Role Limitations due to Physical Health Problems,
Bodily Pain, Vitality, and General Health Perceptions).
2. **Mental Health Summary (MHS)** is an averaging of Vitality, Social
Functioning, Mental Health, General Health Perceptions, and Role
Limitations due to Personal or Emotional Problems.
SF-36 data for the Australian population has been reported in national health surveys (Trewin, 1995, 2001) including the Household Income Labor Dynamics in Australia (HILDA) survey (Wilkins, 2014). This Australia-wide survey includes approximately 14,000 people aged 15 and over. The HILDA survey was the first longitudinal household survey in Australia and is designed to provide a sound evidence base to support research and analysis of income, labour market and family dynamics (Butterworth & Crosier, 2004). Under license agreement, 2015 HILDA survey data was extracted for use as normative data for the Australian population. The age-range for the HILDA data was set at between 20 - 70 years old, reflecting the age-range NSW Ambulance paramedics at the time of the survey.

The IPAQ was developed by the WHO in 1998 to measure PA based on a 31-item form (Lee et al., 2011). A short form version with 9 items exhibits similar psychometric properties and has been validated against accelerometers in a 12-country study (Craig et al., 2003). The IPAQ
survey instrument involves the summation of self-reported levels of PA associated with vigorous-intensity, moderate-intensity, and walking in the week before the survey. The IPAQ scoring reveals weekly energy expenditure for PA as multiples of the resting metabolic equivalent MET-minutes per week.

Data Analysis

All continuous demographic data were inspected visually and statistically checked for normality prior to analyses and are presented in tables as mean ± standard deviation, except for PA data which were presented as median total MET-minutes (interquartile range). Graphs of means and 95% confidence intervals are presented. A Chi-square test for Independence was performed to establish the representativeness of the survey respondents (n= 747) compared to the NSW Ambulance paramedic population (n= 3,302) based on gender and posting. Statistical significance was accepted at p< 0.05.

Comparisons between NSW Ambulance paramedic responses and the Australian population data, the responses of male versus female paramedics, and regional versus metropolitan paramedics are reported with descriptive statistics and one-way Analysis of Variance (ANOVA) tests employed when the data met the requirements for parametric tests. ANOVA was also performed to examine differences in BMI and SF-36 scores by level of certification and primary role. Post hoc comparisons using the Tukey HSD test were employed for multiple comparisons when significance was found.

The Pearson Chi-square test of independence was used to investigate distributions of categorical variables. If the Chi-square (χ²) test was significant, a Bonferroni pair-wise post-hoc analysis was performed to determine which combinations were significantly different. A Pearson population correlation hypothesis test was computed to assess the relationship between SF-36 scores, IPAQ scores and BMI. Linear
regression was used to investigate the relationship between age and BMI, years of service and BMI, age and SF-36 score, and years of service and SF-36 score. The PA data was not normally distributed so was analysed using non-parametric tests. Physical activity data between gender and between postings were analysed using Mann-Whitney U test. Comparisons between level of certification, primary role and PA were analysed using Kruskal-Wallis H Test. A summary of statistical tests is presented in Table 3.1.
<table>
<thead>
<tr>
<th>Statistical measure or test</th>
<th>Model Assumptions</th>
<th>Australian Population (n=12,393)</th>
<th>NSW Ambulance survey (n=747)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-square test of independence</td>
<td>The value of the expected should be 5 or more in 80% of the cells and no cell should have an expected value of less than one.</td>
<td>Overall gender and posting NSW Ambulance survey sample compared to NSW Ambulance population (Hypothesis Test 1)</td>
<td></td>
</tr>
<tr>
<td>ANOVA</td>
<td>Each sample group is drawn from a normally distributed population. All populations have a common variance. Samples are drawn independently of each other. Residuals are normally distributed.</td>
<td>NSW Ambulance BMI compared Australian population BMI (Model A)</td>
<td></td>
</tr>
<tr>
<td>ANOVA</td>
<td>As above</td>
<td>Gender and posting and years of service. Gender and posting with BMI (Model B)</td>
<td></td>
</tr>
<tr>
<td>ANOVA with Tukey HSD</td>
<td>As above</td>
<td>Level of Certification, Primary Role and Yrs. Service by Category with BMI and SF-36 (Model C)</td>
<td></td>
</tr>
<tr>
<td>Pearson Population Correlation Hypothesis Test: $H_0: \rho = 0$</td>
<td>Sample data are normally distributed.</td>
<td>SF-36 with BMI overall and by gender and posting. SF-36 with Met Minutes. Yrs. Service with SF36. (Hypothesis Test 4)</td>
<td></td>
</tr>
<tr>
<td>Hypothesis test for a proportion comparing two populations $H_0: \rho_2 - \rho_1 = 0$</td>
<td>The value of the expected should be 5 or more in 80% of the cells and no cell should have an expected value of less than one.</td>
<td>Barriers to Exercise by posting (Hypothesis Test 2)</td>
<td></td>
</tr>
<tr>
<td>Pearson Chi Square test of independence and Bonferroni post hoc analysis</td>
<td>The value of the expected should be 5 or more in 80% of the cells and no cell should have an expected value of less than one.</td>
<td>Gender, posting with WHO categorical BMI and HEPA. Gender and Exercise Enough. Smoking rates by posting, gender. Posting and Level of Certification. (Hypothesis Test 5)</td>
<td></td>
</tr>
<tr>
<td>Linear Model (Simple Linear Regression)</td>
<td>The residuals are independent. There is normal distribution of residuals and there will be equal variance of the residuals.</td>
<td>Age and Years of Service with BMI (Model D)</td>
<td></td>
</tr>
<tr>
<td>Independent Samples – Mann Whitney U test</td>
<td>The dependant variable is continuous or ordinal. One independent variable consists of two categorical, independent groups. There is independence of observations. The distribution of scores for both groups is known.</td>
<td>MET-minutes by posting and gender (Model E)</td>
<td></td>
</tr>
<tr>
<td>Kruskal Wallis test</td>
<td>Variables have two or more levels. Dependant variable is either ordinal, ratio or interval. Observations are independent. All groups have the same distribution.</td>
<td>MET-minutes by level of certification and primary role (Model F)</td>
<td></td>
</tr>
</tbody>
</table>

*Note: The model assumptions are met unless otherwise notified.*
From the paramedic survey and HILDA responses of self-reported height and weight, body mass index (BMI) was calculated using the formula: 

\[ \text{BMI} = \frac{\text{kilograms}}{\text{metre}^2} \].

To display trends, BMI data were categorised into WHO classifications according to the following guidelines: Class 1 (Underweight) \(18.5 \text{ kg/m}^2<\), Class 2 (Normal Weight) \(18.5-24.9 \text{ kg/m}^2\), Class 3 (Overweight) \(25.0-29.9 \text{ kg/m}^2\), and Class 4 (Obese) \(30.0-34.9 \text{ kg/m}^2\) (Grobschadl, Haditsch, & Stronegger, 2011).

Years of service was categorised into four bandwidths: (1) 0-10 years, (2) 11-20 years, (3) 21-30 years and (4) 30-45 years to compare SF-36 and BMI scores by career stage. SF-36 domain and summary scores were tabulated in accordance with Ware (Ware et al., 1993).

The IPAQ survey was scored according to the Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (Di Blasio, Di Donato, & Mazzocco, 2005).

All quantitative analyses, except for imputation of any missing SF-36 data, were performed using SPSS Version 17.0 (Statistical Package for the Social Sciences Version 17.0, SPSS Inc., Chicago, Illinois, U.S.A.) with the threshold for statistical significance set at \(p \leq 0.05\).

XLStat (Addinsoft SARL, New York, NY, USA) was used to impute missing data in the NSW Ambulance paramedic SF-36 results using the Nonlinear Iterative Partial Least Squares (NIPALS) method according to Wold (1974) to allow principal component analysis with missing values. The NIPALS algorithm was applied to the NSW Ambulance dataset and the obtained Principal Component Analysis (PCA) model is used to predict the missing values (Wasito & Mirkin, 2006). Of the total items to be answered in the SF-36 survey (26,982) a total of 538 (1.9%) items were missing.
Effect sizes ($d$) were calculated according to Cohen (1988) and interpreted with the following thresholds: Trivial (0 - 0.19), Small (0.20 to 0.49), Medium (0.50 - 0.79), and Large ($d \geq 0.80$) for comparisons between two means.

RESULTS

3.0 Representativeness of Sample

There were 3,302 paramedics employed by NSW Ambulance when the survey was deployed and a total of 805 surveys received. Fifty eight surveys were removed because consent was not given, leaving 747 completed surveys. This yielded an overall response rate of 22.6%. The results of the Pearson Chi-square test of Independence (Hypothesis Test 1) showed the overall proportion of survey respondents were not significantly different than the NSW Ambulance population by gender ($\chi^2 = 3.66$, df 1, $p = 0.06$, CI -0.049, 0.001) but were significantly different by posting ($\chi^2 = 10.06$, df 1, $p = 0.002$, CI 0.063, 0.833). See Table 3.2.

Table 3.2
Demographic Characteristics of NSW Ambulance Paramedics and Survey Respondents

<table>
<thead>
<tr>
<th>NSW Ambulance Workforce (n=3,302)</th>
<th>NSW Ambulance Survey (n=747)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metropolitan</td>
<td>Metropolitan</td>
</tr>
<tr>
<td>Regional</td>
<td>Regional</td>
</tr>
<tr>
<td>Male (n=1,138)</td>
<td>Male (n=239)</td>
</tr>
<tr>
<td>Female (n=700)</td>
<td>Female (n=129)</td>
</tr>
<tr>
<td>Male (n=981)</td>
<td>Male (n=268)</td>
</tr>
<tr>
<td>Female (n=483)</td>
<td>Female (n=111)</td>
</tr>
<tr>
<td>62%</td>
<td>65%</td>
</tr>
<tr>
<td>38%</td>
<td>35%</td>
</tr>
<tr>
<td>67%</td>
<td>70%</td>
</tr>
<tr>
<td>33%</td>
<td>30%</td>
</tr>
</tbody>
</table>
Age and years of service for paramedics were examined by gender with males significantly older than females with significantly more years of service. See Figure 3.2

![Figure 3.2. Means and standard deviation of survey respondents. Note that by gender, males were significantly older than females (* p< 0.01, d= 0.7) with significantly more years of service (** p< 0.001, d= 0.64).](image)

3.1 Paramedic Health Status – SF-36

3.1.1 Paramedic Health Status

*SF-36 Differences by Gender and Posting*

When SF-36 scores were assessed by gender only the vitality domain was found to be significantly different, where males scored higher (57.6 ± 16.3 versus 53.2 ± 18.4, p= 0.001, CI 1.72, 7.72, d= 0.26). (Model B). See Figure 3.3.
Figure 3.3. SF-36 scores by gender. The differences in domain and summary scores of the SF-36 by gender with a 95% CI. (*) indicates males had significantly higher vitality domain scores than females (p< 0.001). Physical Function (PF), Role Limitations – Physical (RLP), Bodily Pain (BP), General Health (GH), Vitality (V), Social Function (SF), Role Limitations due to Emotional or Personal Problems (RLEP), Mental Health (MH), Physical Health Summary (PHS), and Mental Health Summary (MHS).

When SF-36 scores were assessed by posting, only the general health domain was significantly different, where regional paramedics scored significantly higher (66.5 ± 18.9 versus 63.9 ± 17.9, p< 0.05, d= 0.14) (Model B). See Figure 3.4.
Figure 3.4. SF-36 scores by posting. This figure illustrates the differences in domain and summary scores of the SF-36 by posting with a 95% CI. (*) indicates regional paramedics had a higher general health domain score than metropolitan paramedics (p< 0.001). Physical Function (PF), Role Limitations – Physical (RLP), Bodily Pain (BP), General Health (GH), Vitality (V), Social Function (SF), Role Limitations due to Emotional or Personal Problems (RLEP), Mental Health (MH), Physical Health Summary (PHS), and Mental Health Summary (MHS).

3.1.2 Paramedic Health Status

*SF-36 Differences by Age and Years of service*

There were only weak, negative correlations (r= -0.08, p< 0.01) between SF-36 domain (PF, RLP, V) and age. There were only weak positive correlations (r= .09, p< 0.09) between SF-36 domain (PF, BP) and years of service. SF-36 differences by age with years of service held constant had a weak, negative correlation (r= 0.12, p< 0.01) for the physical function domain and role limitation due to physical domain.
Years of service were also themed into four categories to examine for differences in SF-36 scores. Where significant differences existed, results are graphed. Differences existed in role limitations due to physical health problems between group 1 and 2 (p< 0.02), group 2 and 3 (p< 0.04 and group 3 and 4 (p< 0.04). General health difference between group 1 and 2 (p< 0.01), vitality difference between group 2 and 3 (p< 0.01), PHS difference between group 1 and 2 (p< 0.01) and group 2 and 3 (p= 0.03). MHS difference between group 1 and 2 (p= 0.04) (Model C). See Figure 3.5.

![Figure 3.5](image_url)

**Figure 3.5.** SF-36 Scores and Years of Service category. There were significant differences in three domain scores and the Physical and Mental Health Summaries. Role Limitations – Physical (RLP), General Health (GH), Vitality (V), Physical Health Summary (PHS), and Mental Health Summary (MHS).
3.2 Paramedic Health Status - BMI

3.2.1 Paramedic Health Status

*BMI Differences by Gender and Posting*

The average BMI, based on self-reported height and weight, for the survey respondents was $27.1 \pm 4.3$ kg/m$^2$. BMI scores by gender were significantly different with male BMI $27.5 \pm 4.1$ kg/m$^2$ versus female BMI $26.1 \pm 4.8$ kg/m$^2$ ($p< 0.001$, CI 0.76, 2.17, $d= 0.07$) (Model B).

There was a significant difference by posting with regional rostered paramedics ($n= 379$) having a higher mean BMI than metropolitan rostered paramedics ($n= 368$) ($27.5 \pm 4.3$ kg/m$^2$ vs $26.6 \pm 5.1$ kg/m$^2$ $p= 0.01$, CI -1.51, -0.22, $d= 0.2$) (Model B).

Regional rostered males ($n= 268$) had significantly higher mean BMI values than metropolitan rostered males ($n= 239$) ($28.0 \pm 3.9$ kg/m$^2$ vs $26.9 \pm 4.1$ kg/m$^2$, $p= 0.002$, CI -1.79, -0.39, $d= 0.28$) whilst there were no differences in mean BMI between regional ($n= 129$) and metropolitan ($n= 111$) females ($26.2 \pm 4.6$ vs $25.9 \pm 4.9$, $p= 0.74$, CI -1.44, 1.02, $d= 0.001$).

When themed by WHO category, BMI by gender and posting was examined (as a percentage of total respondents) and is presented in Figure 3.6.
Figure 3.6 The percentages of paramedics by gender and posting by BMI WHO classification. There was a significant difference between categories.

3.2.2 Paramedic Health Status

**BMI Differences by Age and Years of Service**

There was a significant relationship between age and BMI ($p< 0.001$) and years of service and BMI ($p= 0.004$). A linear mixed model was fitted with age significant and years of service significant. See Figure 3.7.
Figure 3.7 The effect of age and years of service on BMI illustrates a significant relationship between age, years of service and BMI. Age has a more significant effect on BMI than age in the model.

3.2.3 Paramedic Health Status

BMI and SF-36

Examining the relationship between BMI and SF-36 scores, there were weak negative correlations between BMI and PF ($r = -0.245$, $p < 0.001$), BMI and GH ($r = -0.296$, $p < 0.001$) and BMI and PHS ($r = -0.204$, $p < 0.001$).
3.3. Paramedic versus Australian Population – SF-36

3.3.1 Paramedic versus Australian Population Health Status

*SF-36 Differences*

There were significant differences (p < 0.001) with small to large effect sizes in 6 of the 8 domains with paramedics reporting lower scores than the Australian population as well as in PHS score (p < 0.001 CI 1.68, 3.96, d = 0.20) and MHS score (p < 0.001, CI 6.99 9.363, d = 0.54). In the physical function domain, paramedics scored significantly higher with a small effect size (p < 0.001 CI -4.32, -2.95, d = 0.24) (Model A). See Table 3.3.

**Table 3.3**
SF-36 Scores Paramedics and Australian Population

<table>
<thead>
<tr>
<th>Health Domain/Summary Score</th>
<th>NSW Ambulance (n=747) Mean (SD)</th>
<th>Australian Population (n=12,393) Mean (SD)</th>
<th>p-value</th>
<th>Effect size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Function</td>
<td>91.6 (8.3)</td>
<td>88.3 (19.2)</td>
<td>0.001</td>
<td>0.24</td>
</tr>
<tr>
<td>Role Physical</td>
<td>80.1 (31.1)</td>
<td>86.6 (27.7)</td>
<td>0.001</td>
<td>0.22</td>
</tr>
<tr>
<td>Body Pain</td>
<td>75.5 (19.1)</td>
<td>76.5 (21.1)</td>
<td>0.172</td>
<td>0.05</td>
</tr>
<tr>
<td>General Health</td>
<td>65.2 (18.5)</td>
<td>70.4 (19.1)</td>
<td>0.001</td>
<td>0.26</td>
</tr>
<tr>
<td>Vitality</td>
<td>56.2 (17.1)</td>
<td>61.5 (18.4)</td>
<td>0.001</td>
<td>0.28</td>
</tr>
<tr>
<td>Social Function</td>
<td>69.9 (17.7)</td>
<td>86.2 (19.5)</td>
<td>0.001</td>
<td>0.87</td>
</tr>
<tr>
<td>Role Emotional</td>
<td>74.1 (37.2)</td>
<td>87.6 (27.9)</td>
<td>0.001</td>
<td>0.42</td>
</tr>
<tr>
<td>Mental Health</td>
<td>74.5 (16.4)</td>
<td>75.1 (16.1)</td>
<td>0.364</td>
<td>0.01</td>
</tr>
<tr>
<td>Physical Health Summary</td>
<td>73.7 (15.1)</td>
<td>76.7 (15.1)</td>
<td>0.001</td>
<td>0.20</td>
</tr>
<tr>
<td>Mental Health Summary</td>
<td>67.9 (16.1)</td>
<td>76.2 (15.1)</td>
<td>0.001</td>
<td>0.54</td>
</tr>
</tbody>
</table>

*Note:* The table illustrates significant differences in 6 of 8 health domains and both summary scores.
3.4. Paramedic versus Australian Population - BMI

3.4.1 Paramedic versus Australian Population Health Status

**BMI Differences**

When examining BMI, significant differences in mean BMI scores were apparent between the NSW Ambulance paramedics and the Australian population with the paramedics having a significantly higher BMI (27.1 ± 4.3 kg/m² vs 26.5 ± 5.4 kg/m², *p* < 0.01, CI -0.85, -0.13, *d* = 0.13). (Model A) See Figure 3.7.

![BMI Comparison Chart](image)

**Figure 3.8:** BMI differences with means and 95% CI illustrate a small but significant difference in BMI (*p* = 0.01).

A chi-square test of independence was performed to examine the relationship of NSW Ambulance paramedics and Australian population BMI by WHO category. The relationship was significant ($\chi^2$ 37.46 df 3, *p* < 0.001) (Hypothesis Test 5). There was a significantly higher percentage of overweight NSW Ambulance paramedics compared to the Australian population. See Table 3.4.
Table 3.4
BMI by WHO Category, NSW Ambulance and Australian Population.

<table>
<thead>
<tr>
<th>WHO Category</th>
<th>BMI Range kg/m²</th>
<th>NSW Ambulance %</th>
<th>Australia %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Underweight</td>
<td>18.5 &lt;</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2 Healthy</td>
<td>18.5 – 24.9</td>
<td>33</td>
<td>38</td>
</tr>
<tr>
<td>3 Overweight</td>
<td>25 – 29.9</td>
<td>45 *</td>
<td>35 *</td>
</tr>
<tr>
<td>4 Obese</td>
<td>&gt; 30</td>
<td>22</td>
<td>24</td>
</tr>
</tbody>
</table>

* Significant difference (χ² 37.46 df 3, p<0.001)

Note: Bonferroni post hoc analysis revealed a significant difference between NSW Ambulance and the Australian population in the Overweight category (p< 0.001).

3.5 Paramedic Attitudes about Exercise

3.5.1 Paramedic Attitudes

*Barriers to Exercise*

The survey asked paramedics to indicate which barrier or barriers existed to not exercising as much as they would like. Selections and frequencies of response included: lack of time 46% (n= 341), family and other commitments 36% (n= 270), lack of motivation 25% (n= 184), lack of energy 23% (n= 168), cost of gym 15% (n= 110), injury 12% (n= 88), lack of, or distance to, facilities 11% (n= 22), lack of knowledge 5% (n= 39), and childcare 8% (n= 59). Regional paramedics reported lack of, or distance to, facilities more often (regional versus metropolitan (p< 0.001, CI -0.211, -0.122) (Hypothesis Test 2). See Figure 3.9.
Figure 3.9. Barriers to Exercise by posting illustrates the frequency of paramedic responses to perceived barriers. Note the significant difference (* $p < 0.001$) in response rate (regional versus metropolitan) for “lack of or distance to facilities”.

3.6 Paramedic Physical Activity Levels

Paramedics reported the number of vigorous, moderate and walking days and the hours/minutes of activity for each activity for the 7 days preceding the survey (Figure 3.10). These data are presented as median values and interquartile ranges. Median total MET-minutes for all paramedics was 3626 (IQR 1737 – 6537).
3.6.1 Paramedic Physical Activity Levels

*Differences by Gender and Posting*

Male paramedics reported significantly higher median total MET-minutes: 3870 (IQR 1836 – 6720) than female paramedics 3213.5 (IQR 1421 – 5849) (p= 0.02) (Model E). There was no significant difference in median total MET-minutes between metropolitan paramedics 3668 (IQR 1536 – 6451) and regional paramedics 3612 (IQR 1836 – 6696) (p= 0.4) (Model E). See Figure 3.10.

![Figure 3.10](image.png)

*Figure 3.10:* Median total MET-minutes (IQR) by gender and posting illustrates the differences as measured by the IPAQ. The only significant difference was by gender (* p= 0.02).*
3.6.2 Paramedic Physical Activity Levels

Correlation between Total MET-minutes and Age

There was a significant positive correlation between age and total Met minutes (Hypothesis Test 4) ($r = .120$, $p < 0.001$). A simple linear regression equation was found ($F (1, 745) = 10.946$, $p < 0.001$) with an $R^2$ of 0.014.

3.6.3 Paramedic Health Status (SF-36) and Physical Activity

Correlation between Years of Service and Total Met-minutes

There was a significant positive correlation between years of service and total MET-minutes ($r = .111$, $p < 0.001$, trivial effect size) and this did not differ significantly by gender or posting (Hypothesis Test 4). A simple linear relationship was found ($F (1, 744) = 9.216$, $p < 0.001$) with an $R^2$ of 0.011 indicating a trivial effect size.

3.7 Paramedic Health Status and Physical Activity Levels

3.7.1 Paramedic Health Status (SF-36) and Physical Activity

Correlation between SF-36 scores and Total MET-minutes

The relationship between SF-36 scores and total MET-minutes per week was examined (Hypothesis Test 4). The strongest correlations were general health and total MET-minutes ($r = .246$, $p < 0.001$), vitality and total MET-minutes ($r = .253$, $p < 0.001$, small effect size), PHS and MET-minutes ($r = .242$, $p < 0.001$, small effect size), and MHS and total MET-minutes ($r = .182$, $p = 0.001$, trivial effect size). A simple linear regression was calculated to predict PHS based on total MET-minutes (Hypothesis Test 5). A significant linear relationship was found ($F (1,745) = 46.02$, $p < 0.001$) with an $R^2$ of 0.06 indicating trivial effect size. See Figure 3.11.
Figure 3.11 illustrates the relationship between total MET-minutes per week and PHS. As total MET-minutes increase so do PHS scores. Blue shading represents the 95% CI.

3.7.2 Paramedic Health Status (SF-36) and Physical Activity

*Correlation between SF-36 by Gender*

There were significant positive correlations for males (Hypothesis Test 4) ($r = .216$, $p < 0.001$, small effect size) and females ($r = .283$, $p < 0.001$, small effect size) between PHS and total MET-minutes per week.

3.7.3 Paramedic Health Status (BMI) and Physical Activity

*BMI and Total Met-minutes*

Examining the relationship between BMI and total MET-minutes, there was a very weak positive correlation which was not significant ($r = .021$, $p = 0.56$, trivial effect size) between paramedic BMI and total MET-minutes.
DISCUSSION

The key findings from this study were that HRQoL in NSW Ambulance paramedics appears lower than the Australian population in many SF-36 domain and summary scores, but few differences lie within the paramedics when examined by gender and posting. BMI was significantly higher for NSW Ambulance than the Australian population. Paramedics, overall, list perceived barriers to exercise including family and time commitments most frequently. Regional paramedics list lack of, or distance to gyms significantly more often than metropolitan paramedics. Total MET-minutes are higher for males, similar by posting and appear higher than reported in other studies.

The four hypotheses and findings associated with each are as follows:

Hypothesis 1 – Health Status of Paramedics (SF-36 and BMI)

Health status of paramedics will differ by gender and posting and be negatively correlated with age and years of service.

The hypothesis is partly supported.

SF-36: The only significant difference in SF-36 results by gender was in the vitality domain and by posting was in the general health domain. This may suggest little difference in NSW Ambulance paramedics overall HRQoL, specifically summary scores for physical and mental health. There is little in the literature to employ as occupational comparators for paramedics, however recent research by Pek et al. (2015) on the health of paramedics working in Hungary reported SF-36 scores similar with respect to NSW Ambulance paramedics. Both Hungarian and NSW Ambulance paramedics reported low scores on the vitality domain which can indicate feeling tired and worn out. The effect of working a rotating shift schedule may account for the lower vitality scores. Shiftwork has been identified as a factor and was attributed to paramedic fatigue in
Victorian paramedics (Courtney, 2010). The inability to accumulate enough sleep due to shift work can cause accidents as well as contribute to the development of Type II diabetes (RR 1.09-1.40), increase weight and increase risk for cardiovascular disease (RR 1.23) in a meta-analysis of literature on shift work (Kecklund & Axelsson, 2016). Specific factors of shiftwork, that of inability to rest during night shifts, variations in meal times due to workload and working beyond shift finish time were reported by Australian paramedics (n= 49) (Paterson et al., 2014).

HRQoL scores by age and years of service were reported and when age was examined with years of service held constant, there was only a weak negative correlation. This follows an Australian trend of lower SF-36 scores with increasing age (Austalian Bureau of Statistics, 1995; Wilkins, 2016) suggesting that a decline in scores may be due predominantly to aging.

Previous research investigating paramedic health status has not examined differences by career phase. Notable in the present study when examining by career phase (Figure 3.5) there was a significant drop in the role limitations, general health and vitality domains and PHS and MHS scores from “early” career (0-10) to “mid”-career (11-20). This was followed by an increase in these scores for paramedics in the 21-30-year phase. This could indicate a career phase (11-20 years) in a NSW Ambulance paramedics when health status decreases. When matched by age, the iCare insurance statistics indicating a claim rate of 33.3% for paramedics, almost 10% higher than comparator occupations (iCare, 2018). Certainly, this phase should also be examined for prevalence of injury and sick time to see if these follow a similar pattern.

In terms of occupational comparators by career phase, research on Australian police officers surveyed longitudinally, found 21% of officers frequently considered leaving the police force after year 10 of their career (Howes & Goodman-Delahunty, 2015). Data from the United States
refers to average career length of paramedics as 6.5 years, where the author attributed increasing career length with higher scores on the Personality Factor survey (JEMS, 2017). In another US study, paramedic attrition rates of over 10% annual have been reported (Patterson et al., 2010) with no specific cause or causes attributed by the authors. Certainly, career phase should also be examined for prevalence of injury and sick time to see if these follow a similar pattern.

There are similar findings with other occupations who work a rotating schedule, for example nursing (Almajwal, 2015), physicians (Machi et al., 2012) and police officers (Ma et al., 2015). NSW Ambulance paramedics also reported that shiftwork was a barrier to exercise. In terms of the lower PHS scores by paramedics, this may be associated with the higher BMI levels, especially those evidenced by regional male paramedics. These high levels regionally could be linked to shift pattern and limited (or less) access to gyms and fitness facilities than metropolitan paramedics.

**BMI:** The average BMI of NSW Ambulance paramedics was 27.1 ± 4.3 kg/m² placing them in the WHO overweight category. Regional male paramedics had a significantly higher average BMI than their metropolitan counterparts. There appears to be no substantive literature about BMI in paramedics regarding rostering or geographic area, therefore, it is hard to comment if this is a meaningful trend in this paramedic service. Regional paramedics do exhibit a trend followed by rural Australians of having higher BMI (Simmons et al., 2005). In understanding why these differences exist, it is notable that call volumes are generally lower in regional compared to metropolitan postings in NSW. This could contribute to reduced OPA during the shift as the paramedic waits for the next callout. This would be consistent with a U.S. study that found urban nurses had higher levels of PA and lower BMI than rural nurses, concluding that living in a dense, compact city may be conducive to higher levels of physical activity and lower BMI (James et
al., 2013). Occupational physical activity was reduced in paramedics working in low populous areas of Canada, specifically, stretcher movement (50% less often), and handling of medication bags which was 75% less often than high populous areas (Coffey et al., 2016). It seems that if regional paramedics follow the BMI trend of the rural general population, this places these paramedics at a higher risk of BMI-related health disorders.

Examining the increase in paramedic BMI over time, there is an effect due more to age than years of service (Figure 3.7). This reflects similar findings in other studies, not necessarily limited by occupation (Poston et al., 2011; Reas, Nygård, Svensson, Sørensen, & Sandanger, 2007). Internationally, there have been reports of higher BMI in paramedics with increasing age (Buzga et al., 2015; Hegg-Deloye et al., 2015; Studnek et al., 2010; Tsismenakis et al., 2009). The implication is that with age, an increase in BMI coincides with poorer health status including diseases associated with higher BMI.

**SF-36 and BMI:** The results presented that paramedics with higher BMI had a weak negative correlation with three domain scores: physical function, vitality and general health. Paramedic BMI level may have a negative effect on physical function scores (the extent to which respondents’ perceptions are influenced by their physical condition) and this could be linked to the high rate of injury reported in paramedics. Researchers report deficits in physical functioning and increased pain are often associated with any musculoskeletal injury and are the basis for most clinician-based outcomes measures. Low scores in the physical function domain of the SF-36 have been linked to higher rates of injuries in adolescents and collegiate athletes (Valovich McLeod, Bay, Parsons, Sauers, & Snyder, 2009). In terms of vitality (respondents’ experience of feeling energetic) and general health (respondents’ view of overall health), these are consistent with the work of Pek who reported similar findings in vitality and general health scores in
Hungarian paramedics (Pek et al., 2015). There were similar findings in a French general population study (n= 21,239) where the overall effect of obesity (as estimated by BMI) are correlated with a reduction in physical function and a decrease in most mental domains of the SF-36 (Audureau, Pouchot, & Coste, 2016). In paramedic populations, with high levels of BMI, there is an implication that these high levels may be negatively impacting HRQoL, when measured using the SF-36 (Pek et al., 2015).

Further, there is a suggestion that higher BMI in paramedics could be associated with increase in premature mortality. At least one study on BMI and mortality among 1.46 million white adults, demonstrated a hazard ratio of 1.44 (95% CI, 1.38 to 1.50) for the BMI grouping of 25.0 to 29.9 (Berrington de Gonzalez et al., 2010). This has yet to be empirically demonstrated in the paramedic population. What has been demonstrated is that regular PA, be it occupational physical activity, or structured exercise can positively influence BMI (Almajwal, 2015) and thus reduce mortality. Therefore, with a paramedic BMI that is higher than the population, there is a need for them to have the ability to take part in physical activity. Further, the paramedic service must be a partner with the paramedic in identifying strategies to achieve this.

Hypothesis 2 - Health Status of Paramedics versus Australian Population (SF-36 and BMI)

Hypothesis: The paramedic population of NSW Ambulance will have a lower health status when compared to the Australian population.

The hypothesis is supported.

**SF-36:** The paramedic population of NSW Ambulance reported significantly lower SF-36 scores in 6 of 8 domains and both summary scores compared to the Australian population with small to large effect sizes. The only exception was with the physical health domain, where the
NSW Ambulance paramedics scored significantly higher with small effect size (Table 3.3). This is the first reported example of Australian paramedic HRQoL results being compared to the general population.

SF-36 comparators between paramedics and general population data are not common so this research adds a richness to the exploration of health status of paramedics beyond simply reporting of BMI levels. In the present study, the lower scores in most domains and summary scores compared to another population could indicate real health status issues. HRQoL is a valuable predictor of other aspects of health status, such as numbers of physician visits and hospitalisations, and mortality among adults (Dominick, Ahern, Gold, & Heller, 2002). This highlights the need to continue to measure paramedic HRQoL longitudinally and continue to establish comparisons with general population normative data.

Paramedic job characteristics usually involves working rotating shifts which may differentiate them from the Australian population. Almost all of NSW Ambulance paramedics work a shiftwork schedule compared to 16% of the Australian working population (Australian Bureau of Statistics, 2010). Courtney et al. (2010) found that paramedic shift workers in Victoria, Australia are risk for increased levels of depression. This linkage was also examined by Khan et al (2018) in a subsequent study which showed 32% of respondents reported significant levels of depression and fatigue. The also reported significant anxiety in 60% of respondents (Khan, Jackson, Conduit, & Kennedy, 2018). Lower scores in MHS and mental health domains could be linked to shift work and shift patterns and should be further investigated.

**BMI:** Regarding BMI, NSW Ambulance paramedics evidenced significantly higher BMIs than the Australian population (Figure 3.8), although the difference (0.6 kg/m² p< 0.01, CI -0.85, -0.13) is small. In large population studies, it is worth noting that increases in BMI above 25
kg/m² increase the risk of all-cause mortality of a Hazard Ratio (HR) of 1.44 (1.38, 1.50 CI) (Berrington de Gonzalez et al., 2010) with similar HR reported by (Di Angelantonio et al., 2016). Additionally, Table 3.4 illustrates that there is a significantly higher proportion of NSW Ambulance paramedics in the WHO overweight category compared to the Australian population. This is a concern considering both the relatively young age of paramedics (mean age 41.5 ± 9.5 years old), the level of BMI and the fact that a significant portion of a paramedic’s work day can involve occupational tasks such as lifting and carrying patients and equipment and injury rates are high in paramedics (Maguire et al., 2014). Higher levels of BMI are linked to increased incidence of occupational injury in other emergency services personnel (Kuehl et al., 2012) and in public sector employees (Kouvonen et al., 2013) and has been associated with higher levels of musculoskeletal injury in police officers (Nabeel et al., 2007).

The present study presents evidence of higher levels of BMI and, considering paramedic injury rates, this population should be monitored longitudinally. Secondly, the link between high BMI and hypertension has been reported in emergency services recruits in the US (n=370) (Tsismenakis et al., 2009). The incidence of prehypertension and hypertension post-employment has been reported as prevalent in up to 75% of emergency responders (Kales et al., 2009). Therefore, the level of BMI in NSW Ambulance paramedics can affect both injury and markers of illness, specifically, hypertension. The linkage between BMI and blood pressure in a sample of NSW Ambulance paramedics is reported in Chapter 5. Considering the present study, investigation into improving workplace practices to improve health status (specifically BMI level) should form a part of NSW Ambulance corporate practice.

Nationally, the Australian population has one of the highest life expectancies in the world and incidence of heart attacks and mortality from cardiovascular disease have been improving (Australian Institute of
Health and Welfare, 2016). However, there is evidence of high rates of cardiovascular disease and early retirement based on medical grounds that paramedics comprise an “at risk” portion of the general population (Hegg-Delaye et al., 2015; Rodgers, 1998; Sedrez, Kasten, Chaise, & Candotti, 2017). Therefore, the ability to compare health status including measures of HRQoL and BMI between paramedics and population normative data is important.

Finally, given the relatively young workforce as reported in this study the higher BMI and high percentage of paramedics in the WHO categories of overweight and obese might contribute to diminished health outcomes as their careers progress and needs to be monitored carefully on a longitudinal basis with targeted health promotion programs implemented based on the health surveillance findings.

Hypothesis 3 - Barriers to Exercise

Hypothesis: Paramedics reported barriers to exercise will differ by posting.

The hypothesis is partly supported.

Paramedics identified a series of perceived barriers to exercise. Both metropolitan and regional paramedics identified ‘lack of time’ and ‘family or other commitments’ as preventing adequate exercise (Figure 3.9). NSW Ambulance is similar to paramedic services across Australia with 73% of its workforce under the age of 50 years old compared to 77% nationally (Australian Government Productivity Commission, 2017a). This statistic illustrates that many of the paramedics at NSW Ambulance are early to mid-career and may be at similar points in terms of having young families. This seems to have been reflected in a high proportion of paramedics identifying that family commitment and childcare are barriers to exercise. It is difficult to predict if the barriers to exercise, combined with a rotating shift pattern are contributing factors.
From the survey, the barriers to exercise are not significantly different by posting. The one exception was regional paramedics identifying distance to exercise facilities significantly more often than metropolitan paramedics, who may have easier access with more choices. This is important because, in general, level of PA declines with increasing remoteness (National Rural Health Alliance, 2013). This is mirrored by an increasing number of people in the overweight or obese categories with increasing remoteness (Queensland Department of Health, 2014). This may flag the need for paramedics to have access to exercise facilities, for instance, in the workplace, especially in regional paramedic posts in NSW.

This important finding may indicate the need for time during the paramedic’s shift for an exercise program. Merrill (2013) presented recommendations for health improvement in Emergency Medical Services providers. These included service specific exercise education and functional movement training, and general physical ability assessment with lifestyle advice (i.e. healthy eating). Further, they advocate the use of peer fitness trainers as well as support by management. Given that those paramedics who responded to not exercising enough had a significantly higher BMI and significantly lower PHS and MHS scores in the SF-36, these are important indicators of the need for increased levels of PA and exercise.

In 2017 a novel exercise program for paramedics was started. The introduction of the Medic Fit on-station exercise program for regional paramedics appears to be one initiative by NSW Ambulance to provide space, equipment and support. Paramedics will be encouraged to exercise while on duty following an approved workout program. This initiative will also be studied to see if it will improve paramedic health. (High, 2017). Additionally, it has been reported that NSW Ambulance has introduced the Fitness Passport program across all postings and this is seen as a positive move. Fitness Passport is a corporate health and
fitness program that allows members to access a wide range of their local health and fitness suppliers (Fitness Passport, 2018). However, regional areas may have a lower number of facilities per square kilometer compared to metropolitan areas as reported in other research (Parks, Housemann, & Brownson, 2003; Reimers et al., 2014). As well, not all gyms and health clubs participate in Fitness Passport. Given the high Australian paramedic rates of injuries as reported by Maguire et al. (2014) and Roberts et al. (2015), it seems that resources must be expended to ready paramedics for the demands of job performance.

Hypothesis 4 – Physical Activity Levels

Hypothesis: Physical activity levels of paramedics will differ by gender and posting and be negatively correlated with age and years of service.

The hypothesis is partly supported.

Male paramedics reported significantly higher PA in the form of total MET-minutes than females (Figure 3.10) and this is consistent with other studies (Rahimi, Hashemi-Nazari, Etemad, & Soori, 2017), although there was no readily available data on gender differences for paramedics or emergency services generally (Azevedo et al., 2007; Sattler, Deane, Tapsell, & Kelly, 2018). From the Australian population, Wooden (2014) reported on HILDA Wave 13 survey data of IPAQ scores for the age group 15-74, representing an age comparison similar to NSW Ambulance paramedics. HILDA data for males were total MET-minutes of 3,073 and females total MET-minutes of 2067, with an overall mean of 2,570 MET-minutes. This equates to NSW Ambulance paramedics reporting a 36% higher score for total MET-minutes. This does not seem consistent with paramedic reporting of other measures of their health status compared to population data.

Total MET-minutes by posting was not significantly different, yet both regional paramedics and, specifically, regional male paramedics exhibited significantly higher BMI scores than their metropolitan
counterparts. Added to this is the fact that regional paramedics identified more often: a lack of, or distance to fitness facilities in the survey. Both suggest that PA for regional paramedics should be less than metropolitan.

From Figure 3.10, there is large individual variation by gender and posting. These variations may be since the IPAQ captures the previous 7 days of PA. For paramedics on a rotating shift schedule, the period may include most of the time on shift or the majority of time off shift.

The weak positive correlations between age and total MET-minutes and years of service and total MET-minutes were puzzling. This contradicts other studies that illustrate that physical activity and functional fitness decreases with increasing age (Diepetro, 2001; Milanvic et al., 2013). The reporting of results by the present survey respondents may be higher than with other groups. Comparators to peer reviewed public safety population data (for example: firefighters or police officers) using the same instrument are sparse. Research with Ambulance Victoria (AV) paramedics (n= 342) in a study by Courtney et al. (2010) reported a 2,088 median total MET-minutes which is 43% lower than the NSW Ambulance paramedics. Finally, Craig et al. (2003) reported a 12 country (n= 1974) median total MET-minutes of 2,514, again lower than the NSW Ambulance by 30%.

It has been noted in the literature that there is a potential for over-reporting total MET-minutes using IPAQ (Kozey, Lyden, Howe, Staudenmayer, & Freedson, 2010). In comparison to objective measures such as accelerometry, differences of up to 84% have been noted (Lee et al., 2011). This may be the case with NSW Ambulance paramedics in this survey. It is unclear whether paramedics are influenced in this reporting by the busy pace and call volumes consistent with urban paramedic service operation, although this only encompasses 50% of the respondents.
It is also unclear how many respondents spent all or any part of their shift rotation in that “previous 7 day” reporting period. This presents a limitation in the interpretation of results. The use of PA questionnaires is beneficial in monitoring changes in population activity but presently still show limited reliability and validity (Shephard, 2003). It raises an interesting question: Do paramedics accurately estimate their level of PA? In this instance, the higher values suggest perhaps not. Chapter 5 of this thesis reports objectively measured OPA using accelerometers worn by paramedics over a series of shifts.

LIMITATIONS

The use of corporate email to inform and solicit potential study paramedics may have limited participation (for example if the paramedic did not check his/her email account during the study period or if they were concerned about confidentiality). Similarly, the reminder email sent through to corporate email accounts may have limited participation for the same reason. NSW Ambulance survey data was collected using an online survey while the HILDA data was collected through a telephone survey. It is worth noting that self-reported height and weight is known to underestimate BMI, though the magnitude of bias is small (McAdams, Van Dam, & Hu, 2007). Use of the question regarding barriers to exercise may have been leading, however, 117 Paramedics validated the question by responding with their own open text responses.

CONCLUSION

Although decreased health status, specifically high BMI, has been reported for paramedics, the present study added the SF-36 to provide an additional estimate a HRQoL. Combined with BMI and attitudes about exercise, there is new information on paramedic health status. The NSW
Ambulance survey paramedics reported generally lower health status scores than the Australian population and may be because of shift work and perhaps psychosocial demands of the job. The present study using the SF-36 was the first of its type to be deployed with NSW Ambulance paramedics. Results show significant differences between the Australian population and NSW Ambulance paramedics. However, additional longitudinal research should be undertaken with paramedics to determine if the results presented are maintained or evolve over time and to measure potential impact of interventions.

This study demonstrates that paramedics’ BMIs are higher than the Australian population and they are more likely to be overweight or obese. Additionally, regional-rostered paramedics had significantly higher BMIs than those posted to Metropolitan areas and this is concerning, given their relatively young age.

Paramedics need to be fit for duty, but they report not exercising enough and accessing fitness facilities is difficult in regional areas. Paramedic services have an opportunity to be an active partner (with the paramedic) to ensure that the workforce is as healthy and productive as possible in a very challenging and demanding occupation.
CHAPTER 4: BIOMETRIC MONITORING OF PARAMEDICS: VALIDATION OF THE HEXOSKIN® BIOMETRIC SHIRT

“If your goal is to be a paramedic, it’s simple. You should be a paramedic for as long as you want to be a paramedic. That’s not the case presently.”

Shane Code
Former paramedic
ABSTRACT

Introduction

Measuring human physiological responses such as heart rate (HR) and respiratory rate (RR) in applied research settings is important in assessing workload demands. In laboratory settings, the gold standard for measuring HR and RR includes the electrocardiogram (ECG) and metabolic cart, both well validated. However, paramedics work in unpredictable environments where it is challenging to use a metabolic cart or ECG. Recently introduced biometric shirts enable the measurement of a range of physiological and physical activity parameters and can offer an unobtrusive method of data collection in paramedics. The aim of this study was to establish the validity of the Hexoskin® biometric shirt compared to standard laboratory measurement of HR and RR.

Methodology

Six males (age 38 ± 8yrs; height 178.8 ± 4.2 cm; weight 86.8 ± 9.9 kg) and fourteen females (age 44.6 ± 9.6 yrs.; height 164.6 ± 6.9; weight 64.9 ± 7.7 kg) volunteered to use a cycle ergometer in two test conditions: (1) a steady state (SS) condition of 85% of respiratory threshold, and 2) a maximal aerobic power test (\(\dot{V}O_2\) max). Measures of HR obtained by Hexoskin® shirts or ECG were compared in four time points: (1) the start of the 85% SS test, (2) the end of the 85% SS test, (3) the start of the \(\dot{V}O_2\) max test and, (4) the end of the \(\dot{V}O_2\) max test. Measures of RR were obtained by Hexoskin® shirts or metabolic cart and were compared at two time points (1) at the mid-point of the 85% SS test and (2) at the end of the \(\dot{V}O_2\) max test. Means of HR and RR obtained by the Hexoskin® or ECG and metabolic cart were compared for significant differences. Intraclass Correlation Coefficient (ICC) was used as a measure of the reliability of the two measures and Bland-Altman (BA) plots provided a
graphical method of comparing the results obtained by the different measuring devices.

Results

Analysis of mean values for HR revealed no significant differences and there were good ICC between measures obtained by the Hexoskin® shirt and the ECG under the four test conditions (1: $p=0.86$, ICC 0.93, 2: $p=0.92$, ICC 0.92, 3: $p=0.27$, ICC 0.95, 4: $p=0.31$, ICC 0.97). The BA plots for HR indicated only slight deviation of the mean difference from zero and a small variability with narrow agreement limits. For RR there were no significant differences and good ICC between the Hexoskin® and the metabolic cart for both tests (1: $p=0.49$, ICC 0.99, 2: $p=0.69$, ICC 0.98). The BA plots for RR indicated slight deviation of the mean difference from zero and a small variability with tight agreement limits.

Conclusion

The Hexoskin® biometric shirt has validity for measuring HR and RR compared to ECG and the metabolic cart in a sample of 20 cyclists under two exercise intensities and test conditions. Consequently, Hexoskin® biometric shirts could be employed to measure physiological parameters in paramedics during sedentary, moderate and vigorous physical activities in their workplace.
INTRODUCTION

The criteria in monitoring cardiorespiratory functions, heart rate (HR) and respiratory rate (RR) has been the metabolic cart and ECG monitor (Hills, Mokhtar, & Byrne, 2014). They are most suited for use in a static laboratory environment, limiting their use in applied research settings, for instance in monitoring paramedics in their workplace. Recently, smart textiles such as wearable shirts, harnesses, or other like devices are being used to monitor, record and, in some instances transmit physiological data. Manufacturers are incorporating HR, RR, and accelerometry sensors into textiles such as Equivital (Shortz, Franke, Kilic, Peres, & Mehta, 2017), Zephyr bioharness (Smith, Haller, Dolezal, Cooper, & Fehling, 2014) and the Hexoskin® biometric shirt (Villar, Beltrame, & Hughson, 2015).

The use of these smart textiles is now being incorporated into athletic training and game day performance (Montgomery, Pyne, & Minahan, 2010), the surveillance of the general population in activities of daily living (Thompson, 2017) and the monitoring of the physical demand placed on firefighters (Affeldt, 2010; Parker, Vitalis, Walker, Riley, & Pearce, 2017). Technology is now allowing for high quality physiological data to be collected across a variety of settings.

Previously, physiological research in applied settings, such as the paramedic workplace, has been limited due to the lack of availability of reliable and validated monitoring devices suitable for those environments. Of the biometric shirts available, the Hexoskin® biometric shirt appears suited to study the physiological demands placed on paramedics in their workplace. Given the unpredictable nature of paramedic occupational tasks, which can range from long periods of sedentary activity interspersed with vigorous activity (for example performing CPR), a reliable and valid measurement device was needed for all these conditions.
Prior to undertaking the present study on the validity of the Hexoskin® (Carre Technologies, Montreal, PQ) there had only been two previous studies. The first used Hexoskins to monitor physical parameters in daily living such as walking, standing and laying down (Villar et al., 2015). This study used 20 healthy young volunteers walking on treadmills at varying grades until a HR that was 80% of predicted HR$_{\text{max}}$ was achieved. They found low variability, good agreement and consistency in HR, RR and PA when compared to ECG, metabolic cart and accelerometer. In the second study, Montes et al. (2015) trialled Hexoskins on 10 participants hiking trails of differing gradients and found telemetry issues with several the Hexoskins. This previous study recommended further Hexoskin® validation in real-life scenarios. Because of the paucity of data and lack of agreement between the only two published studies on Hexoskin® use and accuracy, a decision was made to undertake a validation study for this thesis. Hence the aims of this study were:

Aims

- To validate the Hexoskin® biometric shirt compared to standard laboratory heart rate measurement equipment.

- To validate the Hexoskin® biometric shirt compared to standard laboratory respiratory rate measurement equipment.

Hypotheses

1. The Hexoskin® biometric shirt will be validated for heart rate monitoring when compared with a standard ECG monitoring machine.

2. The Hexoskin® biometric shirt will be validated for respiratory rate monitoring when compared with a standard metabolic cart.
METHODOLOGY

Study design

This was a prospective validation study comparing the Hexoskin® biometric shirt measurement of HR and RR with accepted laboratory standards for measuring HR and RR utilising an ECG and metabolic cart respectively.

Participants

Twenty healthy individuals that participated in endurance training at least 3 times per week volunteered to participate in the study. Six males (age 38 ± 8 yrs.; height 178.8 ± 4.2 cm; weight 86.8 ± 9.9 kg) and fourteen females (age 44.6 ± 9.6 yrs.; height 164.6 ± 6.9 cm; weight 64.9 ± 7.7 kg) were recruited. All participants were tested between 27/08/2016 and 20/10/2016. All participants completed both test protocols.

Prior to involvement in the present study, participants provided informed consent that was approved by Charles Sturt University Human Research Ethics Committee as Protocol 2014/182. Participants received complete written and verbal details of the study and potential risks involved prior to signing the Participant Informed Consent form. Participants completed the Adult Pre-Exercise Screening Tool (Exercise and Sports Science Australia, Ascot, Queensland, Australia (see Appendix 3)) to determine that they were in good physical health with no musculoskeletal disorders or risk factors towards an adverse event during intense physical activity. Each participant was recruited on a basis of self-reported physical fitness.

Procedure

Participants were tested at the School of Exercise Science, Sport and Health laboratory at Charles Sturt University in Bathurst, NSW, Australia. During the familiarisation session each subject’s height and body mass were recorded. After being informed of the risks associated with the
experiment, each participant signed a Participant Information and Consent form (see Appendix 4). Participants were then fitted with a Hexoskin® biometric shirt (Carre’ Technologies, Montreal, PQ, Canada). A Hexoskin® data pack was assigned and placed in the hip pocket of the Hexoskin®.

Relative humidity, room temperature and atmospheric pressure were recorded before each test session via a weather station (Model: WS5029, Holman Industries, Osborne Park, Western Australia). Mean ± SD for relative humidity (%), room temperature (degrees Celsius) and atmospheric pressure (mmHg) during testing were 47% ± 11; 22° C ± 5; 768 mmHg ± 2, respectively. Prior to testing, each participant was instrumented with ECG electrodes in a 5-lead configuration following the protocol of Francis (2016). These electrodes were connected to the standard laboratory ECG (CASE, GE Healthcare, Waukesha, USA). HR was calculated by analysing the R-to-R interval from the ECG on a beat-by-beat basis recorded at 1,000 Hz and processed after testing with custom developed software (LabVIEW™, National Instruments, Austin, TX, USA). The Hexoskin® data collection pack recorded the ECG signal at 256 Hz from three electrodes embedded in the fabric of the shirt with two located on the chest and another located at the lower right of the rib cage. Each participant had a Hexoskin® shirt selected according to manufacturer’s sizing guidelines to ensure optimal electrode placement.

Hexoskin® utilizes digital ECG recording with 1 channel measuring at 256 Hz capable of detecting HR between 30-220 bpm with a QRS event detection at 4ms resolution. The signal is processed as the average of the last 16 beats. For Hexoskin® respiratory data acquisition, the cyclic movement of the chest was recorded at 128 Hz during the inspiratory and expiratory breath phases through two strain bands located in the garment at the level of the chest and the abdomen. Respiratory rate is calculated as the average of the last seven completed cycles (Figure 4.1).
To ensure good electrode contact and proper strain gauge operation for the Hexoskins, two straps were measured and applied to all male participants at the level of the chest and the abdomen. For female participants, one strap was measured and applied at the level of the abdomen.

Participants were familiarised with the cycle ergometer (Lode Excalibur Sport, Groningen, the Netherlands) with seat height and position adjusted for proficient movement efficiency by an exercise science PhD candidate. Participants were fitted with a multiple one-way T-shaped valve and mouthpiece system, supported by an acrylic head unit (Hans Rudolph, Kansas City, MO, USA) that was positioned to allow measurement of ventilatory parameters on a breath-by-breath basis by a rapid response gas analyser (AEI Technologies, Pittsburgh, PA, USA). The volume transducer was calibrated before each test with a 3-1 calibration syringe (Hans Rudolph, Kansas City, MO, USA) and the analysers were calibrated with gases of known concentration: 100% N₂, room air and medically calibrated gas of 16% O₂, 5% CO₂.

Exercise Protocol

Prior to exercising, each participant was required to remain seated for 5 minutes to establish a resting HR and RR. The participant was then asked to cycle at a 100-watt load for several minutes until they had established a comfortable, and constant pedalling cadence between 70-80 revolutions per minute (rpm). Exercise protocols and subsequent conditions involved rested state, incremental exercise to exhaustion (ramp test), and a steady-state (SS) exercise bout induced by a constant watt-load.

For the ramp test, each participant was instructed to cycle at a 70 - 80 rpm cadence and maintain that cadence for the entirety of the exercise bout. The ramp function for each was based on their self-reported cycling fitness and the need to constrain test duration between 8 and 12 minutes.
(Astorino et al., 2000, Yoon et al., 2007). Consequently, the ramp function varied between subjects from 25 to 40 watts/min. The ramp protocol consisted of two minutes of rested breathing, followed by two minutes at double the ramp function watts for that participant, followed by the near continuous ramp function. Each participant was instructed to continue cycling until volitional exhaustion (Astorino, Robergs, Ghasavand, Marks, & Burns, 2000; Yoon, Kravitz, & Robergs, 2007). The test ended when the participant could no longer maintain a pedalling cadence >40 rpm whilst staying seated. The participant was then instructed to lay supine for a 60-minute rest period before the second exercise trial and was given the opportunity to hydrate.

The ventilatory threshold (VT) was then used to determine the power output required for the following steady-state (SS) cycling bout. The SS exercise bout was limited to 85% VT watts. The test began with the participant sitting in the cycle ergometer seat, resting for a 120 second period. After this point, the participant was encouraged to cycle for an 8-minute period at the 85% VT watts. After this point, the testing was complete.

Figure 4.1 Illustration of the Hexoskin® biometric shirt (Hexoskin, 2017).
Data Analysis

Data were inspected for normality prior to analysis and are presented as mean ± standard deviation. Heart rate data obtained from the laboratory ECG were analysed on a beat-by-beat basis. Heart rate from the ECG was then linearly interpolated at 1-second intervals using Graphpad (Prism version 7.03, Graphpad, La Jolla CA, USA) to match the reporting frequency of the Hexoskin® data using a protocol as proposed by Villar, Beltrame, and Hughson (2015). Data were time aligned by matching the time stamps on the ECG with the Hexoskin® data.

Respiratory rate data obtained from the metabolic cart was analysed on a breath-by-breath basis. Respiratory rate was then linearly interpolated at 1 second intervals using Graphpad (Prism, Graphpad, La Jolla CA, USA) to match the reporting frequency of the Hexoskin® data. Data were time aligned by matching the time stamps on the metabolic cart with the Hexoskin® data.

Data were sampled from the following test conditions and time periods: 1) 85% SS – rest (15 participants included and 5 participants excluded due to noisy data) 2) SS – end (17 participants included and 3 participants excluded due to poor signal from the ECG), 3) \( \dot{V}O_2 \) max rest (15 participants included and 5 participants excluded due to poor signal from the ECG), and 4) \( \dot{V}O_2 \) max end (16 participants included and 4 participants excluded due to poor signal from the ECG). For each, 60 seconds from each device were analysed except for two samples in 85% SS end and two samples in 85% SS rest which were 15 seconds long.

For RR, data were sampled from the same two test conditions: 1) 85% SS (15 participants included and 5 participants excluded), and 2) \( \dot{V}O_2 \) max rest (20 participants included). For the 85% SS, the midpoint of the test was determined visually, and the RR sampled for a 5 second period.
For VO₂ max, the end point (highest RR) was determined visually and the RR sampled for that data point and the 4 seconds previous to that.

Statistical analysis - Data for the validation analysis from the Hexoskin® for both HR and RR was compared to the ECG and metabolic cart by fitting a linear mixed model to assess for statistically significant differences. Intraclass Correlation Coefficient (ICC) was used to assess level of consistency of the measures. Bland-Altman (BA) plots were used to assess the level of agreement between the two methods against an average of the methods for average bias and 95% confidence limits of agreement.

All analyses were performed using SPSS Version 17.0 (Statistical Package for the Social Sciences Version 17.0, SPSS Inc., Chicago, Illinois, U.S.A.) with the threshold for statistical significance set at p<0.05. For a summary of statistical tests, see Table 4.1.

**Table 4.1.**
Summary of Statistical Tests

<table>
<thead>
<tr>
<th>Statistical measure</th>
<th>Model Assumptions</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear Mixed Effect Model</td>
<td>The explanatory variables are related linearly to the response. The errors have constant variance, are independent and normally distributed.</td>
<td>ECG and Hexoskin® HR data. Metabolic cart and Hexoskin® RR data (Model A)</td>
</tr>
<tr>
<td>Intraclass Correlation Coefficient</td>
<td>The variance of observation of a subject before a fixed effect is the same after the fixed effect.</td>
<td>ECG and Hexoskin® HR data. Metabolic cart and Hexoskin® RR data (Model B)</td>
</tr>
<tr>
<td>Bland-Altman Plots</td>
<td>The residuals are normally distributed</td>
<td>ECG and Hexoskin® HR data. Metabolic cart and Hexoskin® RR data (Model C)</td>
</tr>
</tbody>
</table>

Note: The Model Assumptions are met unless otherwise notified.
RESULTS

4.1 Heart Rate

There were no significant differences in HR between the Hexoskin® and ECG in either of the two test conditions and time periods (Model A). The mean difference and ICC values were analysed and presented low variability, small error, and good consistency between methods (Model B). See Table 4.2.

Table 4.2
Comparison of HR by method.

<table>
<thead>
<tr>
<th>Heart Rate (bpm)</th>
<th>Method</th>
<th>Steady State rest</th>
<th>Steady State end</th>
<th>VO₂ max rest</th>
<th>VO₂ max end</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ECG</td>
<td>88.2 ±8.1</td>
<td>134.0 ±23.1</td>
<td>74.4 ±8.9</td>
<td>137.5 ±33.2</td>
</tr>
<tr>
<td>Mean ±SD</td>
<td>Hexoskin®</td>
<td>88.2 ±8.4</td>
<td>134.1 ±23.5</td>
<td>75.0 ±8.4</td>
<td>136.4 ±30.9</td>
</tr>
<tr>
<td>p-value</td>
<td></td>
<td>0.86</td>
<td>0.92</td>
<td>0.27</td>
<td>0.31</td>
</tr>
<tr>
<td>Intraclass Correlation Coefficient</td>
<td></td>
<td>0.93</td>
<td>0.92</td>
<td>0.95</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Note that there were no significant differences by test condition or time period in HR measurement by the Hexoskin or ECG.

The BA plot analysis showed small deviations from the mean value from 0 under the four test time periods (Model C). Figures 4.2 to 4.5 presents the results using the differences between methods (Y axis) plotted against the average of two methods (X axis). Upper and lower confidence limits represent the 95% confidence intervals of agreement.
Figure 4.2 This shows a BA plot for 85% SS rest of the HR differences between the two methods plotted against the average. Horizontal lines are drawn at the mean difference and at the limits of agreement (mean difference ± 1.96 SD). Limits of agreement are -3.2 to 3.2. Bias (mean difference) was 0.
Figure 4.3 This shows a BA plot for the 85% SS end of the HR differences between the two methods plotted against the average. Horizontal lines are drawn at the mean difference and at the limits of agreement (mean difference ± 1.96 SD). Limits of agreement are -5.1 to 5.5. Bias (mean difference) was 0.19.
Figure 4.4: *This shows a BA plot for VO₂ max rest of the HR differences between the two methods plotted against the average. Horizontal lines are drawn at the mean difference and at the limits of agreement (mean difference ± 1.96 SD). Limits of Agreement: -4.9 to 3.7. Bias (mean difference) was 0.59.*
Figure 4.5: This shows a BA plot of the \( \dot{V}O_2 \) max end for the HR differences between the two methods plotted against the average. Horizontal lines are drawn at the mean difference and at the limits of agreement (mean difference \( \pm 1.96 \) SD). Limits of agreement -9.5 to 7.4. Bias (mean difference) was -1.04.
4.1 Respiratory Rate

There were no significant differences in RR measured by the Hexoskin® or the metabolic cart measures for either of the two test conditions (Model A). The mean difference and ICC were analysed and presented low variability, small error, and good consistency between methods (Model B). See Table 4.3.

Table 4.3
Comparison of RR by method

<table>
<thead>
<tr>
<th>Method</th>
<th>Steady State</th>
<th>( \dot{V}O_2 \text{ max} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metabolic Cart</td>
<td>30.4 ± 8.1</td>
<td>48.5 ± 0.9</td>
</tr>
<tr>
<td>Hexoskin®</td>
<td>30.9 ± 8.1</td>
<td>48.9 ± 0.9</td>
</tr>
<tr>
<td>Mean ±SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>0.49</td>
<td>0.69</td>
</tr>
<tr>
<td>ICC</td>
<td>0.98</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Note that there were no significant differences by test condition in RR between devices. RR = Respiratory Rate. ICC = Intraclass Correlation Coefficient.

The BA plot analysis showed small deviations from the mean value from 0 under the two test conditions. (Model C). Figures 4.6 and 4.7 presents the results using the differences between methods (Y axis) plotted against the average of two methods (X axis). Upper and lower confidence limits represent the 95% confidence intervals of agreement.
Figure 4.6 This shows a BA plot for 85% Steady State of the RR differences between the two methods plotted against the average. Horizontal lines are drawn at the mean difference and at the limits of agreement (mean difference ± 1.96 SD). Limits of agreement -0.18 to 0.15. Bias (mean difference) was -0.012.
Figure 4.7 This shows a BA plot for $\dot{V}O_2$ max end of the RR differences between the two methods plotted against the average. Horizontal lines are drawn at the mean difference and at the limits of agreement (mean difference $\pm 1.96$ SD). Limits of agreement -0.50 to 0.46. Bias (mean difference) was -0.019.
DISCUSSION

The key findings of the present study were that the Hexoskin® biometric shirt had good validity of HR and RR with standard laboratory measurements. It was important to establish the validity of the biometric shirts as a measurement device during exercise that could potentially be applied to measure paramedic occupational task performance. Additionally, conducting the validation study allowed the researcher to become oriented to the Hexoskin® biometric shirt for use in subsequent studies.

The two hypotheses and findings associated with each are shown below:

Hypothesis 1 – Validity of Hexoskin® for Heart Rate Measurement

Hypothesis: The Hexoskin® biometric shirt be will be validated for heart rate monitoring when compared with a standard ECG monitoring machine.

This hypothesis is supported.

There were no significant differences between HR measured by either the Hexoskin or the standard ECG monitor. Prior to the present study, there had been one validation study of Hexoskin® compared to ECG and the metabolic cart, with a finding that it was a valid and consistent tool to monitor activities of daily living (Villar et al., 2015). The present study differed from the Villar study in that the methodology used here included (a) a cycle ergometer instead of a treadmill, and (b) the employment of a test condition designed to induce a maximal heart rate, specifically, at the end of the $\hat{V}O_2$ max test. Further, the present study tested the Hexoskins under two test conditions ($\hat{V}O_2$ max and 85% SS) each with a period of rest and a period under load. This was to emulate the HR and RR ranges that can be associated with paramedic occupational tasks. Heart rates
achieved in CPR simulation in studies range from 128 ± 4.4 bpm (Bridgewater et al., 2000) in trained rescuers, to 138 bpm in student paramedics (Gutwirth, Williams, & Boyle, 2012). The present study employed the cycle ergometer methodology used in research on Irish paramedics who exhibited sub-maximal heart rates of 158 ± 6.5 bpm (Gamble et al., 1991). There have been no clear comparators of paramedic’s RR response during calls or in simulation to the present study.

The mean HR values under the conditions of 85% SS (rest and end) and \( \dot{V}O_2 \) max (rest and end) showed no significant differences with high ICC values similar to Villar et al. (2015). The BA analyses as presented in Figures 4.2 to 4.5 for HR differences between the two measures shows data evenly above and below the average, resulting in an average bias close to zero. The limits of agreement range from -3 to +3 bpm for 85% SS rest (Figure 4.2) to -9.5 to +7.5 bpm \( \dot{V}O_2 \) max end (Figure 4.5). Finally, there appears to be no trend in terms of increasing or decreasing differences as the average increases and the variability of the bias is consistent across the graphs (Giavarina, 2015).

More recent validation studies undertaken have presented similar findings to this study. Phillips, Beach, Cathey, Lockert, and Satterfield (2017) tested the Hexoskin® on 6 subjects performing moderate and high intensity activities and found good reliability (p> 0.05) and validity for HR. For RR, in terms of reliability, there was medium correlation (r=0.502, p= 0.311). Elliot, Hamlin, and Lizamore (2017), tested elite cyclists (n= 11) on a cycle ergometer using a ramped protocol similar to the present study. They found that the Hexoskin® when compared to the metabolic cart and ECG, was reliable and valid for the measurements of HR. Both the Phillips and Elliot studies may have been hampered by small sample size. Montes, Young, Tandy, and Navalta (2018) validated HR measurement with the Hexoskin® compared to a Polar T-31 HR monitor during outdoor walking activities. Most recently Cherif et al. (2018)
validated the use of the Hexoskin® (Concordance Correlation Coefficient, ICC and BA) in a maximal exercise test with 28 subjects for HR and RR. This suggests that Hexoskin® is a valid method to measure HR and RR and has validity in a range of activity levels ranging from sedentary to intense. The findings from the present study are consistent with validation of the Zephyr bioharness (Zephyr Technology Corporation, New Zealand) using a similar methodology (Rawstorn et al., 2015). Research validating the Equivital LifeMonitor (Hidalgo, Swavesey, U.K) under low and moderate intensity activities found it was a valid measurement instrument compared to laboratory physiological monitoring devices and therefore would serve as a useful comparator (Liu, Zhu, Wang, Ye, & Li, 2013).

Hypothesis 2 – Validity of Hexoskin® for Respiratory Rate Measurement

Hypothesis: The Hexoskin® biometric shirt will be validated for respiratory rate monitoring when compared with the metabolic cart.

This hypothesis is supported.

There were no significant differences between RR measured by either the Hexoskin or the standard ECG monitor. There are no apparent studies of RR monitoring in paramedics in simulation, laboratory or in situ environments. Therefore, there is no comparable data in terms of RR with the present study. However, the findings from the present study show that the mean RR under the two test conditions (85% SS and $\dot{V}O_2$ max) showed no significant differences with ICC values similar to those reported by Villar et al (2015) and Elliot et al. (2017). Similarly, the findings of Montes et al., (2018) showed validity of the Hexoskin® compared with the Moxus Metabolic System® during outdoor trail walking. Together, this illustrates that Hexoskin® is a valid method for RR monitoring over a range of activities, from sedentary to intense physical activity.
The BA analyses as presented in Figures 4.6 and 4.7, for RR differences between the two measures shows data evenly above and below the average, resulting in an average bias close to zero. The limits of agreement range from -0.18 to 0.15 RR 85% SS rest (Figure 4.6) to -0.50 to 0.46 RR \( \dot{V}_O^2 \) max (Figure 4.7). Finally, there appears to be no trend in terms of increasing or decreasing differences as the average increases and the variability of the bias is consistent across the graphs (Giavarina, 2015).

Additional findings from the present study included allowing the researcher to become oriented to the garment, the telemetry capabilities and data upload and download features of Hexoskin® software prior to use with paramedics in subsequent studies. This familiarisation process improved the process of establishing user profiles and data management.

Findings in this regard included that the cardiac sensors in the Hexoskin® need to be in close contact with skin and worked optimally when moistened with water prior to data collection. Further, observing the participants at levels of high intensity cycling revealed increased torso movement. This resulted in close attention to proper sizing (fit) and ensuring the external straps supplied with each Hexoskin® are appropriately placed and are tightened down. This was a similar finding to Eliot’s study involving elite cyclists, where the fit and sizing of Hexoskins resulted in better data acquisition (Elliot et al., 2017).
LIMITATIONS

There are several limitations to the present study. Firstly, none of the recruited participants were career paramedics, although several were paramedic students in their final year of study. This may present study subjects not representative of the paramedic population. Further, the use of a cycle ergometer may not necessarily replicate levels of exertion that paramedics may routinely experience during shift. This exercise protocol and equipment was chosen to best measure the ability of the Hexoskin to accurately record HR and RR under very strenuous conditions. Therefore, less strenuous activities should be accurately measured in situ while being worn by paramedic subjects.

CONCLUSION

The Hexoskin® biometric shirt is being used to measure and record physiological parameters of HR and RR in a variety of laboratory and applied research settings. It has now been validated in several settings: at rest through to high intensity physical activity.

In this study, HR and RR measured by the Hexoskin® had low variability, small error, and agreed well and consistently with measures obtained with standard laboratory measurement devices. In addition, employing the Hexoskin® and associated hardware and software allowed the researcher a familiarity with the system prior to deployment with NSW Ambulance paramedics in situ in subsequent studies. The Hexoskin® biometric shirt is suitable to be used to measure paramedic physiological measures while responding to emergency calls.
“It’s kind of a unique concept, but it’s totally real, isn’t it? ... I mean, these paramedics put themselves in incredibly stressful situations, are killing themselves to save our lives and they’re not really regarded or appreciated.”

Nicholas Cage, actor and star of “Bringing out the Dead” (Michael, 2001)
ABSTRACT

Introduction:

The work patterns of paramedics have not been well described. A limited number of studies describe their physical, occupational and physiological characteristics, primarily in simulation or laboratory settings. What has been well reported are high rates of injury and markers of illness and poor health status. In a unique approach to describing paramedic work patterns and their effect on health status, this study correlated biometric data of paramedics with their emergency call data. There were four aims. Firstly, to establish a descriptive profile examining the demographic, occupational physical activity (OPA), emergency call responses and physiological characteristics of paramedics. Secondly, to examine if health status, as assessed by BMI affects physiological response during calls. The final two aims were to investigate how (a) occupational tasks and (b) OPA characteristics affect physiological responses of paramedics while responding to emergency calls.

Methods

Participants were thirty-two paramedics employed by NSW Ambulance service. Paramedics wore a Hexoskin® biometric vest to continuously measure HR, RR, OPA, energy expenditure (EE) and steps over a series of shifts and for each emergency call attended. Data were compared between a) shift start (at rest), b) shift average and, c) during each epoch (Assign, Enroute, On Scene, To Hospital and At Hospital) of an emergency call. Participants self-reported exertion levels using the modified Borg Rating of Perceived Exertion Scale (RPE) and acquired their own blood pressure at shift start, after each call and at shift end. Call data (call type, Priority Code and chief complaint) provided by NSW Ambulance was combined with participant biometric data. Measures of health status including: BMI and waist-to-height ratio (WtHR) were
obtained and compared with age, gender, posting, level of certification, years of service, and shift type.

Results

Thirty-two paramedics (38.8 ± 8.8 yrs., 21 males 40.6 ± 8.9 yrs., 11 females 35.7 ± 7.4 yrs.) completed a total of 232 shifts (7.3 ± 2.1 shifts/paramedic). Paramedics completed a total transport to hospital of 3.3 ± 1.7 patients per shift (metropolitan 3.2 ± 1.7, regional 3.4 ± 1.7, p=0.29). Time (hrs) on all calls for each shift were 4.4 ± 2.4 hrs (metropolitan 5.0 ± 2.6, regional 3.9 ± 2.0 hrs, p<0.001, d=0.5). HR and RR increased significantly by Priority Code and by specific epoch (Assign and On Scene epoch). BP and RPE were not significantly different by Priority Code or Chief Complaint, but both measures increased significantly from shift start to shift end (p<0.01). Physical activity levels were classed as “Low” and steps per shift were below Australian recommended steps per day. Paramedics had significant changes in HR and RR by Priority Code, epoch, BMI, posting and type of shift.

Conclusion

Paramedics exhibit low levels of OPA that are consistent by posting and may be lower than estimated previously. This is confirmed through accelerometry, HR and EE. There is evidence of intermittent bouts of relatively isolated high levels of OPA. There is evidence that posting, BMI, priority code and epoch of call affect HR, RR and OPA.
INTRODUCTION

Part 1 Context of Paramedic Job Performance

Paramedics are mobile health care providers who travel to, assess, treat and transport patients in a variety of settings (O’Meara, 2012). Paramedics have high injury rates, high sick time and markers of poor health status (Kales et al., 2009; Maguire et al., 2014; Studnek et al., 2010). This may be due, in part, to the context of their work and occupational physical activity (OPA) patterns but has not been well studied. This includes the effect of, or linkages between the emergency call and paramedic physiological response to those calls. It is important to better quantify these responses in the context of paramedic OPA. This would allow for further investigation to determine how physiological response is linked to OPA.

The literature does not completely describe the role of paramedic, except, perhaps in its broadest terms. This may be due, in part to the varying nature of the occupation. For example, in Australia, a paramedic can be expected to work in a variety of locations ranging from metropolitan to regional settings. Further, there are many physical tasks and complex clinical skills the paramedic must be able to competently and efficiently perform, with no two emergency calls the same. Therefore, predicting paramedic performance is difficult.

At the paramedic service level, data on the work of paramedics are recorded and utilised by the services themselves (NSW Ambulance, 2015). Many services publish annual summaries of statistics such as call volume and response times (Killens, 2017; Lay, 2017). There are also publicly available performance measures, known as Key Performance Indicators (KPI), which focus on patient outcomes such as cardiac arrest survival and patient satisfaction (El Sayed, 2012; Koff, 2016).
While Australian paramedics respond to over 3 million calls annually (Australian Government Productivity Commission, 2017b), there is limited information on the physiological responses of these paramedics during calls. Given the varying nature of paramedic work, it is expected that it may influence the paramedic (e.g. shift work, call type and call severity) (Courtney et al., 2010; Karlsson et al., 2009). This was the motivation to conduct research in this area.

Calls cannot be planned and interspersed with time on calls can be long periods awaiting the next call (Coffey et al., 2016). During these sedentary periods, paramedics can describe the monotony and boredom waiting for the call phone to ring, followed by expedited movement to the ambulance (Aasa, Kalezic, Lyskov, Ångquist, & Barnekw-Bergkvist, 2006). These long waiting periods between calls are particularly true for paramedics working in regional areas (Peacock & Peacock, 2006). This unpredictability in calls can lead to low or irregular OPA patterns, with sudden high levels of OPA (for instance lifting a heavy patient off the floor) (Fischer, Sinden, & MacPhee, 2017). This could be a factor in the high rates of injuries in paramedics.

Anecdotally, paramedics report that the alarm tone signaling a pending call elicits a marked increase in their HR. The alarm going off, whether by phone, radio, or pager denotes a (usually) sudden and urgent response to an emergency (Hall et al., 2016). This physiological response to alarms by paramedics has been studied by Karlsson et al. (2009). They found a significant rise in HR in paramedics (n=20) unrelated to physical effort during the alarm and response (p< 0.05). This finding was regardless of experience, education or gender of the paramedic. Similar findings for firefighters (Kuorinka & Korhonen, 1981; Smith et al., 2014) and police officers (Orr, Wilson, Pope, & Hinton, 2016) suggests that this may be common to emergency responders. This repetitive physiological response, over time, may contribute to poor health (Valent et al., 2016).
An occupational stress response can be expected and perhaps even normal for paramedics (LeBlanc, 2009). However, when coupled with the deleterious effects of shift work including fatigue (Courtney et al., 2010; Takeyama et al., 2009), poor dietary habits (Anstey, Tweedie, & Lord, 2015; Hegg-Deloye et al., 2014), and an increased level of BMI in paramedics (Hegg-Deloye et al., 2015), there may be the potential for injury (Shantz, 2002) or illness such as cardiovascular disease (Sedrez et al., 2017). More research, particularly applied research on paramedics while responding to calls, is required.

Enumerating the types of responses and requisite health status and level of fitness is not well established for paramedics. The literature suggests that paramedic occupational tasks can elicit strong physiological demands, for example carrying a loaded stretcher or performing CPR (Barnekow-Bergkvist et al., 2004; Havel et al., 2008). Given the nature of paramedic work, it is difficult to predict the anticipated tasks, skills, and patient presentations that could be encountered during a shift. Therefore, the factors that could influence job performance such as patient injury or illness severity, type of response, and shift type should be explored.

An important component of paramedic work examined in the present study are physical activity patterns in relation to the overall demands of job performance and how this can impact the paramedic's physiological response to that work. In a nationwide study Canadian paramedic identified stretcher loading and unloading, carrying equipment and pushing and pulling the stretcher as the most physically demanding tasks (Coffey et al., 2016). Further, Chapman et al. (2012) established a physical fitness profile of male Western Australia paramedics (n= 29) indicating above normal levels of aerobic capacity, local muscular endurance and muscular strength.

The risk of serious injury for Australian paramedics is up to 7 times higher than the national average when compared to other occupations (Maguire
et al., 2014) and paramedics in NSW record higher levels of sick time compared with other health workers (Koff, 2016). This also appears to be the case internationally, where Welsh paramedics recorded sick time higher than any other healthcare group in 5 of the last 8 years (StatsWales, 2018). Injury causes are multifactorial and may be due, at least in part, to the low fitness levels, health status (for example BMI), and occupational tasks. Demands and tasks that have, as of yet, not been well measured.

The geographic distribution of paramedics working for NSW Ambulance is approximately equal between metropolitan and regional posts. It is important to examine if where the paramedic works (metropolitan or regional) affects health status. The data presented in Chapter 3 noted elevated BMI, particularly in regionally rostered males. This is consistent with other studies of paramedics (Buzga et al., 2015; Studnek et al., 2010) and highlights the need to investigate the effect on occupational task performance. Increased BMI has been associated with a rise in pulse rate, systolic and diastolic blood pressure, all implicated in the development of metabolic disorders (Martins, Tareen, Pan, & Norris, 2003). This may be the case with NSW Ambulance paramedics, requiring further research.

Part 2 Correlates of Paramedic Job Performance

The impact of OPA has on paramedic job performance in situ is important and has not, to date, been well studied. Heart rate, RR, BP, RPE and OPA are measures that can help describe the paramedic’s response to emergency calls. Biometric monitoring offers an opportunity to undertake that research. Biometric monitoring involves the digitization and recording of physiological responses including cardiorespiratory function, for instance, of HR and RR (Slamon, Penfil, Nadkarni, & Parker, 2018). Heart rate is a good indicator of activity intensity and, as a non-invasive physiological measure, it has been used on paramedics and firefighters.
in the laboratory environments and some workplaces (Barnard & Duncan, 1975; Bridgewater et al., 2000; Gamble et al., 1991; Goldstein et al., 1992; Kuorinka & Korhonen, 1981; Lucia et al., 1999). Respiratory functions (rate and volume) of emergency services providers have previously only been measured in laboratory settings only (Gamble et al., 1991; Kiss et al., 2014; Stamford, Weltman, Moffatt, & Fulco, 1978). However, new wearable instrumentation can now give accurate estimations of respiratory rate (Villar, Beltrame, Ku, & Hughson, 2013). Blood pressure is also a useful non-invasive physiological measure that has been applied in emergency services research including paramedics on shift (Goldstein et al., 1992).

The modified Borg Rate of Perceived Exertion (RPE) is another validated measure of exertion (Borg, 1982). It has been used in sports (Herman, Foster, Mahar, Mikat, & Porcari, 1996) and in police officers while performing occupational tasks (Schram, Hinton, Orr, Pope, & Norris, 2018). Although not reported in research with paramedics, it may be able to add insight into self-reported exertion levels of paramedics including how it may be linked to fatigue.

Application of devices such as accelerometers has previously been shown to be a valid and reliable tool for measuring OPA intensity (e.g. METs, step-count, cadence and g-force) among adults (Crouter, Churilla, & Bassett, 2006; Hart, Swartz, Cashin, & Strath, 2011; Hexoskin, 2017). Accelerometry, combined with HR and cadence, can also yield information on EE. Accelerometers have been employed in research in emergency services in studies of firefighters (Choi, Schnall, & Baker, 2012), and the military (Redmond et al., 2013; Simpson et al., 2013).

Using an observational methods approach as advocated by Salmon (2015), the present study explores paramedic task performance in a novel way. The data collection method captures the activities of participants when and where they are happening. Biometric monitoring
employed in this study yielded physiological data on a call-by-call basis. Further, these data were examined during the epochs of an emergency call (Assign, Enroute, On Scene, To Hospital and At Hospital) to examine if there are periods within a call when physiological demands are higher and if priority code, response code and patient’s chief complaint influenced the physiological responses measured.

Assessment of occupational physiological measures such as HR, RR and BP correlated with OPA, RPE and call data has not yet been conducted in research studies involving paramedics. Exploratory research has been conducted for police (Decker et al., 2016; Orr et al., 2016). Their research established a descriptive profile of police work and examined the physiological responses of police officers in situ. The researchers added the Computer Aided Dispatch data (type of call and all-time stamps) of the police emergency calls was merged with the officers’ physiological data, an approach that was undertaken in the present study.

These data can inform paramedic services, paramedics and researchers about the effect of occupational tasks by providing an understanding of the context of paramedic job performance and how that performance affects the paramedic physiologically. Thus, the aims of this study were:

Aims

- To establish and compare the descriptive profiles of two distinct groups of NSW Ambulance paramedics (metropolitan and regional rostered paramedics), using objective and self-reported measures of (1) demographic characteristics (2) occupational physical activity, (3) emergency call response characteristics, and (4) physiological responses.
• To examine if BMI by category (underweight, normal weight, overweight and obese) affects physiological responses of paramedics (HR: at shift start, shift average, call average, %HR_{max} and MAP).

• To examine how variables of emergency call responses (call priority, time on calls, time on all calls, calls/shift, transports/shift, RPE) affects physiological responses of paramedics (HR, RR, and MAP).

• To examine how variables of occupational physical activity (g-force at shift start, shift average, call average, call maximum, and steps per shift affects physiological responses of paramedics (HR, RR, MAP).

Hypotheses

1. Demographic characteristics, occupational physical activity, emergency call response characteristics and physiological responses will differ by posting (metropolitan and regional).

2. BMI in the WHO categories of Overweight and Obese will elicit a higher physiological response of paramedics compared to Normal and Underweight categories (HR: at shift start, shift average, call average, %HR_{max} and MAP).

3. Variables of emergency call responses (higher call priority, more serious chief complaint, increased time on calls, increased time on all calls, increasing calls and transports/shift, and increasing RPE) will elicit stronger physiological responses in paramedics (HR, RR).
4. Variables of occupational physical activity (higher g-forces at: shift start, shift average, call average, call maximum, and steps/shift) will elicit stronger physiological responses of paramedics (HR, RR).

METHODOLOGY

Study Design

Following the methodology for an observational study (Casadevall & Fang, 2008; Salmon, 2015), the experimental design consisted of a prospective field study of paramedics employed by NSW Ambulance with biometric and other data collected during their scheduled shifts. Paramedics were categorised as either a) metropolitan rostered or b) regional rostered based on NSW Ambulance operational guidelines (See Chapter 1 Section 1.1.6). For metropolitan paramedics, data was collected over a total of up to 8 shifts, and for regional paramedics, a total of up to 12 shifts (each shift is 12 hours in length). Shift rotation varied by posting and did include both day and night shifts.

Because analysis of previous call data revealed a lower number of emergency calls per shift for regional paramedics, more shifts were proposed to allow an equal number of emergency calls to be compared between regional and metropolitan postings. Sampling was based on an equal representation (50:50) from metropolitan and regional stations. This also reflected the demographics by gender and level of certification to reflect rostering of current workforce as described by NSW Ambulance (High, 2015).

Participants

Twenty eight paramedics (14 male and 14 female) were initially enrolled but due to a high level of interest was later increased to 32. Sample size was determined by conducting an a priori power analysis using G*Power (Version 3.1, University of Dusseldorf, Germany) (Faul, Erdfelder, Lang, 169
Effect size was set at 0.3, alpha was set at 0.05 and the power was 1 - alpha = 0.95, yielding a sample size of 27. Due to a potential participant dropout, a minimum sample size was set at 28.

Inclusion and exclusion criteria for participants are outlined in Table 5.1. Each paramedic was required to have access to a computer and a reliable internet connection for uploading data from the Hexoskin® data pack after each shift. NSW Ambulance provided this access allowing the paramedic station computer to be utilised. Informed consent was obtained from all participants and they could withdraw at any time from the study.

**Table 5.1**
Summary of Participant Inclusion/Exclusion Criteria

<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routinely responding to emergency calls</td>
<td>Management, Control Centre or other support staff who do not routinely respond to emergency calls</td>
</tr>
<tr>
<td>Rostered <em>either</em> Metropolitan or Regional</td>
<td>Not on a rotating or fixed shift schedule</td>
</tr>
<tr>
<td>Access to computer and reliable internet connection</td>
<td>Currently prescribed any heart rate limiting medications including beta blockers and/or calcium channel blockers</td>
</tr>
<tr>
<td>Any level of certification</td>
<td>Gravid females</td>
</tr>
<tr>
<td></td>
<td>Riding as a “third” member of the ambulance crew or as a solo responder</td>
</tr>
<tr>
<td></td>
<td>Precepting a student or other staff member</td>
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<tr>
<td></td>
<td>Returning from a musculoskeletal injury within the last six months, or on any return to work program</td>
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</tbody>
</table>
Ethical approval for the study was obtained prior to the study beginning from Southeast Sydney Local Health District (HREC reference number: 15/328 (HREC/15/POWH/584)) and from Charles Sturt University Human Research Ethics Committee (HREC) protocol number H16076.

Procedure

Potential participants from NSW Ambulance (n=3,302) received information about the present study while completing a survey on health status and physical activity levels (described in Chapter 3) utilising their corporate email account. Those interested in participating were asked to contact the researcher. A convenience sample was selected based on the identified inclusion and exclusion criteria (Table 5.1).

Participants were asked to report their height (cm), weight (kg), waist circumference (cm), age (years) and posting. As well they reported, level of certification, years of service (in total) as a paramedic and years of service at their most recent level of certification.

Participants were then oriented to the project by the researcher. Participants received a package with equipment and logbook and were then familiarized with the Hexoskin® shirt (Carre Technologies, Montreal, PQ, Canada), data pack and USB cable, iHealth wrist blood pressure monitor (iHealth, Pomona, California), spray bottle and log book.

For each shift, the Hexoskin® was donned just prior to the beginning of each shift and the participant was to sit quietly for a five-minute period to establish baseline HR, RR and OPA level. At the end of the five minutes, BP and RPE were self-acquired and entered in the logbook (see Appendix 3).

Blood pressure was measured using the wrist BP cuff (iHealth, Pomona, California) at shift start, shift end and immediately after each call was completed. The call completion was defined as when the patient was
transferred to a receiving facility or patient contact had ended. Participants recorded their RPE at the same time points during the shift using the modified Borg RPE scale (Borg, 1982) in the logbook (see Appendix 2).

Hexoskin data were uploaded to a secure website after each shift by the participant. This also charged the data pack for the next shift. The stored data were downloaded as binary data files to a folder on a secure hard drive on the researcher's computer after each shift.

Hexoskin® data were imported into Vivosense (Vivonoetics, San Diego, USA) to be combined with CAD data for analysis. The CAD data was sourced from NSW Ambulance CAD database and consisted of the Priority Code (P1 - 9), Response Code (1A, 1B, 1C), Chief Complaint and time stamps for each call epoch.

Data Analysis

Data were inspected visually and statistically for normality prior to analysis and are presented in tables as mean ± standard deviation and graphically as means and 95% Confidence Intervals. A Pearson Chi-square test of Independence was performed to establish the representativeness of the study participants (n= 32) compared to the NSW Ambulance population (n= 3,302) based on gender and posting.

Differences within each participant were calculated and descriptive statistics and repeated measures ANOVA was used to compare differences in HR, RR, BP, OPA and RPE. These measures were compared between a) at rest - shift start b) average for the entire shift and c) during each call including by call epoch. This was employed where the requirements for parametric tests were met. Significance was accepted at p< 0.05. Associations between physiological demands (HR, RR, BP, PA and RPE were determined using Pearson Product Moment correlational coefficients. A linear mixed model was fitted to examine the
effect of each independent variable on the dependent variables. All statistical analysis was conducted using SPSS statistical analysis software (IBM Corp. Version 24.0, Armonk, NY, USA). A summary of statistical tests is found in Table 5.2.

**Table 5.2**

Summary of statistical tests

<table>
<thead>
<tr>
<th>Statistical measure or test</th>
<th>Model Assumptions</th>
<th>NSW Ambulance (n=3,302)</th>
<th>Study participants (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi Square test of independence</td>
<td>The value of the expected should be 5 or more in 80% of the cells and no cell should have an expected value of less than one.</td>
<td>Overall gender and posting NSW Ambulance compared to study participants (Hypothesis Test 1)</td>
<td></td>
</tr>
<tr>
<td>ANOVA</td>
<td>Each group is drawn from a normally distributed population. All groups have a common variance. All samples are drawn independently of each other. Residuals are normally distributed.</td>
<td>Time on Call, by shift type and posting, WtHR, MAP and BMI by Gender, Posting (Model A)</td>
<td></td>
</tr>
<tr>
<td>ANOVA with Tukey HSD</td>
<td>As above</td>
<td>WtHR, BMI by level of certification (Model B)</td>
<td></td>
</tr>
<tr>
<td>Pearson Population Correlation Hypothesis Test</td>
<td>Sample data is normally distributed.</td>
<td>Years of Service and BMI, WtHR and BMI (Hypothesis Test 2)</td>
<td></td>
</tr>
<tr>
<td>Paired Samples t-test</td>
<td>Each group is drawn from a normally distributed population. All groups have a common variance. All samples are drawn independently of each other. Residuals are normally distributed.</td>
<td>MAP, RPE end to start of shift (Model E)</td>
<td></td>
</tr>
<tr>
<td>Pearson Chi Square test of independence</td>
<td>The value of the expected should be 5 or more in 80% of the cells and no cell should have an expected value of less than one.</td>
<td>Priority Code and Shift Type and Response Code (Hypothesis Test 3)</td>
<td></td>
</tr>
<tr>
<td>Simple Linear Regression</td>
<td>The residuals are independent. There is normal distribution of residuals and there will be equal variance of residuals.</td>
<td>Age with BMI (Model C)</td>
<td></td>
</tr>
<tr>
<td>Linear Mixed Effect Model</td>
<td>The explanatory variables are related linearly to the response. The errors have constant variance, are independent and normally distributed.</td>
<td>(Model D)</td>
<td></td>
</tr>
</tbody>
</table>

Note: The assumptions of the model are met unless otherwise notified.
Body Mass Index (BMI) was calculated using the formula BMI = bodyweight (kg)/standing height (m$^2$) from participant self-reported height and weight. To display trends, BMI data were categorised into World Health Organisation classes using as the guidelines: Class 1 (Underweight) 18.5 kg/m$^2$ <, Class 2 (Normal Weight) 18.5-24.9 kg/m$^2$, Class 3 (Overweight) 25.0-29.9 kg/m$^2$, and Class 4 (Obese) >30.0 kg/m$^2$ (Grobschadl et al., 2011). Waist-to-Height ratio (WtHR) was calculated using the formula: waist measurement (cm)/height (cm) (Ashwell & Gibson, 2016). Waist measurements were self-reported by participants.

Maximum heart rate (HR$_{max}$) for each participant was calculated using the formula: HR$_{max}$ = 208 - 0.7(age) as proposed by Tanaka, Monahan, and Seals (2001).

Vivosense calculated average, minimum and maximum HR, RR and g-force for each participant by: call epoch (Assign, Enroute, On Scene, Enroute to Hospital, At Hospital) and total call. Hexoskin® software calculated summary shift data (average, maximum and minimum HR, RR, and OPA), total steps, and EE. See Figure 5.1.

Blood pressure was to be acquired using the iHealth (iHealth, Pomona, CA) wrist blood pressure cuff. The first participant reported an inability to acquire reliable blood pressure readings, so a decision was made to use either the paramedic's blood pressure cuff or the cuff in the receiving Emergency Department. All blood pressures were converted from systolic and diastolic to Mean Arterial Pressure (MAP) using the formula: Mean Arterial Pressure (MAP) = 1/3 x Systolic Blood Pressure + 2/3 Diastolic Blood Pressure. Normal ranges for MAP are from 70 – 100 mmHg (Kandu, Biswas, & Das, 2017).

Accelerometer signals were expressed relative to gravitational acceleration (g-force). The 3 axis signals were combined by taking the root of the summed squared values ($x^2+y^2+z^2$) to generate one acceleration vector indicating activity levels (Hexoskin, 2017). Values for
g-force were established from previous studies and are as follows: 0 ≤ Very Low < 0.1g, 0.1 ≤ Low < 0.3g, 0.3 ≤ Moderate < 0.6g, 0.6 ≤ High < 1, 1 ≤ Very High ≤ 16g (Barker & Mercer, 2017; Speckhard, Knous, & Coughlin, 2017; Wilkes et al., 2017).

Hexoskin® calculated steps and reported every step at 1 Hz. Energy expenditure was calculated using the formula \[ [(0.6HR_{\text{max}}-HR) \times (0.6HR_{\text{rest}}-HR_{\text{res}}) \times \text{Mifflin equation}] + [(HR-HR_{\text{res}}) \times (0.6HR_{\text{rest}}-HR_{\text{res}}) \times \text{Keytel equation}] \]. Energy expenditure was expressed in kilocalories (Hexoskin, 2017). The Mifflin equation calculates Basal Metabolic Rate (BMR) using participant weight, height, age and a gender based constant (Cancello et al., 2018).

Effect sizes (d) were calculated according to Cohen (1988) and interpreted with the following thresholds: Trivial (0 - 0.19), Small (0.20 to 0.49), Medium (0.50 - 0.79), and Large (d ≥ 0.80) for comparisons between two means.
Figure 5.1 Screenshot of one paramedic’s shift, with calls merged and epochs marked.
RESULTS

Part 1 Context of Paramedic Job Performance

5.0 Representativeness of the Sample

The results of Pearson Chi-square test of Independence (Hypothesis Test 1) showed the overall proportion of study participants were not significantly different than the NSW Ambulance population by gender ($\chi^2 0.03$, df 1, $p=0.86$, CI -0.01, 0.01) or by posting ($\chi^2 0.41$, df 1, $p=0.52$, CI -0.004, 0.001).

5.1 Paramedic Demographic, Occupational Physical Activity, Emergency Call Response Characteristics and Physiological Responses

5.1.1 Paramedic Descriptive Profile

Demographic characteristics

Demographic characteristics for all paramedics and by posting are reported in Table 5.3 by posting and for all paramedics. P values and effect sizes indicate differences between metropolitan and regional paramedics. Note the significant differences (in bold) between paramedics for BMI and WtHR.
Table 5.3
Demographic Characteristics of Paramedics.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Metropolitan (n=16) Mean (SD)</th>
<th>Regional (n=16) Mean (SD)</th>
<th>All Paramedics (n=32) Mean (SD)</th>
<th>p value</th>
<th>Effect Size d=</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years of service</td>
<td>11.1 (7.4)</td>
<td>11.6 (6.7)</td>
<td>11.3 (6.9)</td>
<td>0.85</td>
<td>0.06</td>
</tr>
<tr>
<td>Age (years)</td>
<td>35.6 (10.1)</td>
<td>41.0 (6.7)</td>
<td>38.3 (8.9)</td>
<td>0.08</td>
<td>0.65</td>
</tr>
<tr>
<td>Years at current level</td>
<td>4.5 (4.0)</td>
<td>7.8 (6.6)</td>
<td>6.2 (5.6)</td>
<td>0.09</td>
<td>0.27</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.8 (3.1)</td>
<td>28.8 (4.9)</td>
<td>26.8 (4.6)</td>
<td><strong>0.01</strong></td>
<td>0.98</td>
</tr>
<tr>
<td>WtHR</td>
<td>0.48 (0.04)</td>
<td>0.56 (0.08)</td>
<td>0.52 (0.07)</td>
<td><strong>0.01</strong></td>
<td>2</td>
</tr>
</tbody>
</table>

Note the significant differences (in bold) between paramedics for BMI and WtHR.

5.1.2 Paramedic Descriptive Profile
Occupational Physical Activity Characteristics

Paramedic OPA characteristics are reported in Table 5.4 by posting and for all paramedics.
Table 5.4
Occupational Physical Activity of Paramedics.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Metropolitan (n=16)</th>
<th>Regional (n=16)</th>
<th>All Paramedics (n=32)</th>
<th>p value</th>
<th>Effect size d=</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPA (g-force)/shift</td>
<td>0.06 (0.01)</td>
<td>0.11 (0.21)</td>
<td>0.09 (0.15)</td>
<td><strong>0.003</strong></td>
<td>0.25</td>
</tr>
<tr>
<td>OPA Max (g-force)/shift</td>
<td>0.97 (0.24)</td>
<td>1.01 (0.25)</td>
<td>0.99 (0.24)</td>
<td>0.19</td>
<td>4</td>
</tr>
<tr>
<td>OPA (g-force)/call</td>
<td>0.11 (0.07)</td>
<td>0.12 (0.07)</td>
<td>0.11 (0.07)</td>
<td><strong>0.001</strong></td>
<td>0.14</td>
</tr>
<tr>
<td>OPA Max (g-force)/call</td>
<td>0.34 (0.06)</td>
<td>0.38 (0.15)</td>
<td>0.36 (0.12)</td>
<td>&lt;0.001</td>
<td>0.4</td>
</tr>
<tr>
<td>Steps/shift</td>
<td>4229.8 (1560.1)</td>
<td>4469.1 (1549.2)</td>
<td>4367.5 (1555.0)</td>
<td>0.24</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Note: p values and effect sizes indicate differences between metropolitan and regional paramedics. Note the significant differences (in bold) between paramedics for OPA.

Ranges of PA as expressed in g-force are as follows: Very Low 0 - 0.1g, Low 0.1 - 0.3g, Moderate 0.3 - 0.6g, High 0.6 - 1g and Very High 1 - 16g.

OPA for all paramedics are presented as g-force (g) with the mean and maximum g-force by shift and call periods presented in Figure 5.2.
Figure 5.2. The average and maximum g-force values with means for shift and calls. Error bars represent standard deviation. Data expressed in g-force (g). Overall, OPA is very low to low. Error bars represent SD.

Occupational Physical Activity by Call Epoch: Paramedics attend calls that have five distinct and separate epochs; Assign, Enroute, On Scene, To Hospital and At Hospital. Note that calls could be cancelled, or paramedics re-routed to another call during either of the first two epochs and call could also be cancelled at the On Scene phase if the patient did not meet transport criteria.

Average g-force by epoch were recorded by posting. See Figure 5.3
Figure 5.3. Mean g-force by call epoch with 95% CI by posting and for all paramedics. There were significantly higher OPA in the Assign and On Scene epochs (* # p< 0.002). There was no significant difference in g-force production by epoch between metropolitan and regional paramedics. Error bars represent 95% CI.

OPA by Call Priority: There was no significant difference in mean g-force by Priority Code or by Chief Complaint by posting.
5.1.3 Paramedic Descriptive Profile

Emergency Call Response Characteristics

Emergency call response characteristics were reported for all paramedics and by posting and are presented in Table 5.5.

Table 5.5
Emergency Call Response Characteristics of Paramedics. P values and effect sizes indicate differences between metropolitan and regional paramedics.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Metropolitan (n=100) Mean (SD)</th>
<th>Regional (n=132) Mean (SD)</th>
<th>All Paramedics (n=232) Mean (SD)</th>
<th>p value</th>
<th>Effect size d=</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time on each call (hours)</td>
<td>1.1 (0.6)</td>
<td>1.1 (0.7)</td>
<td>1.1 (0.6)</td>
<td>0.74</td>
<td>0.3</td>
</tr>
<tr>
<td>Time on all calls/shift (hours)</td>
<td>5.0 (2.6)</td>
<td>3.9 (2.0)</td>
<td>4.4 (2.4)</td>
<td>&lt;0.001</td>
<td>0.5</td>
</tr>
<tr>
<td>Calls/shift</td>
<td>5.3 (1.62)</td>
<td>4.5 (2.1)</td>
<td>4.9 (1.9)</td>
<td>&lt;0.001</td>
<td>0.45</td>
</tr>
<tr>
<td>Transports/shift</td>
<td>3.2 (1.7)</td>
<td>3.3 (1.69)</td>
<td>3.3 (1.8)</td>
<td>0.29</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Note: n = number of shifts. The p value indicates significant difference between postings (in bold). Of the 232 shifts included in the present study, only 4 shifts recorded no emergency calls.
Emergency Call Demographics— In total, paramedics responded to 918 emergency calls.

Calls by Priority Code and posting are shown in Figure 5.4. There was a significant difference in Priority Code responses by posting ($\chi^2$ 70.98, df 7, p< 0.001). Post hoc analysis revealed that metropolitan paramedics responded to more Priority 1 calls (* p< 0.001) and regional paramedics responded to more Priority 4-9 calls (p< 0.001). See Figure 5.4.

![Figure 5.4](image)

**Figure 5.4.** The percentage of calls by Priority Code carried out by metropolitan and regional paramedics. Note that regional paramedics completed a higher percentage of lower priority calls than metropolitan paramedics and this may be due to fewer non-emergency transport services outside metropolitan areas.

Calls by Response Code - An alpha-numeric Response Code further delineates the severity of call. Priority 1 calls are coded 1A, 1B and 1C. All cardiac arrest calls and ineffective breathing were coded 1A and elicits the highest level of response (lights and siren response).
Of all calls, 2% (n=20) were 1A of which 17 were confirmed cardiac arrests. Patients with life threatening illness are coded 1B. Three percent (n=20) of all calls were 1B. Patients who were ill and would deteriorate quickly were classed as 1C. Overall, 49% (n= 451) of all calls were 1C.

Emergency Calls by Chief Complaint - Chief complaint is a concise statement describing the symptom or problem. All Priority 1 calls were categorised by Chief Complaint and yielded the following (by frequency): Chest Pain, Difficulty Breathing, Altered Mental Status, Traumatic Injury, Motor Vehicle Accident, Stroke, Interfacility transport, Overdose, Seizure, Cardiac Arrest and Emergency Childbirth. See Figure 5.5.

![Figure 5.5: Priority 1 calls by Chief Complaint. The majority of calls attended were Chest Pain, Difficulty Breathing and Altered Mental Status.](image-url)
Paramedic total time on calls (defined as cumulative time either Assigned, Enroute, On Scene, To Hospital or At Hospital) as a percentage of each 12-hour shift were examined for all paramedics and by posting. See Figure 5.6.

Figure 5.6. The percentage of each 12 hour shift spent on calls. By posting, metropolitan paramedics spent a larger percentage of each shift engaged in patient care. (*) indicates statistical significance (p< 0.01). Error bars represent 95% CI.
Paramedic time on calls by epoch were examined for each posting. See Figure 5.7.

**Figure 5.7** The average time (min) that paramedics spent during each call epoch by posting. Total average time on each call was 82.9 ± 37.3 minutes. By posting, time on each call was not significantly different. Error bars represent 95% CI.
5.1.4 Paramedic Descriptive Profile

Physiological Responses

Physiological responses were recorded for paramedics during each shift and are presented in Table 5.6.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Metropolitan (n=104) Mean (SD)</th>
<th>Regional (n=128) Mean (SD)</th>
<th>All Paramedics (n=232) Mean (SD)</th>
<th>p value</th>
<th>Effect size d=</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR shift average bpm</td>
<td>80.8 (10.7)</td>
<td>80.4 (10.1)</td>
<td>80.6 (10.3)</td>
<td>0.95</td>
<td>0.04</td>
</tr>
<tr>
<td>HR call average bpm</td>
<td>75.5 (15.4)</td>
<td>76.8 (17.5)</td>
<td>76.1 (16.3)</td>
<td>0.33</td>
<td>0.08</td>
</tr>
<tr>
<td>HRMax average/call bpm</td>
<td>86.4 (14.3)</td>
<td>88.3 (16.1)</td>
<td>87.3 (15.2)</td>
<td><strong>0.02</strong></td>
<td>0.13</td>
</tr>
<tr>
<td>%HRmax</td>
<td>46.8 (8.9)</td>
<td>47.5 (9.3)</td>
<td>47.2 (9.1)</td>
<td>0.21</td>
<td>0.12</td>
</tr>
<tr>
<td>RR shift average</td>
<td>14.3 (2.7)</td>
<td>14.9 (3.6)</td>
<td>14.6 (3.3)</td>
<td>0.09</td>
<td>0.23</td>
</tr>
<tr>
<td>RR average/call</td>
<td>20.3 (6.3)</td>
<td>22.3 (5.5)</td>
<td>21.20 (5.9)</td>
<td><strong>0.001</strong></td>
<td>0.3</td>
</tr>
<tr>
<td>EE/hr kcal</td>
<td>185.8 (110.7)</td>
<td>191.5 (95.5)</td>
<td>189.1 (102.1)</td>
<td>0.67</td>
<td>0.06</td>
</tr>
<tr>
<td>MAP (end-start)</td>
<td>1.3 (7.3)</td>
<td>0.7 (10.3)</td>
<td>0.9 (9.1)</td>
<td>0.66</td>
<td>0.07</td>
</tr>
<tr>
<td>RPE (end-start)</td>
<td>0.5 (0.9)</td>
<td>0.4 (0.8)</td>
<td>0.4 (0.9)</td>
<td>0.31</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Note: Significant differences between postings in **bold**. HRMax/call, RR average/call and RRMax/call were all significantly different.
Mean HR and RR were measured for each epoch (all calls) and presented by posting. See Figure 5.8.

**Figure 5.8** The mean HR and RR by posting with significantly higher HR in Enroute, To Hospital and At Hospital (* p< 0.05) and RR in Assign and Enroute epochs for regional paramedics compared to metropolitan (# p< 0.05). Error bars represent 95% CI.
5.2 BMI and Physiological Response

The influence of BMI on physiological responses is presented in Table 5.7. There was a total of 1 paramedic in Category 1 (Underweight), 9 paramedics in Category 2 (Normal Weight), 13 paramedics in Category 3 (Overweight) and 9 paramedics in Category 4 (Obese).

5.2.1 Paramedic Descriptive Profile

**Health Status and Physiological Response**

**Table 5.7**

Paramedic HR and MAP (mean and SD) by BMI Category

<table>
<thead>
<tr>
<th>BMI category</th>
<th>1 Underweight</th>
<th>2 Normal</th>
<th>3 Overweight</th>
<th>4 Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean HR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shift Start</td>
<td>69.6 (5.0) b</td>
<td>72.2 (14.6) b</td>
<td>74.6 (11.4) a,b</td>
<td>78.3 (11.6) a</td>
</tr>
<tr>
<td>(n=232)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean HR</td>
<td>70.9 (4.4) a</td>
<td>79.2 (12.1) a,b</td>
<td>80.0 (7.4) b,c</td>
<td>83.8 (11.4) c</td>
</tr>
<tr>
<td>Total Shift</td>
<td>(n=232)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean HR</td>
<td>70.4 (6.7)</td>
<td>73.2 (17.3)</td>
<td>74.8 (13.9)</td>
<td>81.7 (17.6)</td>
</tr>
<tr>
<td>All Calls</td>
<td><em>(n=918)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% HR\text{max}</td>
<td>46.7 (41)</td>
<td>44.8 (9.7)</td>
<td>47.6 (8.9)</td>
<td>49.3 (8.5)</td>
</tr>
<tr>
<td>All Calls</td>
<td><em>(n=918)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shift Start</td>
<td>81.2 (5.8) a</td>
<td>91.6 (13.2) a,b</td>
<td>93.4 (10.7) b</td>
<td>101.2 (11.9) c</td>
</tr>
<tr>
<td>(n=232)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAP</td>
<td>86.2 (4.7) a</td>
<td>91.5 (12.8) a,b</td>
<td>94.2 (9.2) a</td>
<td>102.6 (10.4) c</td>
</tr>
<tr>
<td>Shift End</td>
<td>(n=232)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** (*) indicates significant differences main effect only. Letters in each column that are different indicate significant differences in post-hoc analysis (a, b, c, d).
Part 2 Correlates of Paramedic Job Performance

5.3 Paramedic Emergency Call Response, Occupational Physical Activity, and Physiological Interactions

5.3.1 Effect of Emergency Call Response Characteristics

**Heart Rate Response**

A Linear Mixed Model was fitted to examine the effect of the demographic and emergency call characteristics of paramedics on the dependant variables of each paramedic: HR difference from shift start (bpm) and HR difference from shift start maximal (bpm). Only variables with significant differences and significant interactions with HR are presented in the following graphs of predicted means with 95% CI.
The effect of Priority Code was examined in relation to maximum heart rate attained during calls and is graphed in Figure 5.9. There were differences in maximum HR response compared to shift start with elevated HR response for higher priority calls.

**Figure 5.9** A significant difference between maximum HR response (BPM) by Priority Code. Higher priority calls elicited a significantly higher HR response. Priority codes with the same letter are not significantly different (a, b). All others are significantly different (p<0.001).
The effect of BMI and Priority Code on HR response is graphed in Figure 5.10. Priority 1 calls had no significant difference based on BMI, however, with Priority 2, Priority 3 and Priority 4-9, paramedics exhibited significantly higher maximal HR with increasing BMI.

**Figure 5.10** The significant effect of BMI and priority of call on the difference in HR maximal response from HR at Shift Start (red line). Predicted means and 95% CI (shaded area) are graphed.
The effect of BMI on maximal HR response by epoch is graphed in Figure 5.11. There were significant differences in maximal HR response difference from shift start based on BMI, especially the To Hospital and At Hospital epochs.

**Figure 5.11** The significant effect of BMI (all calls pooled) on maximal HR response compared to Shift Start HR (red line) by epoch. Predicted means and 95% CI (shaded area) are graphed.
5.3.2 Effect of Emergency Call Response

Respiratory rate

A Linear Mixed Model was fitted to examine the effect of the demographic and occupational task characteristics of paramedics on the dependant variable of RR difference from shift start. Only variables with significant differences and significant interactions with RR difference are presented as graphs of predicted means with 95% CI.
There were significant differences in RR difference from shift start by BMI and epoch shown in Figure 5.12. With increasing BMI there was a significant increase in RR compared to shift start in all call epochs except the Assign phase.

Figure 5.12 The significant effect of BMI and epoch on RR compared to RR at Shift Start (red line). Predicted means and 95% CI (shaded area) are graphed.
5.4 Effect of Occupational Physical Activity

5.4.1 Effect of Occupational Physical Activity

**OPA by age and epoch**

A Linear Mixed Model was fitted to examine the effect of the variables on the dependant variable of g-force Difference from Shift Start. Only variables with significant differences and significant interactions with g-force difference from shift start are presented. There was a significant effect of age and epoch on g-force shown in Figure 5.13.

![Graph showing the effect of age and epoch on g-force](image)

**Figure 5.13.** The significant effect of age and epoch on g-force compared to g-force at shift start (red line). Means and 95% CI (shaded area) are graphed.
5.4.2 Effect of Occupational Physical Activity
OPA by age, BMI and epoch

There was a significant effect of age, BMI and epoch on g-force difference from shift start as shown in Figure 5.14. With increasing BMI and increasing age, there was a decrease in g-force by epoch.

**Figure 5.14.** The significant effect of BMI, epoch and age in g-force production compared to g-force production at shift start (red line). Means and 95% CI (shaded area) are graphed.
DISCUSSION

The key findings from this study fall in two main areas: A descriptive profile including demographics, OPA, emergency call response characteristics and physiological responses were identified and quantified including the influence of BMI on HR, RR and MAP. Secondly, the effects of health status (BMI), posting, age, Priority Code and call epoch on paramedic occupational tasks was demonstrated.

The four hypotheses and findings associated with each are as follows:

Part 1 Context of Paramedic Job Performance

Hypothesis 1 – Descriptive Profiles of Metropolitan and Regional Paramedics

Demographic characteristics, occupational physical activity, emergency call response characteristics and physiological responses will differ by posting (metropolitan and regional)

The hypothesis is partly supported.

Demographics Characteristics
Age and Years of Service - By posting, the paramedics in this study had similar age, years of service, and gender distribution as the sample reported on in Chapter 3 (n=747) and NSW Ambulance human resource data (n=3,302) as presented by High (2015).

The demographic data illustrates a workforce not yet mid-career. There is a paucity of data on the age distribution in paramedic services to comment if other paramedic services have a similar age/years of service distribution. Currently in Australia, over 77% of paramedics are under the age of 50, and in NSW, that number in 2017 was 73% (Australian Government Productivity Commission, 2017a). Age distribution for paramedics contrasts with other healthcare providers such as nursing, with recent data suggesting that only 63.2% of nurses are under 50. The
ramification is that NSW Ambulance paramedics have higher levels of sick time and more claims for injuries than NSW nurses, even though the paramedic workforce are younger from a demographic point of view. If sick time is this high now for NSW Ambulance paramedics, it can very well increase as they progress through their career. This is based on the current reporting of 165/1,000 injury claims versus 25/1,000 injury claims for nurses coupled with the reported median age of 45 (IQR 35-53) for all claimants (Gray & Collie, 2016). Yet the greatest risk group for a claim for ambulance officers was those aged 35-44 years (Gray & Collie, 2017).

Occupational Physical Activity

Occupational Physical activity (OPA) included measures of g-force production and step count (Table 5.4). The overall OPA for most periods of a paramedic shift (average OPA by shift and by call) was classified in the “Very Low” to “Low” categories. This OPA level in the present study is comparable to a US study that noted low OPA in the “protective services” (fire, police and paramedics) category (Steeves et al., 2005). As well, the higher shift OPA scores for regional paramedics may be due to a lower percentage of each shift engaged in patient care, meaning less time travelling to and from calls. This is supported by a slightly higher (although non-significant) step count for the regional paramedics.

The step count for all paramedics (4367.5 ± 1555.1 step/shift) indicate that they would meet the recommendation of 10,000 steps each day during their 12-hour shift (Brown, Bauman, Bull, & Burton, 2012). The 10,000 steps per day exceeds the WHO Global Strategy on Physical Health, Diet and Activity recommendations of 150 minutes of moderate physical activity per week (Hallam, Bilsborough, & de Courten, 2018). Paramedics unable to meet this step goal reflects spending significant periods of time in a 12-hour shift engaged in patient care (32% regionally and 42% metropolitan). Because of the mobile nature of their work driving to calls means they are sitting for a significant portion of their shift.
Interestingly, the regional paramedics are more active (step count) while on shift, but also report significantly higher levels of BMI and WtHR than metropolitan paramedics. These higher health status measures are concerning, given the effect of living and working regionally in Australia is associated with higher levels of being overweight or obese (Cameron et al., 2003; National Rural Health Alliance, 2013) and this appears to be the case with the regional paramedics in the present study and the paramedics surveyed in Chapter 3.

Emergency Call Response Characteristics
Patient contacts - Although metropolitan paramedics have a significantly higher call volume per shift, paramedics in both postings transport a similar number of patients (Table 5.5). The London Ambulance Service (LAS), reports a slightly higher number: 3-6 patient transports (mean 4.37) per 12-hour shift (Rizwan, 2018). This suggests that the call volume and transports are similar to at least one other paramedic service of similar size. Understanding that, given current staffing models, this frequency of calls attended are not likely to change.

Patient Care Delivery - Common UHU rates in paramedic services ranging from .01 - .15/hour (Low) to .45 - .55/hour (High) (Brismar et al., 1984; Smiley & Smiley, 2008) would infer that metropolitan paramedics work at “above average” UHU (approximately 42% of shift engaged in patient treatment and transport) and regional paramedics in the “average” UHU (approximately 32%) (Figure 5.5). Because this measure is published and available for only a small number of paramedic services it is difficult to determine the implications. Prior to the present study, there appears to be no research on the effect of UHU levels on paramedic job performance.

Call Completion - Overall, calls took 82 minutes, on average to complete from the Assign through to the end of the At Hospital epoch, with no significant difference by posting. London Ambulance Service reports
similar call completion times: an 89-minute call completion time for “Blue Calls” (the equivalent of a Priority 1) and 81 minute completion time for all other calls (Rizwan, 2018). It is important to understand the amount of time on each shift that is engaged directly in patient care.

The present results show that less than half of a 12-hour shift engaged directly in patient care (Figure 5.8). From this, examination of the balance of the paramedic’s shift from an OPA point of view is warranted. This is needed to better understand the OPA patterns within and between calls. The OPA levels noted during patient care periods, average shift OPA, as well as step count indicate paramedics have a low activity level (including time in ambulances on mobile deployment). The link between low OPA and increasing BMI has been reported (Singer et al., 2016). Low OPA may be a contributor to the higher levels of BMI in paramedics and risk factors of poor health such as hypertension (Buzga et al., 2015; Hegg-Deloye et al., 2015; Kales et al., 2009).

Priority Code - Metropolitan paramedics responded to a significantly higher percentage of Priority 1 calls and a similar percentage of Priority 2 calls compared to regional paramedics (Figure 5.4). Regional paramedics had a greater percentage of lower priority calls (P4-9) than metropolitan paramedics. Regionally, this may be due a noted underuse of ambulance transport serious medical problems with alternative methods of Emergency Department arrival prevalent (Reed & Bendall, 2015). The number and how often paramedics are responding to high acuity calls is important to quantify in terms of understanding occupational stress associated with these calls.

Priority 1 calls by Chief Complaint - Study data (Figure 5.5) also indicate that the Priority 1 call types are very similar in distribution by posting in terms of Chief Complaint (most frequent: Chest Pain, Shortness of Breath and Altered Mental Status). This appears to be consistent with data from the Bureau of Health Information, reporting on NSW Ambulance call 201
statistics by Priority Code and cardiac arrest responses as recorded by study paramedics (Bureau of Health Information, 2017). In examining HR, the finding that paramedics’ HR is not elevated significantly by the type of Priority 1 call (Chief Complaint) but is by overall priority code is interesting. Paramedics may view all Priority 1 calls equally in terms of seriousness and/or urgency and respond physiologically equally.

The Anatomy of a Paramedic Call - Referenced in the Introduction, was that a paramedic call has five distinct epochs (Assign, Enroute, On Scene, To Hospital and At Hospital). There were two epochs where HR and RR were significantly higher: Assign and On Scene (Figure 5.8 and 5.9). The increase in HR and RR during the Assign epoch can be attributed to a measure of physical exertion as paramedics move quickly to an ambulance. However, the HR and RR recorded during the On Scene phase (on average 20 minutes) does not seem consistent with exertion that may be expected during that time (assessing and treating patients). There would be an initial rise in HR and RR as the paramedic carries equipment to the scene as well as the physical movement of patient (on stretcher) to the ambulance at the end of the On Scene epoch. However, given the low levels of OPA it does not seem that this change is attributable solely to physical exertion. Factors that may be affecting HR and RR over the On Scene phase could be the stress reaction of assessing and treating patients. As an example, pediatric ICU physicians (n=5) who wore Hexoskins during hospital duties showed a significant increase in mean and maximum HR while completing patient assessment and treatments when compared to baseline (Slamon et al., 2018).

Physiological Responses
The highest HR recorded for each call \((HR_{\text{max}})\) was the only measure of HR that differed between postings, with regional paramedics being significantly higher (Table 5.6). This was a similar finding with regional paramedics for average RR per call. As well, with small differences
(although significant), it poses the question if these are clinically meaningful differences.

Energy expenditure - From the present research there was an estimate of EE of approximately 190 kcal/hr, which was similar by posting (Table 5.6). This EE by NSW Ambulance paramedics is comparable to previous research employing similar data collection methods in wildland firefighters (n=21) attending base duties in a Canadian study (189.06±102.14 kcal/hr paramedics versus 137 ±51.1 kcal/hr firefighters) (Robertson et al., 2017). Research into healthy civilian subjects (n= 21) using indirect calorimetry yielded estimates of EE ranging from 79.8 – 181.8 kcal/hr for sitting, standing and walking activities (Levine, Schleusner, & Jensen, 2000). These data may be useful comparators to paramedics, whose work includes sitting, standing and walking periods of OPA. The data suggests that paramedics in this study have an OPA level that is low, and this could be contributing to changes in health status over time, specifically BMI.

Rate of Perceived Exertion – RPE was not significantly different by posting (Table 5.6). Further, RPE did not differ significantly by call type or Priority Code. Of note is that the highest RPE recorded was 7 (consisting of the following calls: a cardiac arrest, an intentional overdose, and a fall in a dangerous area) with most data points ranging from 1-3. These values may represent the physical exertion perceptions of paramedics being low. RPE used in other studies of emergency services personnel were for activities of short duration (significantly less than the paramedics’ 12-hour shift) and were associated with tasks that resulted in an increasing heart rate, for example, soldiers being assessed for shooting accuracy over a 20 minute period (Nibbeling, Oudejans, Ubink, & Daanen, 2014). Similarly, police officers testing body armour over a series of short tasks attributed higher scores than those recorded in this study (Schram et al., 2018). The low mean RPE scores can indicate that OPA (specifically associated with attending calls) for
paramedics is perceived as low. This is supported by the HR, g-force and step counts for paramedics in the present study.

Blood pressure – Paramedics did not have a significant difference by posting in their shift end versus shift beginning blood pressure. There was also no difference in MAP by call type. The clinical significance of an increase in MAP requires further study. These findings should be interpreted with caution as the original blood pressure cuffs were not reliable and were replaced with NSW Ambulance provided BP cuffs in the third week of the study.

Part 2 Correlates of Paramedic Job Performance

Hypothesis 2 – Health Status and Physiological Response

BMI in the WHO categories of Overweight and Obese will elicit a higher physiological response of paramedics compared to Normal and Underweight categories (HR: at shift start, shift average, call average, %HR\text{max} and MAP).

The hypothesis is supported. Key findings were that those paramedics in the overweight and obese BMI categories had significantly elevated physiological responses than those in the normal category.

Given the reported high rates of BMI in paramedics in other studies (Hegg-Deloye et al., 2015; Studnek et al., 2010) and from results in Chapter 3, an examination of the effect of BMI on physiological responses \textit{in situ} was important. There were significant differences in mean HR at shift start (resting), mean HR for entire shift, mean HR during calls and %HR\text{max} during calls (Table 5.7). Further, there were significant differences in MAP by BMI category with the obese paramedics having a MAP of 101.2 ± 11.9 mmHg. These findings are concerning as the linkage of high BMI to elevated resting HR, RR and BP.
is well established in the literature (Martins et al., 2003; Shekharappa, Smilee, Mallikarjuna, & Vedavathi, 2011).

Levels of paramedic BMI reported in Chapter 3 and in the present chapter is a cause for concern. Not only are there health implications of high BMI (Berrington de Gonzalez et al., 2010; Di Angelantonio et al., 2016), but in a 5-year longitudinal study (n= 5,118) those who experienced psychosocial stress had a higher increase in BMI (Harding et al., 2014). The implication is that the nature of the paramedic job (low OPA during long periods of each shift, high BMI, periods of intermittent OPA) along with exposure to traumatic events, may be predisposing paramedics to poorer health status.

The findings of increased MAP at shift start and end for overweight and obese paramedics compared to normal weight paramedics are significantly higher but should be interpreted with caution due to measurement techniques. The findings may indicate a trend consistent with the findings of others (Goldstein et al., 1992; Kales et al., 2009) and in recent research on NSW paramedics (Hunter et al., 2017) therefore further research should be undertaken.

Hypothesis 3 - Emergency Calls and Physiological Response Interaction

Variables of emergency calls responses (higher call priority, chief complaint, time on calls, time on all calls, number of calls and transports/shift, and increasing RPE) will elicit elevated physiological responses in paramedics (HR, RR).

The hypothesis has been partly supported. Key findings were that higher Priority Code responses elicited higher HR and RR response in paramedics. There are significant effects or significant interactions of physical and occupational task characteristics on paramedic physiological response on calls.
Heart Rate – In examining the difference in paramedic mean HR and maximal HR recorded during a) epochs and, b) total call, from the mean heart rate while resting at shift start it shows that age, gender, posting, BMI, years of service, years at current certification level, call epoch and priority of call elicit significantly elevated responses. This included mean HR, maximal HR, and mean RR. Variables that had no significant effects were years of service, type of shift, CC, RPE, and MAP.

The finding that there are significant differences in HR by call epoch is interesting (Figure 5.8). Specifically, HR goes up with specific epoch. Physiologically, the sympathetic arousal to alarms has been studied in firefighters (n= 35) with significant increases in HR by an average of 47 bpm which the authors attributed to high anxiety coupled with heavy work performed in a hot environment (Barnard & Duncan, 1975). The present study has a similar finding of increased HR (during the Assign phase). Paramedic mobilization during the Assign phase takes place in a very short time frame, usually with the crew moving to the ambulance (if at station) or activating warning lights/siren if already mobile. Paramedic HR elevation may differ from firefighters, for example, because they are not donning heavy personal protective equipment (turnout gear and self-contained breathing apparatus). Certainly, both groups experience a sympathetic arousal in response to alarms.

In a Swedish study of paramedics (n= 20) who were continuously monitored for HR during defined call phases showed a significant rise in HR unrelated to physical effort, although the physical effort was determined through self-report (Karlsson et al., 2009). There is a link between sympathetic nervous system activation, HR increase and cortisol release following a stress response (Dickerson & Kemeny, 2004; Ghazali, Ragot, & Oriot, 2016) including paramedics (Backe et al., 2009; Leblanc et al., 2012). Physiological arousal during the alarms response phase could be accompanied by the release of cortisol and over time, may have a deleterious effect on the paramedic (Aardal-Eriksson,
Eriksson, Holm, & Lundin, 1999; Bergen-Cico et al., 2015; Hellhammer, Wust, & Kudielka, 2009). Specifically, increased cortisol level has been associated with incident hypertension (Hamer & Steptoe, 2012). The incidence of hypertension in paramedics has been established (Hunter et al., 2017; Kales et al., 2009). However, for the purposes of this study, there has not been a hypertension response, only a small but significant increase in MAP over the course of a shift and an incidence of higher MAP with increasing BMI by category.

The second observation from Figure 5.8 is that there is a second increase in HR, when the paramedic is with the patient (On Scene phase). Generally, this can be one of the longer periods of a call (mean 17 min.). This does not appear to be in relation to significant physical exertion as average g-forces, although elevated, are in the “Very Low” category, yet HR elevates. As in the Assign phase, this may be a period of sympathetic arousal as the paramedic must quickly assess and treat injured or ill patients. RR change is also higher in the Assign and On Scene phases. The HR response by Priority Code is illustrated in Figure 5.9 with Priority 1 calls eliciting the highest HR response. This may be expected, given the serious nature of that priority, however, there appears to be a significant effect of BMI on paramedic response to their serious calls as evidenced in Figure 5.10. Firstly, there are significantly higher HR responses through all call epochs with increasing BMI. The range of BMI in this study was 18-39 kg/m² with a higher mean BMI noted in regional paramedics. While Priority 1 calls elicit an equal HR response for all BMI, as priority decreases (severity of call), there is a lower HR response for paramedics with lower BMI. Regional paramedics from Chapter 3 had an average BMI of 28.3 ± 3.9 kg/m². While there is no available injury data from NSW Ambulance by geographic posting, the higher BMI in the regional postings, coupled with low OPA, and their self-reported of barriers to exercise including lack of, or distance to facilities could be factors contributing injuries. This would need to be further studied. In similar research by Aljerian et al. (2018) on pre-hospital workers in Saudi
Arabia indicate a significant increase in musculoskeletal injury of the neck, upper back, low back and knees with increasing BMI.

Respiratory Rate - When measuring the effect of RR change from shift start, there is a significant increase in RR with increasing BMI through all epochs of an emergency call (Figure 5.12). While there are no reports of research on paramedics’ RR, similar RR were evidenced in a study of NSW police officers (n= 40) revealing elevated RR ranging from 21-23 breaths/minute while attending a variety of high priority calls (Decker et al., 2016). In that study, BMI or other measures of health status were not reported, so it is difficult to draw any other parallels with the current research.

Hypothesis 4 – Occupational Physical Activity and Physiological Response Interaction
Variables of OPA (g-forces at: shift start, shift average, call average, call maximum, and steps/shift) will elicit stronger physiological responses of paramedics (HR and RR).

The hypothesis is supported. Key findings were that g-force changes were influenced by call epoch and by age.

There is a decrease in g-force production through all call phases with increasing age (Figure 5.13), a trend that may be hard to quantify. Interestingly, there was a significant interaction between BMI, epoch and age on g-force production (Figure 5.14). With increasing BMI and increasing age, there was a significant decrease in PA as measured as g-force across all call epochs. This may be due to an increasing activity efficiency or movement economy with task familiarity. It would also be interesting to study the division of tasks requiring manual labor on calls by age to understand if older paramedics contribute the same amount of labor to a call.
Occupational Physical Activity on Shift and Calls - Mean OPA was significantly higher in regional paramedics, during calls and by overall shift activity. However, OPA measurements in the Very Low to Low categories were found for both postings. When average shift step count and HR (Table 5.4 and Table 5.6) are examined, this low level of OPA seems to be supported. Interestingly, the development of higher g-forces seems equal between non-patient care and patient care periods of a paramedic shift. This could suggest that the moving and handling of patients may only be one period of a shift where there is appreciable physical exertion. More research needs to be conducted to ascertain the tasks/activities completed on shift when not responding to emergency calls.

In terms of g-force while on calls, there appears to be a significant difference between epochs with higher forces measured during the Assign and On Scene phase (Figure 5.3). The Assign phase is marked by a relatively short and usually expedient movement to an ambulance to begin travelling to the call. The On Scene phase has the second highest average g-force. Firstly, it is usually marked by travel from the ambulance to the patient followed by a period of patient assessment and treatment. Included in this could be positioning the patient on a stretcher or stair chair (foldable chair used to move patients to a stretcher) and moving back to the ambulance.

LIMITATIONS

Subjects for this study were a convenience sample of self-identified paramedics. While subjects approximated the distribution of NSW Ambulance paramedics by gender, posting and level of certification, they may not necessarily represent the true population. Instructions from the researcher to the subject was frequently done electronically due to geographic location of the subject. This may have impacted subsequent 209
self-acquired measures. As well, the measure of blood pressure was acquired by several different blood pressure cuffs and machines, therefore results should be interpreted with caution.

Subjects were asked to sit quietly at shift start to establish a resting physiological state. The measures could have been affected by: a) shift in rotor (for instance first day of a four-day rotation), b) exogenous stimulants or depressants (i.e. caffeine or anxiolytics), c) timing (specifically, this was done immediately before shift start and physiological response may be affected by proximity to the workplace, pending calls, or other operational matters. Paramedics also were not monitored on “days off” therefore the level of physiological arousal on work days could not be compared to off work days.

The quantification of OPA using Hexoskins is limited to identifying only minimum, average and maximum g-forces generated by call epoch, by call and over the entire shift. There is no corresponding qualification or self-report by the subjects of what was taking place in terms of exact physical activity during those time periods. Future research using objective measures of OPA such as the Hexoskin should include data on the amount, type and frequency of the OPA.

CONCLUSION

The context of paramedic job performance for NSW Ambulance paramedics has been established and adds insight into the frequency, type and response to calls both in metropolitan and regional posting.

This research demonstrates that paramedic OPA is significantly lower than self-reported PA, even in busy metropolitan settings. Approximately half of a paramedic shift actively engaged in patient care which may contribute to an increasing BMI over time. The increasing BMI in turn
contributes to elevated physiological measures both at rest (compared to those in the normal category), during the shift and on emergency calls.

Paramedic health status influences several physical, physiological and occupational task demands. Importantly, when paramedic measures of health status and occupational task performance is combined with their call response characteristics, new understandings are gained. There are within call variations in HR, RR and OPA which are significantly affected by BMI, posting and type of emergency calls. This builds on evidence from Chapter 3 of findings of higher BMI in NSW Ambulance survey respondents. There appears to be a change in physiology when responding to calls not associated with level of physical exertion. Hence, some of these changes may be due to a stress response, and this stress response might be influenced by health status (for example BMI).

Paramedic response to calls may, therefore, be placing a strain on cardiovascular health, already under pressure from the nature of the job and this is compounded by the effect of increased BMI and delivering care in a profession where adequate levels of PA may not be achievable.
CHAPTER 6: THE INFLUENCE OF CARDIORESPIRATORY FITNESS AND HEALTH STATUS ON PARAMEDIC JOB PERFORMANCE

“We learn more by looking for an answer to a question and not finding it that we do from learning the answer itself”

Lloyd Alexander (1964)
ABSTRACT

Introduction:

The influence of cardiorespiratory fitness (CRF) on paramedic job performance has not been well studied in simulation or in situ. In terms of understanding the job demands of paramedics, this has made it hard to examine associations between physiological responses of paramedics and their CRF during job performance. Further, paramedic physiological responses have not been compared to HRQoL scores, or health status measures (BMI). The ability to compare health status with the CRF of paramedics will better describe the occupational demands and better understand if they contribute to the high reported rates of injury.

The primary aim was to examine how CRF (\(\dot{V}O_2\) max and \(\dot{V}O_2\) max by category) and health status (BMI) influences physiological response (HR, \(\%HR_{max}\) and RR) during emergency call responses (by epoch and Priority Code), including while performing CPR during cardiac arrest calls. The secondary aim was to explore the relationship between measures of health status (BMI and HRQoL), and CRF.

Methods

From the 32 paramedics enrolled in Study 2 (Chapter 5), 14 (8 males and 6 females) volunteered to complete the Multi-Stage Shuttle test while wearing Hexoskin® biometric shirts to measure \(\dot{V}O_2\) max and to establish each participant’s HR_{max}. Each participant also completed self-reported measures of HRQoL (SF-36). Each paramedics’ call data (type of call and Priority Code) were combined with their biometric data (HR, \(\%HR_{max}\) and RR) to examine trends in response associated with measured CRF.
Results

Fourteen paramedics (age 40 ± 6.0 years, years of service 12.9 ± 6.9 years) had a mean $\dot{V}O_2\max$ of 33.1 ± 6.7 mL/kg/min and a mean $HR_{\max}$ of 183.4 ± 9.7 bpm. Fitting a linear mixed model, there were associations between $\dot{V}O_2\max$ and HR during calls, related by call type. Paramedics with higher $\dot{V}O_2\max$ values had lower HR and %$HR_{\max}$ whilst on calls and over the entire shift when compared to those paramedics with lower $\dot{V}O_2\max$ values. From 7 cardiac arrests, there was no difference in mean HR during arrest compared to performing CPR ($p=0.11$). Mean g-force produced during CPR averaged between 0.18 - 0.72 g with maximum 0.6 - 1.55 g. There was a positive correlation between score on the general health domain of the SF-36 and $\dot{V}O_2\max$ ($r=.571$, $p=0.03$).

Conclusion

From this sample, there was a significant effect of $\dot{V}O_2\max$ on HR during calls, with increasing CRF associated with lower physiological responses of paramedics. This indicates that CRF is an important factor for paramedic health during occupational task performance. There was an association between one SF-36 domain score and physiological response on calls. Sample size may be too small to establish the effect of $\dot{V}O_2\max$ on HR during CPR although this methodology adds insight into rescuer physiological changes during CPR. The findings are important because paramedics and paramedic services may be able to design wellness programs using results of these tests ($\dot{V}O_2\max$ and HRQoL).
INTRODUCTION

As evidenced from the results presented in Chapter 5, the unpredictable nature of emergency responses, in a variety of settings make it difficult to predict how a paramedic will respond from a physiological perspective while performing occupational task. This chapter will investigate paramedic cardiorespiratory fitness (CRF) levels and how it may influence their physiological responses during emergency calls. This will aid in informing paramedics, paramedic services and those who train paramedics, to address what appears to be high levels of injury combined with many indicators of poor health status. The area of CRF in paramedicine is not well explored, nor is there a clearly established requisite level of CRF to perform occupational tasks.

A recent scientific statement from the American Heart Association indicates that low levels of cardiorespiratory fitness are associated with increased risk of cardiovascular disease and all-cause mortality (Ross et al., 2016). Research by Jae et al. (2018) linked high levels of CRF in 2,357 males aged 42-60 with a 39% lower risk of sudden cardiac death. High incidence of cardiovascular disease and increased BMI in paramedics has been measured (Buzga et al., 2015; Hegg-Deloye et al., 2015; Sedrez et al., 2017; Studnek et al., 2010; Wong, 2012) and these risk factors can infer a higher risk premature mortality. However, examination of CRF in this population remains under-explored. The impact of CRF needs exploration considering the physiological demands of paramedic occupational tasks, especially for example while performing CPR. There is also evidence that increased CRF is a protective factor in injury occurrence. Soldiers with the slowest quartile times in an unweighted shuttle test were at twice the risk for both overall injury and overuse injury (Lentz, Randall, Gross, Senthilselvan, & Voaklander, 2019).

Some research has been carried out to measure the CRF of paramedics. The CRF and the cardio-metabolic demands reported by Gamble et al
(1991) measured \( \dot{V}O_2 \) max levels of Irish ambulance personnel (n= 85). Paramedics had an average \( \dot{V}O_2 \) max of 33.67 mL/kg/min, which was below the average \( \dot{V}O_2 \) max of sedentary officer workers (Brighenti-Zogg et al., 2016). Gamble had a subgroup of eight wear heart rate monitors during ambulance shifts (n= 21), demonstrating periods of high activity during manual tasks (CPR, chair carrying) with raised HR above anaerobic thresholds for periods of up to 11 minutes (Gamble et al., 1991). Finally, Aasa, Ängquist, and Barnekow-Bergkvist (2008) studied 34 paramedics who were divided into two groups (exercise intervention versus no intervention) and found \( \dot{V}O_2 \) max at the end of the study was 40.5 \( \pm \) 6.0 mL/kg/min (control group) compared to 47.3 \( \pm \) 5.2 mL/kg/min (exercise group). These results highlight a wide variability in CRF scores in paramedics and appear to differ from \( \dot{V}O_2 \) max results for paramedic students specifically, although this may be due in part to age related \( \dot{V}O_2 \) max differences (Loe, Rognmo, Saltin, & Wisloff, 2013).

Low or variable levels of CRF in paramedics may be a result of the occupation. While in training to become a paramedic, the CRF levels of paramedic students have been measured. Finnish paramedic students (n= 40, mean age 21.5 \( \pm \)1.8 yrs.) were tested with researchers reporting a mean \( \dot{V}O_2 \) max of 42.9 \( \pm \) 7.1 mL/kg/min (Paakkonen et al., 2018). There were similar findings in a Czech study of students (n= 32, mean age 24.4 \( \pm \)3.2 yrs.) of 47 \( \pm \) 6.1 mL/kg/min (Buzga et al., 2015). Finally, South African male paramedic students (n= 20, 22.8 \( \pm \)3.6 yrs.) had a mean \( V_O_2 \) max of 47.9 \( \pm \) 7.8 mL/kg/min (Davies, Naidoo, & Parr, 2008). These results indicate a good level of CRF of students although there is a paucity of literature in this area.

While students are in training to enter the profession, there is a varying approach to assessing the fitness, including the CRF, either prior to admission or before graduation. Further, several universities appear not to have a validated assessment tool for students during training, nor a final assessment before graduation (Australian Catholic University, 2017; Charles Sturt University, 2018; Victoria University, 2017). It is, therefore,
unclear if graduates possess the CRF to perform the occupational tasks of a paramedic and further, if CRF contributes to the reported poor health status of paramedics (Betlehem et al., 2013; Hegg-Deloye et al., 2015; Pek et al., 2015).

However, it is unclear from the literature if there are defined physical employment standards describing CRF levels for paramedics in Australia or internationally. In Australia, with there is evidence of one service measuring aerobic capacity in new recruits (Jansz, 2016). However, there is no established level minimum level of CRF to pass the test, participants must simply to stay on a treadmill at 7.4 km hr at a gradient of 5% for 3 minutes. The validity of this testing protocol for paramedics has not been reported in the literature.

As well as $\dot{V}O_2$ max, $\%HR_{max}$ may also help describe a paramedic’s physiological response to occupational tasks. Research in this area with paramedics is not apparent, however, Decker et al. (2016) studied NSW police officers (n= 40) over 2-4 shifts each, whilst responding to 0-0-0 calls and found a mean $\%HR_{max}$ from 47 ± 7.2% to 50 ± 9.4%. This in situ monitoring is important as it presents a measure of cardiovascular response in emergency responders (Decker et al., 2016). Understanding paramedics’ $\%HR_{max}$ is important given the reported rates of cardiovascular disease (Buzga et al., 2015; Hegg-Deloye et al., 2015; Sedrez et al., 2017; Wong, 2012) and high BMI levels (Studnek et al., 2010).

As part of the present study, there is an examination of paramedic physiological response while performing CPR during cardiac arrest calls. CPR performance has been studied in laboratory settings with paramedics and other rescuers (Riera, Gonzalez, Alvarez, Fernandez Mdel, & Saura, 2007; Yannopoulos et al., 2006). Physiologists report that CPR elicits a metabolic demand of between 24% and 59% of $\dot{V}O_2$ max describing it as an aerobic activity (Pierce, Eastman, McGowan, & Legnola, 1992). There is evidence that CPR efficacy declines quickly
even in trained rescuers (Bridgewater et al., 2000; Ko et al., 2008) and may be dependent on rescuer fitness levels (Lancaster, 2015). The current study may be the first presentation of physiological (HR and RR) and accelerometer data recorded while paramedics are responding to cardiac arrests and performing CPR. Understanding the actual physiological response and OPA level of paramedics may aid in determining requisite fitness levels for optimum CPR.

As well as objective measures of health such as CRF, the assessment of the HRQoL, as a measure of paramedic health status could be useful (Hansen, Rasmussen, Kyed, Nielsen, & Andersen, 2012; Micalos et al., 2017; Pek et al., 2015). In Chapter 3 of this thesis, the use of the SF-36 has identified lower HRQoL scores in NSW Ambulance paramedics compared to normative data from the Australian population. The ability to compare HRQoL scores with CRF in paramedics would yield valuable information. Garcia-Lopez, Bedoya, Gutierrez, and Postigo (2016) examined a sample of healthy workers (n=250), finding significant positive correlations in physical function (PF), bodily pain (BP), general health (GH) and vitality (V) with \( \dot{V}O_2 \) max. The ability to use HRQoL results to explore associations with CRF could yield information on health not previously explored and aid in health surveillance and the development of health promotion programs for paramedics.

The association between BMI and \( \dot{V}O_2 \) max with occupational task performance in paramedics has not been previously studied. What has been reported are high levels of BMI in paramedics (Studnek et al., 2010), a trend that NSW Ambulance paramedics seem to follow. The implication is that if high levels of BMI are negatively associated with \( \dot{V}O_2 \) max, the physiological demands of paramedic work could be affected and evidenced by increased injury rates or level of reported illness.

The present study will assess how CRF influences physiological and other responses in paramedics before, during and after emergency calls.
The ability to examine paramedic health through this new perspective will be undertaken by comparing physiological responses, with CRF and HRQoL scored. Hence the study has a primary and secondary aim:

Aims

Primary aim

- To examine if CRF (VO$_2$ max and VO$_2$ max by category) and health status (BMI) influences physiological response (HR, %HR$_{max}$, MAP and RR) during emergency call responses (by epoch, Priority Code) and shifts, including while performing CPR during cardiac arrests.

Secondary aim

- To explore relationships between measures of health status (BMI, HRQoL and PA), CRF and physiological responses (HR, %HR$_{max}$, MAP and RR).

Hypotheses

1. Paramedics with higher levels of CRF and better measures of health status (BMI) will have lower HR, %HR$_{max}$ and RR on emergency calls and shifts than those with lower CRF and lower measures of health status, including while performing CPR during cardiac arrest calls.

2. Lower measures of health status (increased BMI, decreased SF-36) will be negatively correlated with higher levels of CRF.
METHODOLOGY

Study Design

The experimental design consisted of a prospective field study of a subset of paramedics who had participated in Study 2 (described in Chapter 5). A convenience sample of 14 paramedics were recruited from the original 32 paramedics.

Participants completed the SF-36 and the Multi-Stage Shuttle test. The SF-36 was employed to provide a HRQoL measure and the Multi-Stage Shuttle Test provided an estimate of $\bar{V}O_2$ max (mL/kg/min) and $HR_{\text{Max}}$. $\bar{V}O_2$ max was also themed by age and gender specific categories of CRF (1=very poor, 2=poor, 3=fair, 4=average, 5=good, 6=very good and 7=excellent) (Heyward, 1998; Ramsbottom, Brewer, & Williams, 1988).

Participants

Paramedics for this study (n=14, 8 males and 6 females) were recruited by way of an email to corporate email accounts to all 32 paramedics who had participated in Study 2, inviting those interested to participate in the present study. Participants were evaluated to see if they still met the inclusion criteria (see Chapter 5, Table 5.2). Eight were from regional stations and 6 were from metropolitan stations. All participants completed all testing.

Ethical approval for the study was obtained prior to this study from Southeast Sydney Local Health District (HREC reference number: 15/328 (HREC/15/POWH/584)). This was the ethics application for Study 2 (Chapter 5) with an amendment approved by SESLHD on September 23, 2016. The ethics number remained the same. CSU Human Research Ethics Committee (HREC) protocol number H16006.
Demographic Information:

Participants reported an estimate of their height (cm), weight (kg), age (years), years of service (years), waist circumference (cm), geographic posting (metropolitan or regional), level of certification and how long at their current level (years).

Procedure

The Multi-stage 20 metre shuttle test was employed to measure CRF. It has been used to measure aerobic fitness and is a predictor of VO₂ max (Paradisis et al., 2014). The test has moderate to high criterion related validity (Mayorga-Vega, Aguilar-Soto, & Viciana, 2015) and was chosen because it is a useful alternative when laboratory testing is not available or feasible. This was the case with 14 paramedics living in a variety of locations across NSW and therefore unable to attend laboratory testing. See Table 6.1
Multi-Stage Shuttle Test Protocol

1. Multi-stage shuttle testing was conducted during paramedics’ scheduled days off. There was at least a one-day break between their last shift and testing.

2. Participants were asked to complete the Adult Pre-Exercise Screening Tool – Stage One (see Appendix 4).

3. Participants wore a fitted Hexoskin® biometric shirt and data pack (Carre Technologies, Montreal, PQ, Canada) to record heart rate data. Participants could use a 15-minute period prior to the test beginning for a warm up.

4. At the start, participants positioned themselves on the start-line of the 20-metre course. The audio CD alerted when the test was to start, with the sound of a ‘triple beep’.

5. Participants were to jog 20 metres to the opposite end line. Upon arrival, they were to place one foot on or over the line, pivot and turn, and make their way back to the start line in time for the next single beep.

6. After approximately each minute, a triple beep sounded, indicating the start of the next level of the test. Each time this occurred, the time between beeps decreased.

7. Participants continued back and forth over the course until they could no longer reach the end lines in time with the beeps. The test finished when they (a) reached volitional exhaustion, or (b) recorded two consecutive misses by not reaching the lines in time for the beep. At this point the test concluded and the score recorded as the last successfully completed level and shuttle.

8. Testing took place in gyms or fitness clubs with suitable indoor space (57%, n= 8) or outside on a hard surface (43%, n= 6).
<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Test Location</th>
<th>Date/time of Test</th>
<th>Temp. during test (°C)</th>
<th>Rel. Hum. %</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Male</td>
<td>Orange</td>
<td>03/01/17 0930 hr</td>
<td>15</td>
<td>69</td>
<td>Indoor, Gym</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>Camden South</td>
<td>07/02/17 1100 hr</td>
<td>22</td>
<td>81</td>
<td>Outdoor, Multisport stadium</td>
</tr>
<tr>
<td>3</td>
<td>Female</td>
<td>Coff's Harbour</td>
<td>18/01/17 1100 hr</td>
<td>24</td>
<td>52</td>
<td>Indoor, Gym</td>
</tr>
<tr>
<td>4</td>
<td>Female</td>
<td>Sydney</td>
<td>10/01/17 1100 hr</td>
<td>24</td>
<td>73</td>
<td>Indoor, Gym</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>Port Macquarie</td>
<td>01/02/17 0900 hr</td>
<td>28</td>
<td>85</td>
<td>Indoor, Gym</td>
</tr>
<tr>
<td>6</td>
<td>Male</td>
<td>Bateman's Bay</td>
<td>06/02/17 1200 hr</td>
<td>24</td>
<td>83</td>
<td>Outdoor, Rugby field</td>
</tr>
<tr>
<td>7</td>
<td>Male</td>
<td>Sydney</td>
<td>10/01/17 1200 hr</td>
<td>26</td>
<td>72</td>
<td>Indoor, Gym</td>
</tr>
<tr>
<td>8</td>
<td>Female</td>
<td>Shell Harbour</td>
<td>14/02/17 1400 hr</td>
<td>20</td>
<td>71</td>
<td>Outdoor, Multisport stadium</td>
</tr>
<tr>
<td>9</td>
<td>Female</td>
<td>Camden South</td>
<td>14/02/17 1100 hr</td>
<td>19</td>
<td>56</td>
<td>Outdoor, Multisport stadium</td>
</tr>
<tr>
<td>10</td>
<td>Male</td>
<td>Dubbo</td>
<td>20/01/17 1030 hr</td>
<td>25</td>
<td>43</td>
<td>Indoor, Gym</td>
</tr>
<tr>
<td>11</td>
<td>Male</td>
<td>Cave's Beach</td>
<td>02/02/17 0900 hr</td>
<td>19</td>
<td>72</td>
<td>Outdoor, Netball court</td>
</tr>
<tr>
<td>12</td>
<td>Female</td>
<td>Orange</td>
<td>13/02/17 0900 hr</td>
<td>23</td>
<td>70</td>
<td>Indoor, Gym</td>
</tr>
<tr>
<td>13</td>
<td>Male</td>
<td>Bathurst</td>
<td>04/01/17 1400 hr</td>
<td>22</td>
<td>68</td>
<td>Indoor, Gym</td>
</tr>
<tr>
<td>14</td>
<td>Male</td>
<td>Rozelle</td>
<td>02/02/17 1630</td>
<td>26</td>
<td>70</td>
<td>Outdoor, Tennis court</td>
</tr>
</tbody>
</table>
Instrumentation

The instrument comprised the SF-36 (Gandek et al., 2004). This instrument has been described previously in this thesis (Chapter 3).

Data Analysis

Data were inspected visually and statistically for normality prior to analysis and are presented in tables as mean ± standard deviation. A Pearson Chi-square test of Independence was performed to establish the representativeness of the study participants \( (n=14) \) compared to the NSW Ambulance population \( (n=3,302) \) based on gender and posting. Participant shift and call data sets were derived from Hexoskin® measures and NSW Ambulance call data.

A statistical analysis using repeated measures One-Way ANOVAs were used to compare differences in HR, RR, MAP, RPE and \( \dot{V}O_2 \text{max} \). These measures were compared between a) at rest (shift start) b) average for the entire shift and c) during each callout. A linear mixed model was fitted to examine the effect of each variable on the dependent variables. Significance was accepted at \( p<0.05 \). For comparisons between two means, graphs of the mean differences and 95% confidence interval are illustrated.

Associations between physiological demands (HR, RR, MAP, and OPA) and \( \dot{V}O_2 \text{max} \) were determined using Pearson Product Moment correlational coefficients. Hexoskin® data was examined to determine \( HR_{\text{max}} \) at the end of the Multi-Stage Shuttle test. A Pearson Population Correlation Hypothesis test was computed to assess the relationship between the following: SF-36 scores, \( HR_{\text{max}} \) by epoch, and BMI.

\( \dot{V}O_2 \text{max} \) score in mL/kg/min was determined as a decimal score of the level and shuttle that was successfully completed during the shuttle test. For example: Level Six, Shuttle Eight was recorded as 6.8. The \( \dot{V}O_2 \text{max} \)
was calculated with the formula \( \dot{V}O_2 \text{max} \text{ (mL/kg/min) = 3.46 * (Decimal Score)} + 12.2 \) (Ramsbottom et al., 1988).

Body Mass Index (BMI) was calculated using the formula \( \text{BMI} = \frac{\text{body weight (kg)}}{\text{height (m}^2\text{)}} \). To display trends, BMI data were categorised into World Health Organisation classes using the following guidelines: Class 1 (Underweight) \(<18.5 \text{ kg/m}^2\), Class 2 (Normal Weight) 18.5-24.9 kg/m\(^2\), Class 3 (Overweight) 25.0-29.9 kg/m\(^2\), and Class 4 (Obese) >30.0 kg/m\(^2\) (Grobschadl et al., 2011).

Hexoskin® data were analysed according to the same guidelines described in Chapter 5 using the Vivosense software (Vivonoetics, San Diego, USA). This included HR, RR and g-force production (shift start, shift average, epoch average and call average).

Participants recorded cardiac arrest calls (n= 7) attended where they performed at least one period of CPR and cross-referenced in the CAD data for confirmation. For the investigation of CPR performance on during these calls, physiological and accelerometer data were analysed in Vivosense comparing a) mean and maximal HR and RR and b) mean and maximal g-force production for each CPR period (n= 38) and for the total cardiac arrest time period with each period of CPR. To the researcher’s knowledge, this is the first time these data have been measured during cardiac arrest calls.

All analyses were performed using SPSS Version 17.0 (Statistical Package for the Social Sciences Version 17.0, SPSS Inc., Chicago, Illinois, U.S.A.) with the threshold for statistical significance set at \( p<0.05 \). Effect sizes (d) were calculated according to Cohen (1988) and interpreted with the following thresholds: Trivial (0 - 0.19), Small (0.20 to 0.49), Medium (0.50 - 0.79), and Large (d \( \geq 0.80 \)) (Cohen, 1988). A summary of statistical measures and tests is presented in Table 6.2.
**Table 6.2**
Statistical Measures or Tests Employed.

<table>
<thead>
<tr>
<th>Statistical measure or test</th>
<th>Model Assumptions</th>
<th>NSW Ambulance population (n=3,302)</th>
<th>Study 3 participants (n=14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi Square test of independence</td>
<td>The value of the expected should be 5 or more in 80% of the cells and no cell should have an expected value of less than one.</td>
<td>Overall gender and posting NSW Ambulance compared to study 3 participants (Hypothesis Test 1)</td>
<td></td>
</tr>
<tr>
<td>ANOVA</td>
<td>Each sample group is drawn from a normally distributed population. All populations have a common variance. Residuals are normally distributed.</td>
<td></td>
<td>Differences by gender and posting by age, years' service, years this level, BMI, (Model A)</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Each sample group is drawn from a normally distributed population. All populations have a common variance. Residuals are normally distributed.</td>
<td></td>
<td>Differences between laboratory CPR performance and Study 3 participants completing CPR during cardiac arrest, (Model C)</td>
</tr>
<tr>
<td>ANOVA with Tukey HSD</td>
<td>As above</td>
<td></td>
<td>VO_{2max} by category (Model B)</td>
</tr>
<tr>
<td>Pearson Population Correlation Hypothesis Test H₀:ρ=0</td>
<td>Sample data are normally distributed.</td>
<td></td>
<td>SF-36 with BMI overall and by gender and posting (Hypothesis Test 2)</td>
</tr>
<tr>
<td>Pearson Chi Square test of independence</td>
<td>The value of the expected should be 5 or more in 80% of the cells and no cell should have an expected value of less than one.</td>
<td></td>
<td>Age, years of service, years this level with BMI, VO_{2}max and HRMax. (Hypothesis Test 3)</td>
</tr>
<tr>
<td>Independent Samples – Mann Whitney U test</td>
<td>The dependant variable is continuous or ordinal. One independent variable consists of two categorical, independent groups. There is independence of observations.</td>
<td></td>
<td>MET-minutes by posting and gender (Model E)</td>
</tr>
<tr>
<td>Linear Mixed Effect Model</td>
<td>The explanatory variables are related linearly to the response. The errors have constant variance,</td>
<td></td>
<td>(Model F)</td>
</tr>
</tbody>
</table>

Note: The model assumptions are met unless otherwise notified.
RESULTS

6.0 Representativeness of the Sample

The results of Pearson Chi-square test of Independence (Hypothesis Test 1) showed the overall proportion of study participants were not significantly different than the NSW Ambulance population by gender ($\chi^2$ 0.2995, df 1, p= 0.58, CI -0.01, 0.01) and by posting ($\chi^2$ 0.9261, df 1, p= 0.34, CI -0.01, 0.01).

Additionally, this analysis showed that these participants were not significantly different from Study 1 (Chapter 3) participants by posting ($\chi^2$ 0.2256, df= 1, p= 0.63, CI -0.01) or gender ($\chi^2$ 0.7230, df=1, p= 0.39, CI -0.01). Demographic information is presented in Table 6.3.

Table 6.3
Demographic Characteristics of NSW Ambulance Paramedics and Study Paramedics

<table>
<thead>
<tr>
<th>NSW Ambulance Paramedic Workforce (n=3,302)</th>
<th>NSW Ambulance Study 3 Paramedics (n=14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metropolitan Male (n=1,138)</td>
<td>Female (n=700)</td>
</tr>
<tr>
<td>Metropolitan Female (n=981)</td>
<td>Female (n=483)</td>
</tr>
<tr>
<td>Regional Male (n=2)</td>
<td>Female (n=4)</td>
</tr>
<tr>
<td>62%</td>
<td>38%</td>
</tr>
</tbody>
</table>
Participant’s demographic and physiological characteristics were measured and are presented in Table 6.4.

### Table 6.4
Paramedic Demographic and Physiological Response Characteristics for Metropolitan, Regional, and all Paramedics.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Metropolitan (n=6) Mean (SD)</th>
<th>Regional (n=8) Mean (SD)</th>
<th>All Paramedics (n=14) Mean (SD)</th>
<th>P value</th>
<th>Effect Size d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>2</td>
<td>6</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>40.0 (8.3)</td>
<td>41.4 (4.6)</td>
<td>40.8 (6.2)</td>
<td>0.69</td>
<td>0.21</td>
</tr>
<tr>
<td>Years of service</td>
<td>15.3 (8.3)</td>
<td>11.0 (5.6)</td>
<td>12.9 (6.9)</td>
<td>0.27</td>
<td>0.62</td>
</tr>
<tr>
<td>Years at Current Level</td>
<td>6.8 (3.9)</td>
<td>6.2 (3.0)</td>
<td>6.34 (3.3)</td>
<td>0.78</td>
<td>0.18</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.8 (2.1)</td>
<td>26.8 (3.2)</td>
<td>26.8 (3.2)</td>
<td>0.43</td>
<td>0.73</td>
</tr>
<tr>
<td>HRmax (bpm)</td>
<td>181.9 (10.1)</td>
<td>184.6 (9.9)</td>
<td>183.4 (9.7)</td>
<td>0.61</td>
<td>0.27</td>
</tr>
<tr>
<td>VO2 max (mL/kg/min)</td>
<td>33.7 (8.4)</td>
<td>32.6 (5.6)</td>
<td>33.1 (6.7)</td>
<td>0.917</td>
<td>0.16</td>
</tr>
<tr>
<td>Calls/shift</td>
<td>4.9 (2.1)</td>
<td>3.5 (2.2)</td>
<td>4.1 (2.2)</td>
<td><strong>0.01</strong></td>
<td>0.65</td>
</tr>
<tr>
<td>Transports/shift</td>
<td>3.1 (1.7)</td>
<td>2.7 (1.8)</td>
<td>2.8 (1.7)</td>
<td>0.32</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Note that significant differences between metropolitan and regional paramedics are denoted in **bold**.
6.1 Paramedic Health Status and Cardiorespiratory Fitness

6.1.1 Paramedic Cardiorespiratory Fitness

\( \text{VO}_2 \text{ max} \) and Paramedic Demographics

The mean \( \text{VO}_2 \text{ max} \) for all paramedics was 33.1 ± 6.7 mL/kg/min and was not significantly different by posting, gender or level of certification (\( p > 0.05 \)).

6.1.2 Paramedic Cardiorespiratory Fitness

Health Status and HR Response

A Linear Mixed Model was fitted to examine the effect of \( \text{VO}_2 \text{ max} \), BMI, WtHR, and the emergency call response variables (call epoch, Priority Code) on the dependant variable of HR Difference from Shift Start Maximal (bpm). Only those variables with significant effects or significant interactions are presented in the following graphs.
The effect of BMI on HR maximal response by epoch is graphed in Figure 6.1. With increasing BMI, there is a significant increase in maximum HR in all epochs of a call, most notably during the At Hospital epoch. (Model F).

Figure 6.1. The effect of BMI on participants displays a significant difference by call epoch on the maximal heart rate attained during each epoch compared to HR at shift start (red line). Predicted means and 95% CI (shaded area) are graphed.
6.1.3 Paramedic Cardiorespiratory Fitness

**VO₂ max and HR Response**

The effect of VO₂ max was examined in relation to maximum HR and results are graphed in Figure 6.2. With increasing VO₂ max, there is a significant decrease in maximal HR in all call epochs. This is most notable during the On Scene epoch (Model F).

![Figure 6.2](image)

**Figure 6.2** The effect of VO₂ max on attenuating maximal heart rate response compared to HR at shift start (red line) by call epoch. Predicted means and 95% CI (shaded area) are graphed.
6.1.4 Paramedic Cardiorespiratory Fitness

**CRF, HR, and MAP**

The effect of CRF (by category) on HR and MAP was examined with results presented in Table 6.5 for all 14 participants over a total of 111 paramedic shifts.

**Table 6.5**
The effect of cardiorespiratory fitness on HR and MAP.

<table>
<thead>
<tr>
<th>Cardiorespiratory Fitness Category</th>
<th>Poor</th>
<th>Fair</th>
<th>Average</th>
<th>Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean HR Shift Start (bpm) (n=111)</td>
<td>81.3 (14.6) a</td>
<td>77.7 (6.2) a, b</td>
<td>74.6 (13.2) a</td>
<td>67.9 (14.4) b</td>
</tr>
<tr>
<td>Mean HR Shift (bpm) (n=111)</td>
<td>85.2 (9.2) a</td>
<td>85.1 (3.9) a</td>
<td>82.36 (9.4) a</td>
<td>73.9 (10.1) b</td>
</tr>
<tr>
<td>Mean HR Call (bpm) (n=432)</td>
<td>87.5 (20.3) a</td>
<td>77.8 (11.6) a,b</td>
<td>80.5 (20.2) a,b</td>
<td>70.9 (16.8) b</td>
</tr>
<tr>
<td>%HR_{max} Call (n=432)</td>
<td>54.1 (10.3) a</td>
<td>48.5 (6.9) a,b</td>
<td>49.9 (10.6) a</td>
<td>44.3 (9.9) b</td>
</tr>
<tr>
<td>MAP Shift Start (mmHg) (n=111)</td>
<td>101.6 (13.8) a</td>
<td>94.4 (8.5) a,b</td>
<td>100.1 (9.7) a</td>
<td>89.9 (13.1) b</td>
</tr>
<tr>
<td>MAP Shift End (mmHg) (n=111)</td>
<td>102.5 (13.5) a</td>
<td>98.0 (7.4) a,b</td>
<td>99.8 (9.4) a</td>
<td>90.6 (13.7) b</td>
</tr>
</tbody>
</table>

Letters in each row that are different indicate significant differences in post-hoc analysis (a, b, c, d) (p<0.01).
6.1.5 Paramedic Cardiorespiratory Fitness

CRF and %HR\textsubscript{max} all calls

The effect of CRF rating on the %HR\textsubscript{max} for all calls was examined and graphed in Figure 6.3. Those paramedics with a lower CRF rating had a significantly higher percentage of HR\textsubscript{max} (p<0.05) compared to those with higher CRF rating. There was a similar finding of significantly higher paramedic HR\textsubscript{max} with lower CRF rating for Priority 1 calls (not graphed) (p< 0.01).

**Figure 6.3** The %HR\textsubscript{max} by cardio-respiratory fitness rating. %HR\textsubscript{max} is significantly higher with lower CRF rating. Columns with different letters are significantly different (a, b, c, d). All others are significantly different (p<0.05). Means and 95% CI are graphed.
A Linear Mixed Model was fitted to examine the effect of \( \dot{V}O_2 \text{ max} \) and BMI, on the emergency call response variables of call epoch, and Priority Code on the dependent variables of RR difference from shift start. Only those variables with significant effects or significant interactions are presented in the following graphs.

6.1.7 Paramedic Cardiorespiratory Fitness
\( \dot{V}O_2 \text{ max} \) and RR by epoch

There were significant differences in RR from shift start by \( \dot{V}O_2 \text{ max} \) and epoch (significant RR increase with lower \( \dot{V}O_2 \text{ max} \) in the Enroute, To Hospital and At Hospital epochs) which are graphed in Figure 6.4. (Model F).
Figure 6.4 Significantly higher RR differences by Enroute, To Hospital and At Hospital epochs and \( \text{VO}_2 \text{ max} \) in RR difference from shift start (red line). Predicted means and 95% CI (shaded area) are graphed.
6.1.8 Paramedic Cardiorespiratory Fitness

Cardiac Arrest and Physiological Response

A summary of the demographic information of the paramedics who responded to cardiac arrests is presented in Table 6.6. Each paramedic performed CPR from between 1 to 13 times per arrest with an average CPR time of 42 seconds ± 22 seconds.

Table 6.6
Demographics of Paramedics Performing CPR.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Posting</th>
<th>BMI</th>
<th>VO₂ max</th>
<th>Cardiac Arrests</th>
<th>Shift start HR (bpm)</th>
<th>Shift start %HRmax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>39</td>
<td>Metro</td>
<td>22</td>
<td>40.2</td>
<td>1</td>
<td>66</td>
<td>36.7</td>
</tr>
<tr>
<td>Male</td>
<td>42</td>
<td>Regional</td>
<td>24.2</td>
<td>42.4</td>
<td>1</td>
<td>72</td>
<td>35.5</td>
</tr>
<tr>
<td>Female</td>
<td>36</td>
<td>Metro</td>
<td>26.5</td>
<td>32.2</td>
<td>3</td>
<td>79</td>
<td>42.1</td>
</tr>
<tr>
<td>Female</td>
<td>38</td>
<td>Regional</td>
<td>25.7</td>
<td>28</td>
<td>2</td>
<td>73</td>
<td>40.1</td>
</tr>
</tbody>
</table>

Heart rate response - There was no difference in mean HR for the entire On Scene epoch of each cardiac arrest of 89.5 ± 12.3 bpm compared to the CPR portion with a mean HR of 94.8 ± 7.4 bpm (p= 0.11). There was no difference in %HRmax for the entire On Scene epoch of cardiac arrest of 51.4 ± 7.1% compared to the CPR only portion of the arrest %HRmax of 54.8 ± 7.4% (p= 0.11). There were no significant correlations between paramedic VO₂ max and HR or VO₂ max and %HRmax.
CPR - compressions during arrests generated mean g-forces of 0.25 ± 0.11g and maximum g-forces of 1.46 ± 0.81 g (Figure 6.6). Neither mean nor maximum g-force were significantly different by gender (p > 0.05). An example of paramedic performing CPR is shown below in Figure 6.5.

**Figure 6.5** CPR performance during cardiac arrest (CPR periods illustrated by ← →). The peak of each wave represents the bottom of a chest compression.

**Figure 6.6.** The mean and maximum g-forces produced by paramedics during CPR periods of 7 cardiac arrests.
6.2 Paramedic Health Status, CRF and Physiological Response

Scores from the SF-36 and the IPAQ are presented in Table 6.7.

### Table 6.7
SF-36 Results by Posting and Overall.

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Metropolitan Mean (SD)</th>
<th>Regional Mean (SD)</th>
<th>All Paramedics Mean (SD)</th>
<th>p-value</th>
<th>Effect Size d=</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Function</td>
<td>81.7 (35.5)</td>
<td>90.6 (9.8)</td>
<td>86.8 (23.6)</td>
<td>0.50</td>
<td>0.39</td>
</tr>
<tr>
<td>Role – Physical</td>
<td>95.8 (10.2)</td>
<td>93.6 (17.7)</td>
<td>94.6 (14.5)</td>
<td>0.81</td>
<td>0.15</td>
</tr>
<tr>
<td>Body Pain</td>
<td>87.7 (10.3)</td>
<td>76.6 (15.1)</td>
<td>81.4 (13.6)</td>
<td>0.15</td>
<td>0.87</td>
</tr>
<tr>
<td>General Health</td>
<td>73.5 (21.5)</td>
<td>67.1 (14.7)</td>
<td>69.9 (17.4)</td>
<td>0.52</td>
<td>0.35</td>
</tr>
<tr>
<td>Vitality</td>
<td>73.3 (6.1)</td>
<td>66.9 (13.9)</td>
<td>69.94 (11.34)</td>
<td>0.31</td>
<td>0.62</td>
</tr>
<tr>
<td>Social Function</td>
<td>95.8 (6.5)</td>
<td>95.3 (9.3)</td>
<td>95.5 (7.9)</td>
<td>0.91</td>
<td>0.07</td>
</tr>
<tr>
<td>Role – Emotional</td>
<td>94.4 (13.6)</td>
<td>91.7 (15.4)</td>
<td>92.9 (14.2)</td>
<td>0.72</td>
<td>0.19</td>
</tr>
<tr>
<td>Mental Health</td>
<td>86.0 (4.9)</td>
<td>81.5 (7.9)</td>
<td>83.3 (6.9)</td>
<td>0.25</td>
<td>0.69</td>
</tr>
<tr>
<td>Physical Health Summary</td>
<td>82.4 (10.4)</td>
<td>79.0 (10.1)</td>
<td>80.5 (9.9)</td>
<td>0.55</td>
<td>0.33</td>
</tr>
<tr>
<td>Mental Health Summary</td>
<td>84.6 (5.1)</td>
<td>80.5 (8.9)</td>
<td>82.3 (7.6)</td>
<td>0.33</td>
<td>0.59</td>
</tr>
</tbody>
</table>
6.2.1 Paramedic Health Status, CRF and Physiological Response
SF-36, BMI and CRF

The relationship between VO$_2$ max and SF-36 scores was examined for participants.

VO$_2$ max was positively correlated with General Health domain ($r = .571$, $p= 0.03$) and there were weak to moderate non-significant correlations with Role Physical domain ($r = .379$, $p= 0.18$), Physical Health Summary ($r = .433$, $p= 0.12$) and Mental Health Summary ($r = .256$, $p= 0.38$).

There were non-significant negative correlations between BMI and the SF-36 domain of General Health ($r = -.297$, $p= 0.30$). BMI had a non-significant correlation with VO$_2$ max ($r = -.400$, $p= 0.16$).

6.2.2 Paramedic Health Status, CRF and Physiological Response
Health Status, CRF and HR and %HR$_{max}$

The correlation between physiological measures while on calls ($n = 432$ calls completed by 14 participants) and cardiorespiratory fitness was examined.

VO$_2$ max was negatively correlated with HR at shift start ($r = -0.304$, $p< 0.001$), HR by shift average ($r = -.390$, $p< 0.001$) and HR by call ($r = -.369$, $p< 0.001$), and by total shift ($r = -.227$, $p< 0.001$). When examining %HR$_{max}$ there was a significant negative correlation by total call ($r = -.410$, $p< 0.001$).

6.2.3 Paramedic Health Status, CRF and Physiological Response
Health Status, CRF and RR

VO$_2$ max was negatively correlated with RR at shift start ($r = -.257$, $p< 0.001$) and RR shift average ($r = -.188$, $p< 0.001$). There was no correlation between VO$_2$ max and RR by call.
DISCUSSION

Key findings in this study were that lower $\dot{V}O_2$ max levels combined with higher levels of BMI elicit a higher physiological response for paramedics on calls. The strength of response is influenced by call priority and epoch of call. Paramedics performing CPR during cardiac arrests have increased heart rates and $\%HR_{max}$, although it is unclear if this increased response is influenced by CRF level. The relationship between HRQoL and CRF levels appear similar to the research of others, however, findings cannot be generalised, perhaps due to sample size.

The two hypotheses and findings associated with each are below:

Hypothesis 1 – $\dot{V}O_2$ max and BMI

Paramedics with higher levels of CRF and lower level of health status (BMI) will have lower HR, $\%HR_{max}$ and RR on emergency call responses and shifts than those with lower CRF and higher level of health status (BMI) including while performing CPR during cardiac arrest calls.

The hypothesis is partly supported.

$\dot{V}O_2$ max had an influence on HR and RR on all calls. Those paramedics with lower BMI and higher $\dot{V}O_2$ max had lower maximal HR (Figure 6.1 and 6.2) and RR (Figure 6.4) on emergency calls and by epoch than those with a higher BMI and lower $\dot{V}O_2$ max. This is comparable to findings from Chapter 5 in terms of BMI and its effect on HR and RR. The influence of $\dot{V}O_2$ max on paramedic physiological response on calls and within the epochs of calls are new findings. It is important to note that prior to the present study, the estimation and influence of CRF (specifically $\dot{V}O_2_{max}$) of paramedics only appears in a very small number of studies.
With a mean $\dot{V}O_2$ max of 33.1 ± 6.7 mL/kg/min, the paramedics appear to have a low level of CRF, compared to a sample of Western Australian paramedics studied by Chapman, Peiffer, Abbiss, and Laursen (2012) and in the present study this did not differ significantly by gender or posting (Table 6.4). Research examining paramedics (n= 11) by Gamble, Boreham, and Stevens (1993) and more recently with paramedics and paramedic students (n= 74) by Buzga et al. (2015) present comparable $\dot{V}O_2$ max findings. This low level of CRF may develop through the paramedic career as it appears that student paramedics exhibit higher $\dot{V}O_2$ max scores than the paramedics in this study (Buzga et al., 2015; Davies et al., 2008; Paakkonen et al., 2018). If so, a lower CRF could be linked to the paramedic occupation. Factors such as shift work and the inability to accrue PA or OPA of enough activity to maintain or improve $\dot{V}O_2$ max may be contributors and more research is needed in this area (Mundwiler et al., 2017).

In examining the effect of BMI on HR (Figure 6.1) and the effect of $\dot{V}O_2$ max on HR (Figure 6.2), there appears to be an inverse relationship between BMI and $\dot{V}O_2$ max. The ability to measure or estimate BMI and $\dot{V}O_2$ max in paramedics may be useful in predicting physiological response to calls. This is important for two reasons. Firstly, is that there are higher HR responses with lower $\dot{V}O_2$ max scores and high BMI. There is an association of BMI and CRF with metabolic syndrome (the group of risk factors related to cardiovascular disease and Type 2 diabetes) and has been demonstrated in the literature as an odds ratio in one study of 18.8 with a CI of 5.0 - 70.5 (Hong et al., 2014). Secondly, the development of higher BMI (overweight and obese categories) are associated with higher a higher incidence of injuries in emergency services personnel, for example firefighters (n= 298) who exhibited a relationship between back pain and BMI (Damrongsak, Prapanjaroenvis, & Brown, 2017).
The significant finding that $\text{VO}_2 \text{ max}$ and the $\%HR_{\text{max}}$ that paramedics exhibit during calls is noteworthy (Table 6.5 and Figure 6.3). There has been exploratory work in emergency services, for example, in police officers ($n=40$) responding to frequently attended task types. They had a $\%HR_{\text{max}}$ while attending a domestic incident of $49 \pm 8.8\%$ (Decker et al., 2016). In the present study, a paramedic’s equivalent to this was attending a Priority 1 call, where their $\%HR_{\text{max}}$ ranged from 48.1 to 55.7 % with lower percentages displayed by the paramedics with higher $\text{VO}_2 \text{ max}$. Paramedics can be directly engaged in high priority calls on average for 30-50% of the time during a 12 hour shift. Given the level of cardiovascular risk that paramedics exhibit in the literature (Hegg-Deloye et al., 2015; Sedrez et al., 2017), there is purpose to ensure paramedics have an adequate level of CRF to attenuate elevated heart rate. What is known, is that an elevated HR is associated with elevated blood pressure, increased risk of hypertension and increased risk of cardiovascular disease (Reule & Drawz, 2012). The findings presented in the present study are new and not previously reported for paramedics.

The results also highlighted interesting findings in terms of the effect of CRF on physiological response on emergency calls. Higher maximal HR, firstly, may indicate a stress response by activation of the sympathetic nervous system with release of catecholamines (epinephrine and norepinephrine) with simultaneous vagal withdrawal (Jouven et al., 2009). Catecholamine response has been studied in paramedics by Dutton, Smolensky, Leach, Lorimor, and Hsi (1978), finding elevated levels of catecholamines in paramedics during work days compared to days off. The results may further support that not only do paramedics undergo stress responses during shift, but that CRF and BMI may influence the level of response. Linked to this are the findings that the higher CRF paramedics in this study had a lower percentage of $HR_{\text{max}}$ across all epochs and all calls. This difference was significant as with Priority 1 calls there was over a 10% greater HR response for lower CRF paramedics, and for that group, a higher $\%HR_{\text{max}}$ than other emergency
services occupations such police officers driving urgently to a 0-0-0 call (Decker et al., 2016).

There are findings of significantly lower HR in paramedics with a CRF rating of “Good” (those with the highest VO$_2$ max in the study) (Table 6.5), specifically, lower HR at shift start, mean HR, all call HR. This is important considering research on the protective role of resting heart rate (RHR) on all cause and cardiovascular disease. Saxena et al. (2013) found participants (n=51,936) in a study with a RHR greater than 80 bpm were at greatest risk when compared to those with a RHR less than 60. Research on professional firefighters (n=288, mean age 42.7 ± 8.9 years, mean VO$_2$ max 46.1 ± 7.1 mL/kg/min) investigated associations of resting heart rate (RHR), heart rate reserve and VO$_2$ max with metabolic syndrome finding a linear association between VO$_2$ max and metabolic syndrome (Choi, Ko, & Kojaku, 2017). Drawing from the firefighter research, the implication is that lower RHR and higher VO$_2$ max attenuate development of metabolic syndrome. More research is warranted in paramedics to establish if there would be similar findings.

From the same results (Table 6.5) HR reported as shift average and HR during calls follows a similar trend of increasing with lower levels of CRF and may highlight, the effect of CRF in situ. Whether this HR response may be more closely linked to stress response, attenuated by increased VO$_2$ max and intensified by higher levels of BMI requires further research.

While BMI may not, by itself, be a precise tool to estimate health risks in populations or occupations (Nuttall, 2015), examining it in relation to VO$_2$ max may add insight into the health status of paramedics. It is known that VO$_2$ max, when precisely measured is a strong predictor of mortality similar to other risk factors such as cigarette smoking, hypertension, high cholesterol and Type 2 Diabetes Mellitus (O'Donovan et al., 2013). In the present study, results indicate that BMI and VO$_2$ max are variables that
influence physiological response. Whether the increase in HR is clinically meaningful should be further studied.

Cardiac Arrest
Research on paramedics responding to cardiac arrest calls while monitoring their physiological and OPA levels has not been previously reported. In the present study, cardiac arrest calls comprised approximately 2% of the call volume of paramedic. This presented a unique opportunity to examine paramedic response to patients frequently termed the “sickest of the sick”. Anecdotally, paramedics will describe cardiac arrest calls as some of the most stressful they will attend.

The findings that \( \dot{V}O_2 \) \( \text{max} \) did not appear to influence HR during cardiac arrest calls was potentially due to the small sample size (4 paramedics and a total of 7 cardiac arrests). What was apparent, was that there was a significant HR and %HR\( \text{max} \) response by the four paramedics during a cardiac arrest compared to shift start. HR from shift start increased from 72.5 ± 4.6 bpm to 94.8 ± 7.4 bpm and %HR\( \text{max} \) from 38.6 ± 2.6% to 54.8 ± 7.4%.

There were no significant correlations between paramedic \( \dot{V}O_2 \) \( \text{max} \), BMI and mean or maximum heart rates either during the entire cardiac arrest or while specifically performing CPR. A larger sample size may yield more meaningful data. There are also multiple factors that should be researched including crew composition, type of shift and time of day, the number of rescuers performing CPR and whether the patient regained spontaneous circulation. In the present study, of 7 arrests, only 1 was transported to hospital, indicating one successful resuscitation on scene.

Examining accelerometer data revealed that they completed a total of 38 periods of CPR ranging from 11 seconds to 110 seconds, (mean 42 ± 22 seconds). Riera et al. (2007) studied 23 health care providers who completed 2 minutes of uninterrupted CPR on a manikin. Results of their
%HR\textsubscript{max} while performing CPR (61.0 ± 8.0\%) were not significantly different that the %HR max of the present study participants (61.0 ± 4.7\%) (p= 0.84, CI -5.51, 6.71). This could indicate that simulation based research matches outcomes in situ, although further research is needed to confirm.

Outcomes from paramedic cardiac arrest research indicate that the ability to perform effective CPR is linked to measures of fitness (Bridgewater et al., 2000). The relatively short periods of CPR performance (mean time 42 ± 22 seconds) by the present study paramedics could indicate that there are sufficient resources (other responders) to participate in CPR. The findings of mean CPR time mean and maximum g-forces recorded by paramedics during chest compressions are new and will require further study to better understand associations between accelerometry, rescuer physiology and CPR efficacy. This could help inform services and paramedics that expectations are shorter periods of CPR may be the norm and therefore plan to be able to deliver high quality CPR over shorter periods of time. CPR efficacy could therefore be improved.

The CPR compression data showed mean and maximum g-force of 0.25 ± 0.11 g and 1.46 ± 0.81 g respectively (Figure 6.8). Further research is required to better understand if these forces are associated with recommended CPR guidelines for depth and rate of compression, however, this is the first indication for the use of a triaxial accelerometer worn by a rescuer during a cardiac arrest.

Hypothesis 2 – Health Status and Cardiorespiratory Fitness Interactions

Lower measures of health status (increased BMI and decreased SF-36 scores) will be negatively correlated with higher levels of CRF.

The hypothesis is partly supported.

The intent was to examine correlations between health status measures (BMI and SF-36 scores) and physiological measures (∆VO\textsubscript{2} max).
Regarding BMI and SF-36 scores, there was evidence of weak, non-significant correlations of BMI and general health domain. In a systematic review, there were findings of reduced quality of life (physical and mental health SF-36 scores) associated with above normal BMI (Ul-Haq, Mackay, Fenwick, & Pell, 2012). This should support further research into paramedic BMI and HRQoL, to provide insight into their health status.

There was a moderate non-significant correlation between BMI and VO$_2$ max with results potentially influenced by sample size. As well, the BMI for the group (26.8 ± 3.2 kg/m$^2$) is relatively low when compared to the findings from Chapter 3 and the research of others (Studnek et al., 2010). In research with university students, there was a significant correlation between BMI and VO$_2$ max reported in previous research ($r= -.37$, $p< 0.001$ and for males, $r= -.28$, $p< 0.001$) and young adults ($r= .80$, $p< 0.05$) (Arabmokhtari, Khazani, Bayati, Barmaki, & Fallah, 2018; Setty, Padmanahda, & Doddamani, 2013). Therefore, more research is recommended to further explore this in paramedics.

The results of associations between paramedic VO$_2$ max and SF-36 scores (HRQoL) reveals a significant correlation with the general health domain, but weak to moderate non-significant correlations with role physical, physical health summary and mental health summary. These findings partially agree with earlier research. Garcia-Lopez et al. (2016) studied a group of healthy workers ($n=250$) and reported significant correlations in physical function (0.276), bodily pain (0.189), general health (0.155), vitality (0.241) and mental health (0.129) domains with VO$_2$ max suggesting a higher HRQoL with increased VO$_2$ max.

The positive correlations between the domains of role physical ($r= .379$) and physical Health Summary ($r= .433$) and VO$_2$ max, although non-significant, should promote further research with a larger sample size of paramedics than the current study ($n=14$). The ability to use self-reported health status, estimating HRQoL to assist in providing an estimate of the CRF for paramedics could be useful. This is important because of the
reported high rates of pre-hypertension and hypertension (Hunter et al., 2017; Kales et al., 2009), elevated BMI (Buzga et al., 2015) and cardiovascular disease (Hegg-Deloye et al., 2015; Janka & Duschek, 2018). If monitoring paramedic population health, for instance with NSW Ambulance were a goal of the organisation then the strategies to undertake surveillance may have to include survey tools to estimate health status, especially if that health status can infer a level of CRF.

LIMITATIONS

Recruitment for the testing was negatively impacted by availability of paramedics and hampered by a number being on annual leave during the testing period. More subjects would have improved the power of the study. As with subjects from the previous study, the subjects self-identified for the present study and therefore may not be representative of the larger NSW Ambulance population. As well, CRF testing took place after the data from the previous study was collected. Therefore, subject CRF may have changed (improved or decreased) in the interim period. The choice of both the CRF test (Multi-Stage Shuttle test) and the variety of locations (both indoor and outdoor) and weather conditions may have affected the results. The same limitations regarding baseline physiological assessments are relevant here.

CONCLUSION

The utilisation of a cardiorespiratory fitness test and additional self-reported measures of health and health status has yielded new insight into paramedic job performance. CRF levels in the present study are very low and this may influence overall health. From this research, paramedics who have a lower CRF have elevated physiological responses to all calls and by Priority Code.

Paramedic BMI influenced physiological response on emergency calls. The direct measurement of $\dot{V}O_2$ max and the establishment of a $HR_{max}$
for the 14 participants allows a further understanding of the role of cardio-respiratory fitness and its role in paramedic job performance.

The new variables of $\dot{V}O_2$ max and $\%HR_{max}$ examined here provide two key indicators of physiological performance on emergency calls for paramedics.

With both physiological and self-reported health status data from the paramedics in this study, it was thought that the self-reported health status could aid in estimating, indirectly, an association with the CRF of a paramedic population. Finally, although there is not a strong association between the HRQoL and physiological measures (for instance $\dot{V}O_2$ max), initial findings support further research in this area. Rather than be included in injury statistics, paramedic participation in health surveillance programs could proactively inform paramedic services on strategies to support good health and good health practices.
When there is a problem, there is not something to do, there is something to know.

Dr Raymond Charles Barker
Thesis Overview

The research comprising the thesis has focused on describing the health status of paramedics in an occupational setting. The intent was to highlight issues of paramedic health in an effort to better understand the variables that may contribute to reported decrements in health status. While the focus in this thesis has been paramedics working in regional and metropolitan postings for New South Wales Ambulance, aspects of their health status mirrors paramedics in other countries.

It was important to begin this research by surveying NSW Ambulance paramedics, allowing them to speak about their health. Then, by following them in situ, this allowed an exploration of the influence of health status on job performance. Finally, the ability to explore the influence of CRF level on emergency call response, and self-reported HRQoL advances new knowledge in this area. A result of the research could point to the fact that the job is contributing to paramedics’ inactivity (both while on and off shift) and this inactivity is showing up in their overall poor health and their physiological responses to occupational demands.

Part of the intent was wanting to understand more about why there are high levels of illness and injury in paramedics (Maguire et al., 2014; Roberts et al., 2015; Weaver et al., 2015). It was not fully clear which factors may be causing them, but the result are paramedics who appear unwell and accrue increasing amounts of sick time (Goodwin, 2017). Until there is a clearer understanding of health status and its impact on paramedic physical, physiological and occupational task characteristics, there may not be a change from the present reported rates of paramedic illness and injury other than to hire more paramedics to replace the broken ones.
The Health Status and Physical Activity Levels of NSW Ambulance Paramedics – Study 1

Health status from a survey of NSW Ambulance paramedics indicates low HRQoL scores consistent with the research of others, although overall data on paramedics in this area (HRQoL) is scant. The HRQoL scores of paramedics were lower than the Australian population in most domains and summary scores. BMI levels differed significantly by gender (males were higher) and posting (regional was higher). BMI of paramedics was higher than the Australian population. Paramedics reported lack of time and family commitments, and regionally, the lack of facilities for exercise as perceived barriers to exercise. Physical activity levels were not different by posting, however, male paramedics reported significantly higher total MET-minutes than females. PA levels appear high and are not consistent with the findings of others researching paramedics. From this research, paramedic health status appears to be adversely affected evidenced by high levels of BMI, uniform low self-reported rates of HRQoL and perceived barriers to exercise.

From this research, paramedic BMI is unhealthy, and level seems to be linked to geographical posting (regional versus metropolitan). In other words, where a paramedic works can affect their health. This is an important finding because approximately 50% of the 3,800 paramedics of the NSW Ambulance workforce are rostered in regional areas. This is consistent with research into the BMI levels of those living in rural Australia (Australian Institute of Health and Welfare, 2016; National Rural Health Alliance, 2013). From the present research, this finding could be attributable to lack of PA or exercise or both. Regional paramedics identified lack of exercise facilities as a significant barrier to exercise. The BMI findings in the present study agree with the research findings of paramedic studies internationally (Boreham et al., 1994; Hegg-Delaye et al., 2015; Studnek et al., 2010), although this is the first study to examine paramedic BMI by geographic posting. This will add to the existing literature for those paramedic services whose coverage area has a rural
or regional component. So, while the literature describes the work of paramedics as physically demanding (Aasa et al., 2008; Coffey et al., 2016; Corbeil & Prairie, 2012), the amount and frequency of those physical demands may be low, therefore not contributing significantly to OPA and decrements in health status.

In Chapter 3 findings a survey tool was employed to estimate HRQoL scores in paramedics. Presently, this information describes a snapshot of the paramedic respondents in time. There was a disparity, evidenced by lower paramedic HRQoL scores compared to the Australian population. Health promotion and targeted interventions for paramedics need to be based on the best available data and HRQoL should be included. Currently, there is no apparent literature on longitudinal monitoring of paramedic HRQoL therefore these efforts should be repeated.

NSW Ambulance paramedics provide a contrast. They are healthcare professionals, looking after the general population in times of greatest need. Yet this same group recorded the highest sick time levels of all health care providers in NSW in 2017 (Goodwin, 2017) with time off due to injuries higher than other occupations (iCare, 2018). Certainly, more research into the aetiology of their sick time needs to be conducted. BMI levels, SF-36 domain and health summary scores seem to indicate a population with a reduced health status in comparison to the Australian general population. What was noted from the present research is that their self-reported PA levels describe a very active population, and this seems to contrast with their BMI levels. This incongruence became more apparent in the second study where paramedic OPA was objectively measured through accelerometry. Mean g-force levels from Chapter 5 illustrate very low to low levels of OPA.

The significance of paramedic high BMI level is important. There are factors contributing to injury rates, particularly in emergency services,
and BMI is a significant one. Police officers with a BMI greater than 35 kg/m² (obese) were three times more likely to report back pain than those with a BMI in the normal range (Nabeel et al., 2007). This has also been demonstrated in firefighters with a significant correlation of r= .351 between back pain and BMI (Damrongsak et al., 2017). Paramedic BMI has been well reported in the literature, as well as paramedic injury rates (Studnek et al., 2010). Therefore, further research needs to be undertaken to quantify the relationship between BMI and injuries. Further, research is needed to explore interventions that promote a healthier BMI and examine if this influences injuries in paramedics. There is not enough evidence presently to suggest this is being done effectively in paramedic services.

Findings from Chapter 3 were included in a presentation for NSW Ambulance Workplace Safety and Wellbeing Resilience Advisory Committee, whose membership included the Chief Executive Officer of NSW Ambulance. The service collated this information, and introduced, in late 2016, an on-station physical fitness program for regional paramedics titled “Medic Fit”. This effect of this fitness program is currently being studied by a research team from Charles Sturt University. A randomised control trial (RCT) was implemented to compare (a) the Medic Fit program, (b) the Medic Fit program and a health coach and (c) a control group that did not receive either. By late 2017, 139 regional paramedics were enrolled with baseline physical fitness and musculoskeletal data collected. Following a six month trial period, final data collection was completed in mid-2018. Data analysis and reporting are expected in late 2018.

Additionally, it has been reported that NSW Ambulance has introduced the Fitness Passport program for all paramedics and this is seen as a positive move. Fitness Passport is a corporate health and fitness program that allows members to access a wide range of their local health and fitness suppliers. However, there is concern that there are fewer facilities
honoring Fitness Passport in rural and regional NSW than in metropolitan areas. Regardless of setting, paramedics must have time available to engage in exercise. With young families and other commitments, paramedics have challenges not just associated with shiftwork and the unpredictable nature of their job. NSW Ambulance management and paramedics must equally recognise and value good health in designing any interventions to ensure the best possible outcome.

The NSW paramedic workforce is young (mean age 41.5 ± 9.5 yrs.) with over 70% under the age of 50. They are presently evidencing illness, injury and associated sick time rates that are unlikely to attenuate as paramedics advance through their career. This presents an opportunity for developing interventions that will enhance health status, most specifically, healthy BMI levels.

Biometric Monitoring of Paramedics: Validation of the Hexoskin® Biometric Shirt – Study 2

This study established the validity of the Hexoskin® biometric shirt, a key instrument used in occupational data acquisition for two studies in this thesis. The Hexoskins showed good validity in the measurement of HR and RR when compared to standard ECG and the metabolic cart during exercise. In the context of this study, the opportunity to become oriented to the textile, hardware and software of Hexoskin® allowed the researcher a familiarity that was useful for the subsequent studies.

The use of biometric monitors allows a wider range of physiological data collection in applied research settings. There was scant literature on the Hexoskin® biometric shirt prior to the present study with only two published studies offering differing perspectives on the shirt’s validity (Montes et al., 2015; Villar et al., 2015). The present study investigated the Hexoskin® HR and RR validity in a trial of cyclists’ maximal and sub-maximal bouts of exercise. To that end, there was a level of agreement
between accepted laboratory testing devices and the Hexoskin® in exercise conditions involving varied body movement. This confirmed that the Hexoskin® shirts could be suitable for paramedic research, where the ability to monitor a wide range of tasks from sedentary to intense OPA (e.g. performing CPR).

Since undertaking the present study, there have been additional validation studies of the Hexoskin®, from laboratory to outdoor trail walking across several physical activities (cycling walking, sitting, high intensity interval training). The findings of researchers are that the Hexoskin® is valid for HR and RR, however, it is not valid for estimating tidal volume (Al Sayed, Vinches, & Halle, 2017; Cherif et al., 2018; Elliot et al., 2017; Montes et al., 2018; Moriarty, Feito, Monahan, & Williamson, 2018; Phillips et al., 2017; Tanner et al., 2015).

The validation study was an opportunity for the researcher to gain a familiarity with the garment, associated hardware and software which was key to the successful deployment for the subsequent studies with paramedics. As well, the present study served as an orientation to the data management from Hexoskin® to cloud to Vivosense analytical software.

Context and Correlates of Paramedic Health Status and Job Performance – Study 3

Thirty two paramedics were monitored during 232 shifts responding to a variety of calls (n= 918) ranging from non-emergency transfers to mass casualty events to cardiac arrests. This study added to the literature in presenting the physical, physiological and emergency call response characteristics of paramedics to yield a descriptive profile of regional and metropolitan paramedics. Overall, OPA levels were low with total average time engaged in patient care and transport at less than 50% per 12 hour shift. The research examined key performance variables on
physiological responses. It established the effect of increasing BMI level on eliciting higher physiological responses (HR, %HRmax and MAP). Findings that age, posting, BMI, epoch and Priority Code significantly influenced HR, RR and g-force production are important and raises topics for future research. Health status affects physiological response of paramedics.

Paramedics can anecdotally report their anticipated pattern of work based on their lived experience, but there is little available data on paramedic occupational task performance. Therefore, it makes it difficult to describe the context of paramedic job performance. Understanding the context can set the stage for research into how job performance influences health status, particularly injury and illness rates. Previous to the current research, examining paramedic occupational task performance, researchers measured some of the physiological responses in simulated work environments (Karlsson, Niemela, Jonsson, & Tornhage, 2015), to isolated lifting and carrying (Barnekow-Bergkvist et al., 2004) and in rare instances responding to calls (Gamble et al., 1991; Goldstein et al., 1992).

Understanding the context of paramedic job performance is useful for those who will educate paramedic students. Currently, there appears to be an inconsistent approach to both training for and assessing paramedic physical demand readiness. This is important because presently the entry to paramedic training and subsequently, employment is variable, with little evidence of validated fitness standards that align with OPA. Work on validating physical demands continues (Coffey et al., 2016; Fischer, 2014; Fischer et al., 2017) and is important because injury rates are high, sick time is high and there is a question of career longevity as a result (Rodgers, 1998a). This will help inform those who educate students on how to best prepare them for the demands of the occupation.
Further, the establishment of a descriptive profile yielded a diverse range of data not previously shown. For example, whether metropolitan or regionally rostered, from this sample data, was that calls and transports averages approximately 50% or less (on average) of a paramedic’s shift. Physical activity patterns for paramedics describe average steps/shift of less than half the recommended daily step count (Australian Government Department of Health, 2017). This is further supported by the present data showing paramedic EE aligns with workers in offices, with g-forces that are generally classed in the “low” OPA category, including on most calls and shifts measured (Brighenti-Zogg et al., 2016). This raises the issue of the effect of the occupation on health status, specifically, with low rates of OPA, and geographical areas without exercise facilities can impede regular exercise outside the workplace.

Paramedics exhibited significant changes, especially in HR response by posting, Priority Code, epoch and BMI. While it has been established that high BMI is linked to premature mortality and markers of poor health (Di Angelantonio et al., 2016; Huxley et al., 2010; Nowicki et al., 2018), its effect elicits higher physiological responses (increased HR and RR) in situ from the present data. In Chapter 3, paramedics reported high levels of BMI, especially in regional areas and when compared to the Australian population data. In Chapter 5, paramedics with high BMI had higher HR and RR responses during calls. From this, there is a demonstration that higher BMI not only poses a health risk but is linked to elevated physiological responses of paramedics while on calls.

Paramedics in the present study evidenced very low to low levels of OPA measured with a triaxial accelerometer. These low levels of OPA seem consistent with low reported RPE in the same study. Low OPA may be common in emergency services, specifically, police officers PA while on shift (Ramey et al., 2014) and emergency services workers also displayed low OPA in the U.S. National Health and Nutrition Examination Survey, (Steeves et al., 2005). The implication is that the volume of OPA
may not change significantly, therefore there needs to be strategies to promote healthy workplace practices. The focus needs to be on PA and exercise, combined with healthy lifestyle choices.

On March 5th, 2018, the A/Executive Director of People and Culture announced a series of Wellbeing Workshops for all NSW Ambulance staff. Described as “a major commitment which will be rolled out to ensure all staff…are able to attend this face-to-face education and training support course” (High, 2018). All NSW Ambulance paramedics will receive training about being well at work, Mind Fit and Body Fit modules, over a three year period. The senior management team have put forward this training plan, in part, due to the results shown in Chapters 5 and 6.

The Influence of Cardiorespiratory Fitness and Health Status on Paramedic Job Performance – Study 4

This study examined paramedic CRF. The aim was two-fold: to examine the influence of CRF on physiological response during calls, including cardiac arrests, and to examine linkages between self-reported health status, CRF and occupational task performance. This study added to the paramedic occupational descriptive profile, showing the influence of CRF. The results showed that higher CRF (\(\dot{V}O_2\) max) was significantly associated with a lower HR response, as measured by %HRmax across all categories of emergency call responses. Paramedic level of BMI was correlated with higher HR responses. CRF did not appear to influence HR or %HRmax of paramedics during cardiac arrests, including while performing CPR and managing patients in cardiac arrest. This will be a promising area to explore with a larger sample size. Finally, there were associations between measures of health status (BMI and SF-36) and physiological responses, although results should be interpreted with caution due to the sample size (n=14). Paramedic CRF appears low and
coupled with higher levels of BMI indicate a group that would be susceptible to injury and illness (specifically metabolic syndrome).

Paramedics are drawn from the general population. Therefore, their health status can mirror that of the greater population. This is especially true in that the ability to demonstrate job specific fitness attributes and to maintain them are not apparent generally for paramedics in Australia.

BMI measures from Chapter 3 and Chapter 5 demonstrated that paramedics had a higher prevalence of being overweight or obese, placing them at greater risk of cardiovascular and metabolic diseases (Hegg-Deloye et al., 2015; Studnek et al., 2010). This prompted a decision to directly measure paramedic CRF fitness as there were few comparators in the literature. How CRF and their self-reported health status were linked to physiological responses during paramedic OPA yielded new knowledge.

These new results that CRF ($\dot{V}O_2$ max), had a significant effect on HR, %HRmax and RR during emergency calls is an important finding. Research done by Poplin et al. (2014) demonstrated an association between $\dot{V}O_2$ max and musculoskeletal injuries in firefighters (n= 799). For example, firefighters with a $\dot{V}O_2$ max of less than 43 mL/kg/min were 2.2 times more likely to be injured than those with higher $\dot{V}O_2$ max (greater than 48 mL/kg/min) values. It is worth noting the paramedic CRF levels measured in the present study (33.1 ± 6.7 mL/kg/min) fall well below the 43 mL/kg/min category as identified by Poplin. As with the association between BMI level and injury incidence (Kuehl et al., 2012), the Poplin study reveals the relationship between $\dot{V}O_2$ max and injuries and remains one of few studies of CRF, specifically researching emergency services personnel. Certainly, research into CRF and injuries of paramedics is necessary based on the present findings.
Significant associations between HRQoL, CRF and measures of health status (BMI) were not conclusively demonstrated in the present study. However, from the work of others, the ability to employ survey instruments (for example SF-36) may serve as an aid in health surveillance. Ul-Haq et al. (2012), in a meta-analysis of the SF-36 found reduced physical and mental quality of life in overweight and obese adults. Similarly, Garcia-Lopez et al. (2016) explored associations between SF-36 scores and \( \dot{V}O_2 \) max and showed significant positive associations between physical function, general health and vitality domains. In the present study, there was a positive association between general health and \( \dot{V}O_2 \) max. Survey instruments can aid in assessing health status and could be useful with paramedics working over a geographic area the size of New South Wales.

Impact

Previous research informs that Australian paramedics, in general, are often injured and report record levels of sick time. Work Cover costs as well as impact to the operating budget of the paramedic service for cover of ill or injured crew would be consequently high as a result. (Maguire et al., 2014; Maguire & Smith, 2013). The reported high levels of sick time in paramedics are more serious given the relative youth of the NSW Ambulance workforce, with the possibility that these costs will only increase in the future. The present research identified decrements in paramedic health status and the effect on job performance from a physiological perspective.

Research Limitations

The research had the following limitations that had the potential to impact the quality of the findings and influence the ability to effectively answer the hypotheses.
(1) In Chapter 3, paramedics self-selected to answer the online survey.

(2) Chapter 5 and 6 participants were from a convenience sample of NSW Ambulance paramedics.

(3) Chapter 5 and 6 participants may have had elevated HR, MAP and RR at shift start (rest) as they were just starting their work shift.

(4) Physiological responses were not measured on paramedic’s days off to serve as comparators to the on-shift responses.

To minimise the effects of (1) to (4), the following steps were undertaken:

(1) Representativeness testing from a demographic perspective indicates that aspects of the sample were not different from the paramedic population of NSW Ambulance. Future research should include more methods of encouraging enrolment including social media.

(2) Selection of paramedics for the two studies was dependent upon potential participants accessing corporate email for study messaging. Additional messaging was distributed to all paramedics through corporate channels and through station level briefings. Representativeness testing from a demographic perspective indicates aspects of the sample were not different from the paramedic population.

(3) It was recognised that establishing shift start resting HR and RR would be difficult, but due to the applied nature of the research, could not be avoided.

(4) Physiological responses can only be interpreted regarding occupational tasks. Future research should monitor paramedics off shift as well as on shift.

Direction for Future Research

The paramedic role overlaps public safety (e.g. police and firefighters) and healthcare (e.g. physicians and nurses). It seems likely that paramedics will continue to be engaged in the emergent care of the sick and injured as part of the core business of paramedic services. It is unlikely that the unpredictable nature of emergency response will change. Research into how tertiary education and the paramedic services themselves define and measure the occupational readiness of 261
the prospective paramedic needs to be undertaken. The same is true for post-employment, where currently there appears to be little need to evidence any level of fitness to a standard. Physical employment standards are a necessity and need to be developed using sound methodology.

The effect of interventions to enhance health status and encourage PA, specifically exercise, should be studied in the paramedic population. The effect of either “on station” exercise programs (most notably more widely employed in the fire service) or access to programs and facilities would be two areas to explore. The former is being studied presently in NSW Ambulance with the Medic Fit research project. The impact of nutrition, shift pattern and effect of sleep deprivation are also areas that should be further studied (Guadagni, Cook, Hart, Burles, & Iaria, 2018; Hegg-Deloye et al., 2018).

While this thesis has examined selected physiological and other variables, more research should be undertaken in this area. Specifically, the effect of stress on paramedics, as measured by heart rate variability which has not been well studied. Additionally, the neuro-hormonal responses (for example cortisol, and adrenergic response) should be examined. Establishing baseline values of these variable may shed light on illness and injury of paramedics. This thesis has not spoken specifically about the incidence of mental health claims by paramedic, including Post Traumatic Stress Disorder. Future research needs to explore the linkages between health status, physiological response on calls and resiliency.

Finally, with assessment of occupational demands of paramedics there is also the potential to research how this affects their clinical performance. Does a paramedic with a low VO₂ max perform at the same level of clinical skill as a paramedic with a higher score? Do other fitness
and wellness factors affect drug calculations or CPR efficacy, for example?

Concluding Remarks

The pathway I have taken on this PhD journey has changed my outlook on paramedicine. I had undertaken this research with the mindset of a career paramedic looking at other paramedics to try and answer questions influenced by my lived experience. How I reacted to patients, to calls, to chaotic scenes coloured my view and at the same time sparked a passion to ask some intriguing and very hard questions.

What we know that from the literature there is a growing body of knowledge that the studying the health of paramedics is important. This is not just in terms of the economic costs of accommodating paramedics who may become ill or injured, but also a knowledge that paramedic staff need to be healthy to deliver excellent clinical care. Promotion of good health and maintaining a good health status is therefore important to keep on the forefront. The paramedic population is relatively young in Australia but showing signs of stress in several areas. The paramedics I started my career with are fewer and fewer, and not all due to retirement after a full career. More alarming is those whom I have taught the craft of paramedicine to over the years and are ill, injured or have left the industry.

From the present research, the descriptive profile of the paramedic occupation has been further defined. Paramedicine, by its own definition, operates outside of the walls of health institutions in oftentimes unpredictable settings. Being able to quantify what might be expected in terms of the physical, physiological and emergency call characteristics can assist those who train, recruit and employ paramedics. And, of course, the paramedics themselves.
The thesis began by posing two questions that were akin to the paradox of Schrödinger’s famous experiment. That is: Does being a paramedic affect health status and does health status affect being a paramedic? No complete answer to either question has been produced through this research, but it appears that the occupation affects health and level of health status can affect being a paramedic, at least from a physiological point of view. Through the reporting in this thesis, we are at least closer to a more definitive answer for both.

Meanwhile, paramedic work continues, 24 hours a day, 7 days a week, and 365 days a year. Paramedics around the world are on-station, on a call or getting ready to answer the next call. Keebler et al. (2017) sum up paramedics and paramedic care this way:

“Delivering healthcare in a mobile, volatile, unpredictable and unforgiving environment. As such, they arguably have one of the most cognitively and physically demanding jobs in healthcare.”

In the Preface of this thesis the question was posed of whether paramedics were “Fit for Duty”. That call for help from the patient’s family has been placed through 0-0-0. They were ready for the paramedics but the question of whether the paramedics were ready for the patient.

This research journey has been a rewarding one and it is now time to look forward, to take steps to ensure paramedics can be paramedics for as long as they want to be. And that they are ready….really ready, for that next patient.
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APPENDICES

APPENDIX 1 SURVEY INSTRUMENT STUDY ONE

Survey Instrument

NSW Ambulance and Charles Sturt University are cooperating on a research project to study Paramedics.

Mr. Alex (Sandy) MacQuarrie is a Charles Sturt University Paramedic program lecturer who is currently undertaking a PhD. Sandy has been a paramedic for over 20 years and has a strong interest in paramedic wellness.

Evidence on the health status of emergency services workers shows there appear many instances of markers of poor physical health in emergency personnel.

The project involves a series of experimental studies to quantify the physical effects of paramedic job performance on job specific skills, as well as examining paramedic attitudes towards health and wellness and physical activity.

This survey of paramedics aims to establish and potentially correlate linkages between health status, physical activity and the physical demands of the occupation.

Please take a few moments to complete this survey. You can provide valuable insight for this project.

If you would like further information or wish to discuss the project, please contact:

Candidate: Mr Alexander (Sandy) MacQuarrie Phone: (02) 6338 4757 Email:amacquarrie@csu.edu.au

Principal Supervisor: Dr James Wickham

Secondary Supervisors: Dr James Crane & Dr Peter Micalos
The results of this survey may be used in research publications such as journals or at conferences.

Such use will be completely anonymous and will not contain any identifying information.

* 1. I have read the information provided and I am willing to participate in this survey.

I acknowledge that any information I provide may be used anonymously as specified.

O I consent
O No thank you

Demographic questions

This section has some questions about your gender and age to aid in comparing results. The information will only be used to help inform our research, not to identify any individuals.

2. Please indicate your gender:

O Male
O Female

3. How old are you? (Please enter as numerals):

Age: ____________

4. What is your height (in cms)?

Height: ____________

5. What is your approximate weight (in kgs)?

Weight: ____________
This information will only be used to help inform our research. It will not be used to identify any individuals or groups.

6. How many years' service as a paramedic have you completed?

Years' service: ___________

7. What is your level of practice?

O Trainee Paramedic
O Paramedic Intern
O Qualified Paramedic
O Intensive Care Paramedic
O Extended Care Paramedic
O Specialist Group (SOT, SCAT, Rescue)

8. What is your primary role?

O Clinically practicing paramedic
O Management
O Education
O Control Centre Staff
O Other (for example IT)

9. What type of area do you generally work in?

O Metropolitan O Regional

10. Are you currently exercising as much as you would like?

O Yes
O No

11. What are the barriers to you not exercising as much as you would like?

(Please select all that apply)
O Injury
O Lack of energy
O Lack of time
O Lack of, or distance to, facilities
O Cost of gym or club membership
O Lack of knowledge about appropriate exercises
O Lack of motivation
O Family and other commitments
O Cost or lack of childcare
Other (please specify) _______________________________

12. Please indicate how you feel about the statement: "Paramedics need to be physically fit to do their job effectively."
O Strongly disagree   O Disagree   O Neither agree nor disagree
O Agree O Strongly agree

13. What aspects of physical fitness do you feel are important to effectively undertake the role of a paramedic? (Please select all that apply)
O Strength
O Flexibility
O Endurance
O Aerobic capacity
O Healthy Body Mass Index
Other (please specify): _______________________________
This set of questions asks for your views about your health. This information will help keep track of how you feel and how well you are able to do your usual activities.

Please answer every question. If you are unsure about an answer to a question please give the best answer you can.

14. In general, how would you say your health is?
   O Excellent
   O Very Good
   O Good
   O Fair
   O Poor

15. Compared to one year ago, how would you rate your health in general now?
   O Much better than one year ago
   O Somewhat better than one year ago
   O About the same as one year ago
   O Somewhat worse than one year ago
   O Much worse than one year ago

16. The following questions are about activities you might do during a typical day:

Does your health now limit you in any of these activities? If so, how much?

Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports
   O No, not limited   O Yes, limited a little   O Yes, limited a lot

Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf
   O No, not limited   O Yes, limited a little   O Yes, limited a lot
Lifting or carrying groceries
O No, not limited  O Yes, limited a little  O Yes, limited a lot
Climbing several flights of stairs
O No, not limited  O Yes, limited a little  O Yes, limited a lot
Climbing one flight of stairs
O No, not limited  O Yes, limited a little  O Yes, limited a lot
Bending, kneeling, or stooping
O No, not limited  O Yes, limited a little  O Yes, limited a lot
Walking more than a kilometer
O No, not limited  O Yes, limited a little  O Yes, limited a lot
Walking several blocks
O No, not limited  O Yes, limited a little  O Yes, limited a lot
Walking one block
O No, not limited  O Yes, limited a little  O Yes, limited a lot
Bathing or dressing yourself
O No, not limited  O Yes, limited a little  O Yes, limited a lot

17. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

Cut down on the amount of time you spent on work or other activities
O Yes  O No

 Accomplished less than you would like
O Yes  O No
Were limited in the kind of work or other activities  
Yes  O No

Had difficulty performing the work or other activities (for example, it took extra effort)  
O Yes  O No

18. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (e.g. feeling depressed or anxious)?
Cut down on the amount of time you spent on work or other activities  
O Yes  O No

Accomplished less than you would like  
O Yes  O No

Didn’t do work or other activities as carefully as usual  
O Yes  O No

19. During the past 4 weeks, to what extent have your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?
O Not at all  
O Slightly  
O Moderately  
O Quite a lot  
O Extremely
20. How much physical pain have you had during the past 4 weeks?
- None
- Very mild
- Mild
- Moderate
- Severe
- Very Severe

21. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?
- Not at all
- A little bit
- Moderately
- Quite a bit
- Extremely

22. These questions are about how you feel and how things have been with you during the past 4 weeks. Please give the one answer that is closest to the way you have been feeling for each item.

Did you feel full of life?
- All of the Time
- Most of the Time
- A Good Bit of the Time
- Some of the Time
- A Little of the Time
- None of the Time

Have you been a very nervous person?
- All of the Time
- Most of the Time
- A Good Bit of the Time
- Some of the Time
- A Little of the Time
- None of the Time
Have you felt so down in the dumps that nothing could cheer you up?

Have you felt calm and peaceful?

Did you have a lot of energy?

Have you felt downhearted and blue?

Did you feel worn out?

Have you been a happy person?

Did you feel tired?
24. During the past 4 weeks how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives)?

O 1 - All of the time   O 2 – Most of the time   O 3 – Some of the time
O 4 – A little of the time   O 5 – None of the time

25. How TRUE or FALSE is each of the following statements for you?

I seem to get sick a little easier than other people

O Definitely True O Mostly True O Don’t Know O Mostly False
O Definitely False

I am as healthy as anybody I know

O Definitely True O Mostly True O Don’t Know O Mostly False
O Definitely False

I expect my health to get worse

O Definitely True O Mostly True O Don’t Know O Mostly False
O Definitely False

My health is excellent

O Definitely True O Mostly True O Don’t Know O Mostly False
O Definitely False

We are interested in finding out about the kinds of physical activities that paramedics do as part of their everyday lives. These questions will ask
you about the time you spent being physically active in the last 7 days. Please answer each question even if you do not consider yourself to be an active person. Think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the VIGOROUS activities that you did in the last 7 days.

Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal.

Think only about those physical activities that you did for at least 10 minutes at a time.

24. During the last 7 days, on how many days did you do VIGOROUS physical activities like heavy lifting, digging, aerobics, or fast bicycling for at least 10 minutes at a time?

O 0 days
O 1 day
O 2 days
O 3 days
O 4 days
O 5 days
O 6 days
O 7 days

25. How much time did you usually spend doing VIGOROUS physical activity on those days? (Please answer in hours and/or minutes)

Hours: ______
Minutes: ______

Think about all the MODERATE activities that you did in the last 7 days.

Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal*.
Think only about those physical activities that you did for at least 10 minutes at a time.

* Please do not include walking as this will be considered separately.

26. During the last 7 days, on how many days did you do MODERATE physical activities* like carrying light loads, bicycling at a regular pace, or doubles tennis for at least 10 minutes at a time?

O 0 days
O 1 day
O 2 days
O 3 days
O 4 days
O 5 days
O 6 days
O 7 days

27. How much time did you usually spend doing MODERATE physical activity on those days? (Please answer in hours and/or minutes)

Hours: __________
Minutes: __________

Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

28. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

O 0 days
O 1 day
O 2 days
O 3 days
29. How much time did you usually spend walking on those days? (Please answer in hours and/or minutes)

Hours: _________
Minutes: _________

This question is about the time you spent sitting on work days over the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

30. Over the last 7 days, how much time did you spend sitting on a work day?

(Please answer in hours and/or minutes)

Hours: _________
Minutes: _________

Fit for Duty

31. Has your exercise frequency and duration been about the same for a period of 6 months or more?

O Yes, about the same

O No, I am now exercising more often and/or for longer duration

O No, I am now exercising less often and/or for shorter duration
32. Are you a smoker?

O Yes
O Occasional
O No, ex-smoker
O No, never smoked

33. Have you considered or attempted to quit smoking?

O Yes
O No

Thank you for taking the time to complete this survey. Please encourage your coworkers to complete it as well.

We will be starting studies shortly to quantify the physiological changes of paramedics while working, in simulation and after an exercise intervention.

If you are interested in the upcoming studies of this project and/or would like to be a participant than you can contact me by clicking this link.

Please know that your answers and responses to this survey will remain anonymous at all times.
# APPENDIX 2 RPE CHART

## Rating of Perceived Exertion (RPE Scale)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
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<tbody>
<tr>
<td>10</td>
<td>Maximal</td>
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<tr>
<td>9</td>
<td>Really, Really, Hard</td>
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<tr>
<td>8</td>
<td>Really Hard</td>
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<tr>
<td>7</td>
<td></td>
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<tr>
<td>6</td>
<td>Hard</td>
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<td>5</td>
<td>Challenging</td>
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<td>4</td>
<td>Moderate</td>
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<td>3</td>
<td>Easy</td>
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<td>2</td>
<td>Really Easy</td>
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<td>1</td>
<td>Rest</td>
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<td>Date</td>
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<td>12 hours</td>
<td>5</td>
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<td>14 hours</td>
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</tbody>
</table>
PARTICIPANT INFORMATION & CONSENT FORM

CLINICAL RESEARCH

The Physical Demands of Paramedic Job Performance:

Examining Physical and Job Specific Demands in the Workplace

Invitation

You are invited to participate in a research study into how physiological and other selected variables may be affected by attending emergency call outs as a paramedic.

Mr Alexander MacQuarrie, School of Biomedical Sciences, Charles Sturt University and Mr Richard High, NSW Ambulance are conducting the study

The study is part of a collaborative project between Charles Sturt University and NSW Ambulance.

Before you decide whether or not you wish to participate in this study, it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully and discuss it with others if you wish.

1. What is the purpose of this study?

The purpose of this study is to study several physiological and other parameters of paramedics while they are working and responding to calls. We will be measuring heart rate, respiratory rate and volume, blood pressure, force production (through accelerometry) and self-reported exertion levels (Rate of Perceived Exertion - RPE).

We hypothesise that these parameters will increase markedly during an ambulance response. This information gathered will be used in two ways: to inform researchers, industry and paramedics about physiological changes while a paramedic works and to design a testing protocol for further studies as part of this research project.

2. Why have I been invited to participate in this study?

...
You have been invited to participate because you are a paramedic employed by NSW Ambulance. Recently, you completed an online survey as part of another study in this project. As part of the information package accompanying that survey, paramedics who may be interested in participating in this study were asked to forward contact details to the principal researcher. You have provided those details.

3. What if I don’t want to take part in this study, or if I want to withdraw later?

Participation is voluntary. It is completely up to you whether or not you participate. If you decide not to participate, it will not affect the treatment you receive now or in the future.

If you wish to withdraw from the study once it has started, you can do so at any time without having to give a reason.

4. What does this study involve?

If you agree to participate in this study, you will be asked to sign this Participant Consent Form.

Research will be conducted over a series of scheduled shifts (a total of eight shifts if you are Metropolitan rostered paramedic or a total of twelve shifts if you are a Rural/Regional rostered paramedic)

The study procedures are as follows:

1. Potential participants are asked for expression of interest through NSW Ambulance corporate messaging and through an online health survey. Interested paramedics are asked to submit contact details. The Principal Researcher will contact all on the list with more information on the project;
2. Potential participants will review the information and determine if they a) wish to participate and b) meet all the inclusion and none of the exclusion criteria. If (a) and (b) are met, then they are to contact the researcher;
3. Potential participants will be oriented to the study by the researcher on a one to one basis either in person, by phone or by other electronic means;
4. Participants will be expected to be sized for and wear a Hexoskin biometric shirt that will be worn while on duty under the uniform shirt. It will include a data pack and cable. For metropolitan paramedics, the data collection period will be eight shifts. For rural/regional paramedics the data collection will be twelve shifts (this will not include “on call” portions of the roster). Participants have to have access to a smartphone (Android or Apple) to monitor the Hexoskin®. An app will have to be downloaded from
iTunes or Play Store at no cost to the participant for that purpose.

5. They will also be issued a wrist blood pressure cuff (iHealth) meant for intermittent blood pressure testing. This cuff can be kept in a uniform pocket when not in use. Participants will have to have access to a smartphone (Android or Apple) to use the cuff. An app will be downloaded from iTunes or Play Store at no cost to the applicant for that purpose;

6. They will be issued a Study Logbook to record blood pressure and rate of perceived exertion data at various points through the shift;

7. At the beginning of each shift, the participant will don the Hexoskin® and ensure it is monitoring and recording. He/she will also take their own baseline blood pressure and rate of perceived exertion readings (to be recorded in the logbook)

8. The participant is responsible for acquiring and recording blood pressure and RPE readings intermittently through the shift: either every two hours or after the end of each call. All data must be recorded in the logbook supplied. Hexoskin® data is taken and recorded continuously throughout the shift in a data pack embedded in the shirt. **Note that the participant can postpone these two hourly BP measures due to operational demands**;

9. At the end of each shift, the participant must connect the data pack from the Hexoskin® to a computer with access to the internet. The computer must have the Hexoskin® software for downloading installed (supplied at no cost to participant) Data will be uploaded to a secure website for later analysis. At the same time, the data pack will be recharged for the next shift. The participant must also re-charge the wrist blood pressure cuff in the same manner;

10. At the end of the 8 or 12 shifts, the participant will post the Hexoskin®, accessories, blood pressure cuff, and logbook in a pre-addressed and stamped package to the Principal Researcher at Charles Sturt University;

11. The data collected from the Hexoskin®, blood pressure cuff and RPE report will be analysed with respect to calls and call times from each shift. The call times will be derived from data from the NSW Ambulance Communications Center

5. How is this study being paid for?

The study is being sponsored a grant from Paramedics Australasia. The researchers declare no conflict of interest.

6. Are there risks to me in taking part in this study?

All medical procedures involve some risk of injury. In addition, there may be risks associated with this study that are presently unknown or unforeseeable. In spite of all reasonable precautions, you might develop
medical complications from participating in this study. The known risks of this study are:

1. The Hexoskin® biometric shirt will be individually sized for each participant. The shirt is meant to be tight and may cause slight discomfort. Wearing the shirt in hot weather may cause a slight increase in core temperature. The participant may discontinue wearing if too hot.
2. The wrist blood pressure cuff will cause slight discomfort while inflating. The participant can discontinue or stop the inflation at any time.

There may also be risks associated with this trial that are presently unknown or unforeseeable.

7. What are the alternatives to participation?

There are no identified alternatives to participation.

8. What happens if I suffer injury or complications as a result of the study?

If you suffer any injuries or complications as a result of this study, you should contact a doctor as soon as possible, who will assist you in arranging appropriate medical treatment.

You may have a right to take legal action to obtain compensation for any injuries or complications resulting from the study. Compensation may be available if your injury or complication is caused by the procedures, or by the negligence of any of the parties involved in the study. If you receive compensation that includes an amount for medical expenses, you will be required to pay for your medical treatment from those compensation monies.

If you are not eligible for compensation for your injury or complication under the law, but are eligible for Medicare, then you can receive any medical treatment required for your injury or complication free of charge as a public patient in any Australian public hospital.

9. Will I benefit from the study?

This study aims to further knowledge about the physical demands of paramedic job performance and may improve workplace practices. There is no direct benefit to the study participant.

10. Will taking part in this study cost me anything and will I be paid?
Participation in this study will not cost you anything. There is no compensation for study participants. You will be asked to upload stored data from the data pack of the Hexoskin® biometric shirt. NSW Ambulance will make a station computer and internet connection available for you to do this. If you are uploading from a personal home computer and need reimbursement for internet use, please contact the researcher.

11. How will my confidentiality be protected?

Your participation will be anonymous and your individual data will not be shared with your employer or any other body, or except as required by law.

Every effort will be made by the researcher to preserve your confidentiality including the following:

- Assigning code names/numbers for participants that will be used on all research notes and documents
- Keeping any cloud storage site (i.e. Hexoskin®) password protected by the Principal Researcher – Alex MacQuarrie
- Keeping electronic data files on the password protected computer and/or shared drive of the Principal Researcher - Alex MacQuarrie
- Keeping notes and any other identifying participant information in a locked file cabinet in the personal possession of the Principal Researcher – Alex MacQuarrie

Participant data will be kept confidential except in cases where the researcher is legally obligated to report specific incidents. These incidents include, but may not be limited to, incidents of abuse and suicide risk.

12. What happens with the results?

If you give us your permission by signing the consent document, we plan to discuss/publish the results in peer-reviewed journals and as part of a doctoral thesis, the HREC for monitoring purposes, presentations at conferences or other professional forums.

In any publication, information will be provided in such a way that you cannot be identified. Results of the study will be provided to you, if you wish.

13. What should I do if I want to discuss this study further before I decide?

When you have read this information, the researcher, Alex MacQuarrie will discuss it with you and any queries you may have. If you would like
to know more at any stage, please do not hesitate to contact him on 02 6338 4757 or amacquarrie@csu.edu.au

14. Who should I contact if I have concerns about the conduct of this study?

The South Eastern Sydney Local Health District Human Research Ethics Committee has approved this study. Any person with concerns or complaints about the conduct of this study should contact the Research Support Office which is nominated to receive complaints from research participants. You should contact them on 02 9382 3587, or email RSOseslhd@sesiahs.health.nsw.gov.au and quote 15/328 (HREC/15/POWH/584)

The conduct of this study at NSW Ambulance has been authorised. Any person with concerns or complaints about the conduct of this study may also contact the Research Governance Officer on (02) 9779 3851 and quote protocol number 14/270.

Thank you for taking the time to consider this study.

If you wish to take part in it, please sign the attached consent form.

This information sheet is for you to keep.

END OF FORM
The Physical Demands of Paramedic Job Performance:
Examining Physical and Job Specific Demands in the Workplace

1. I.............................................................
   Of............................................................................................................
   agree to participate in the study described in the participant information statement (attached as a separate form).

2. I acknowledge that I have read the participant information statement, which explains why I have been selected, the aims of the study and the nature and the possible risks of the investigation, and the statement has been explained to me to my satisfaction.

3. Before signing this consent form, I have been given the opportunity of asking any questions relating to any possible physical and mental harm I might suffer as a result of my participation and I have received satisfactory answers.

4. I understand that I can withdraw from the study at any time without prejudice to my relationship to Charles Sturt University or New South Wales Ambulance

5. I agree that research data gathered from the results of the study may be published, provided that I cannot be identified.

6. I understand that if I have any questions relating to my participation in this research, I may contact Mr Alex MacQuarrie on telephone 02 6338 4757 or mobile 04 9717 9447 or amacquarrie@csu.edu.au, who will be happy to answer them.

7. I acknowledge receipt of a copy of this Consent Form and the Participant Information Statement.

Complaints may be directed to the Research Ethics Secretariat, South Eastern Sydney Local Health District, Prince of Wales Hospital, Randwick NSW 2031 Australia (phone 02-9382 3587, fax 02-9382 2813, email RSOseslhd@sesiahs.health.nsw.gov.au.)
Charles Sturt University and NSW Ambulance

The Physical Demands of Paramedic Job Performance:
Examining Physical and Job Specific Demands in the Workplace

WITHDRAWAL OF CONSENT

I hereby wish to WITHDRAW my consent to participate in the study described above and understand that such withdrawal WILL NOT jeopardise any treatment or my relationship with Charles Sturt University or NSW Ambulance
PARTICIPANT INFORMATION & CONSENT FORM

CLINICAL RESEARCH

Study 3

The Physical Demands of Paramedic Job Performance:

Examining Physical and Job Specific Demands in the Workplace
Invitation

Recently, you participated (or are currently participating) in a research study into the physiological changes that occur when a paramedic attends emergency and non-emergency calls (HREC/15/POWH/584)

This study is being conducted by Mr. Alexander MacQuarrie, Doctoral Researcher, Charles Sturt University and Mr Richard High, Health and Wellness Program Manager, NSW Ambulance and is part of a collaborative project between Charles Sturt University and NSW Ambulance.

We are exploring several more aspects of the physical demands of paramedic job performance and are inviting you to participate. Before you decide whether or not you wish to participate, it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully and discuss it with others if you wish.

1. ‘What is the purpose of this study?’

The first part of this study you completed focused on quantifying some of the physical demands of paramedic job performance through the measurement of heart rate, respiratory rate and volume and blood pressure, as well as cumulative acceleration forces before, during and after emergency and other calls. Data were gathered on heart rate, respiratory rate and blood pressure, accelerometry, and self-rating of exertion using the Rate of Perceived Exertion (RPE) scale.

This amendment to the original study has three objectives:

a) Beep Test: To establish your level of cardio-respiratory fitness through participation in the “Beep Test” also known as the 20 m multistage shuttle test. This data can then be used to better interpret the data acquired through the recent field collection. See 4A below

b) Survey: To survey you about your attitudes towards exercise, health and wellness and recent physical activity. These data can then be compared to NSW Ambulance paramedic population and the Australian general population responses from Study 1 (HREC ref no: 15/031 (LNR/15/POWH/68) See 4B below

c) On Call Nights: To include the collection of physiological data via Hexoskin® for the “on call” portion of your regular rotating schedule (only in Rural/Regional settings). See 4C below
2. ‘Why have I been invited to participate in this study?’

You have been invited to participate because you are currently enrolled as a participant in Study 2.

3. ‘What if I don’t want to take part in this study, or if I want to withdraw later?’

Participation in this portion of the study is voluntary. It is completely up to you whether or not you participate. If you decide not to participate, it will not affect your relationship with your employer, NSW Ambulance.

You will be kept informed of any significant new findings that may affect your willingness to continue in the study. If you wish to withdraw from the study once it has started, you can do so at any time without having to give a reason.

There are no consequences that may arise from withdrawing from the study.

4. ‘What does this study involve?’

If you agree to participate in this study, you will be asked to sign the Participant Information and Consent Form found at the end of this document.

If you agree to participate in this portion of the study, you will then be asked to follow the testing protocol:

A) Beep Test Protocol

1. Prior to the test you will be asked to complete the Adult Pre-Exercise Screening Tool – Stage One. IF YOU ANSWERED ‘YES’ to any of the 7 questions in Stage One, please seek guidance from your GP or appropriate allied health professional regarding your ability to complete the test.

2. You will be asked to wear the same Hexoskin® biometric shirt as you had previously used in this study. It will record your heart rate and respiratory data.

3. Wearing comfortable clothes and sneakers, you will be asked to position yourself on the start-line at one end of the 20 metre course. The audio CD will alert you that the test will start in 5 seconds, with the sound of a ‘triple beep’.

4. When the test starts, you need to jog the 20 metres so that your arrival at the opposite end line coincides with the next single beep. When you arrive, you need to place one foot on or over the line, pivot and turn, making your way back to the ‘start’ line in time for the next single beep. If you arrive at either end of the course prior to the beep, you must wait there...
until the beep sounds before making your way back in the opposite direction.

5. After approximately each minute, a triple beep will sound, indicating the start of the next 'level' of the test. Each time this occurs, the time between beeps decreases. Your running speed must then increase to maintain the required pace.

6. You must continue back and forth over the 20 metre course until you can no longer reach the end lines in time with the beeps. The test finishes when you (a) reach volitional exhaustion and cannot go any further, or (b) you record two consecutive misses at reaching the lines in time for the beep. Once either of these occurs, your test is finished and your score will be recorded as the last successfully completed level and shuttle. Once you have finished the test, you will be directed to cool down by slowly moving around away from the test area.

B) Survey

You will be asked to complete a short, paper based survey (approximate time to completion is 10 minutes) that has previously been used to survey the population of paramedics working for NSW Ambulance. Please note the survey results will be identifiable to the Chief Investigator only.

C) If you are currently rostered in the Rural/Regional posting area of NSW Ambulance and a portion of your regular rotating scheduling includes an “on-call” shift or shifts we would like to continue data collection with you similar to what you have (or had) been doing. We are asking for you to wear the Hexoskin® shirt as per the original protocol for Study 2. The objective is to monitor all your shifts in one rotation, including on call nights.

5. ‘How is this study being paid for?’

The study is being sponsored with funding partially provided through a grant from Paramedics Australasia. There is no declared conflict of interest between the researchers, the university and the funding body.

All of the money being paid by the sponsor to run the trial will be deposited into an account managed by Charles Sturt University. No money is paid directly to individual researchers.

6. ‘Are there risks to me in taking part in this study?’
All procedures involve some risk of injury. In addition, there may be risks associated with this study that are presently unknown or unforeseeable. In spite of all reasonable precautions, you might develop medical complications from participating in this study.

The known risks of this amended study are:

3. For (A) you are being asked to participate in a fitness test. You will be closely monitored before, during and after the test. You may feel a level of discomfort from participating and can stop at any time.
4. The Hexoskin® biometric shirt worn for the test will be individually sized for each participant. The shirt is meant to be tight and may cause slight discomfort. Wearing the shirt in hot weather may cause a slight increase in core temperature. The participant may discontinue wearing if too hot.
5. For (B) you are being asked to complete a short survey. You may feel uncomfortable in answering questions and can discontinue at any time.
6. For (C) you will be following the same testing protocol as with your previous participation in Study 2, with the exception that you will be wearing the Hexoskin® during sleep hours. See (2) above.

There may also be risks associated with this trial that are presently unknown or unforeseeable.

7. 'What happens if I suffer injury or complications as a result of the study?'

If you suffer any injuries or complications as a result of this study, you should contact a doctor as soon as possible, who will assist you in arranging appropriate medical treatment.

You may have a right to take legal action to obtain compensation for any injuries or complications resulting from the study. Compensation may be available if your injury or complication is caused by the procedure, or by the negligence of any of the parties involved in the study. If you receive compensation that includes an amount for medical expenses, you will be required to pay for your medical treatment from those compensation monies.

If you are not eligible for compensation for your injury or complication under the law, but are eligible for Medicare, then you can receive any medical treatment required for your injury or complication free of charge as a public patient in any Australian public hospital.
8. ‘Will I benefit from the study?’

This study aims to further knowledge of paramedic health and wellness and may improve future workplace practices for paramedics; however, it will not directly benefit you.

9. ‘Will taking part in this study cost me anything, and will I be paid?’

Participation in this study will not cost you anything. You will not be reimbursed for your time.

10. ‘How will my confidentiality be protected?’

Of the people involved in this research involving you, only Mr. Alexander MacQuarrie will know whether or not you are participating in this study. Any identifiable information that is collected about you in connection with this study will remain confidential and will be disclosed only with your permission, or except as required by law. Only the researcher named above will have access to your details and results that will be held securely at Charles Sturt University, Panorama Avenue, Bathurst, NSW, AUSTRALIA, 2795.

Your participation will be anonymous and your individual data will not be shared with your employer or any other body, or except as required by law.

Every effort will be made by the researcher to preserve your confidentiality including the following:

- Assigning code names/numbers for participants that will be used on all research notes and documents
- Keeping any cloud storage site (i.e. Hexoskin®) password protected by the Principal Researcher – Alex MacQuarrie
- Keeping electronic data files on the password protected computer and/or shared drive of the Principal Researcher - Alex MacQuarrie
- Keeping notes and any other identifying participant information in a locked file cabinet in the personal possession of the Principal Researcher – Alex MacQuarrie

Participant data will be kept confidential except in cases where the researcher is legally obliged to report specific incidents. These incidents include, but may not be limited to, incidents of abuse and suicide risk.

11. ‘What happens with the results?’

If you give us your permission by signing the consent document, we plan to discuss/publish the results in the following ways: the HREC for monitoring purposes, peer-reviewed journals, presentation at 331
conferences or other professional forums, and to form part of a doctoral thesis.

In any publication, information will be provided in such a way that you cannot be identified. Results of the study will be provided to you, if you wish.

14. ‘What should I do if I want to discuss this study further before I decide?’

When you have read this information, the researcher, Mr. Alex MacQuarrie will discuss it with you and any queries you may have. If you would like to know more at any stage, please do not hesitate to contact him on 02 6338 4757, or 04 9717 9447 or amacquarrie@csu.edu.au

15. ‘Who should I contact if I have concerns about the conduct of this study?’

The South Eastern Sydney Local Health District Human Research Ethics Committee has approved this study. Any person with concerns or complaints about the conduct of this study should contact the Research Support Office, which is nominated to receive complaints from research participants. You should contact them on 02 9382 3587, or email SESLHD-RSO@health.nsw.gov.au and quote HREC reference number 15/328 (HREC/15/POWH/584).

The conduct of this study has been authorised by NSW Ambulance. Any person with concerns or complaints may also contact the NSW Ambulance Research Governance Officer on 02 9779 3851, or email research@ambulance.nsw.gov.au and quote protocol number 14/270.

Thank you for taking the time to consider this study.

If you wish to take part in it, please sign the attached consent form.

This information sheet is for you to keep.

END OF FORM
The Physical Demands of Paramedic Job Performance:
Examining Physical and Job Specific Demands in the Workplace

1. I, .................................................................................................................................
of.................................................................................................................................
agree to participate in the study described in the participant information statement (attached as a separate form).

2. I acknowledge that I have read the participant information statement, which explains why I have been selected, the aims of the study and the nature and the possible risks of the investigation, and the statement has been explained to me to my satisfaction.

3. Before signing this consent form, I have been given the opportunity of asking any questions relating to any possible physical and mental harm I might suffer as a result of my participation and I have received satisfactory answers.

4. I understand that I can withdraw from the study at any time without prejudice to my relationship to Charles Sturt University or New South Wales Ambulance

5. I agree that research data gathered from the results of the study may be published, provided that I cannot be identified.

6. I understand that if I have any questions relating to my participation in this research, I may contact Mr Alex MacQuarrie on telephone 02 6338 4757 or mobile 04 9717 9447 or amacquarrie@csu.edu.au, who will be happy to answer them.
1. I acknowledge receipt of a copy of this Consent Form and the Participant Information Statement.

Complaints may be directed to the Research Ethics Secretariat, South Eastern Sydney Local Health District, Prince of Wales Hospital, Randwick NSW 2031 Australia (phone 02-9382 3587, fax 02-9382 2813, email SESLHD-RSO@health.nsw.gov.au)

Signature of participant
Date

Please PRINT name

__________________________________________

Signature of witness
Date

Please PRINT name

__________________________________________

Signature of investigator
Date

Please PRINT name

__________________________________________

END OF FORM
ADULT PRE-EXERCISE SCREENING TOOL

This screening tool does not provide advice on a particular matter, nor does it substitute for advice from an appropriately qualified medical professional. No warranty of safety should result from its use. The screening system in no way guarantees against injury or death. No responsibility or liability whatsoever can be accepted by Exercise and Sports Science Australia, Fitness Australia or Sports Medicine Australia for any loss, damage or injury that may arise from any person acting on any statement or information contained in this tool.

Name: ____________________________
Date of Birth: ____________________ Male [ ] Female [ ] Date: ____________________

STAGE 1 (COMPULSORY)

Aims: to identify those individuals with a known disease, or signs or symptoms of disease, who may be at a higher risk of an adverse event during physical activity/exercise. This stage is self-administered and self-evaluated.

Please circle response

1. Has your doctor ever told you that you have a heart condition or have you ever suffered a stroke? [ ] Yes [ ] No

2. Do you ever experience unexplained pains in your chest at rest or during physical activity/exercise? [ ] Yes [ ] No

3. Do you ever feel faint or have spells of dizziness during physical activity/exercise that causes you to lose balance? [ ] Yes [ ] No

4. Have you had an asthma attack requiring immediate medical attention at any time over the last 12 months? [ ] Yes [ ] No

5. If you have diabetes type I or type II have you had trouble controlling your blood glucose in the last 3 months? [ ] Yes [ ] No

6. Do you have any diagnosed muscle, bone or joint problems that you have been told could be made worse by participating in physical activity/exercise? [ ] Yes [ ] No

7. Do you have any other medical condition(s) that may make it dangerous for you to participate in physical activity/exercise? [ ] Yes [ ] No

If you answered ‘Yes’ to any of the 7 questions, please seek guidance from your GP or appropriate allied health professional prior to undertaking physical activity/exercise.

If you answered ‘No’ to all of the 7 questions, and you have no other concerns about your health, you may proceed to undertake light-moderate intensity physical activity/exercise.

I believe that to the best of my knowledge, all of the information I have supplied within this tool is correct.

Signature ____________________________ Date ____________________

This tool is designed to assist individuals in determining their fitness level and to identify those who may need medical consultation before starting an exercise program. It is not intended to be used as a substitute for medical advice.

V1 (2011)

ESSA • Fitness Australia • Sports Medicine Australia
19 February 2015

Alexander MacQuarrie
Lecturer, Paramedic Program
School of Biomedical Sciences Paramedic Program
Charles Sturt University
Panorama Avenue
BATHURST NSW 2795

Dear Alexander,

HREC ref no: 15/D31 (LNR/15/POWH/68)

Project title: Physical Demands of Paramedic Job Performance and their effect on Job Specific Skills – Study 1: Surveying paramedic Health Status and Physical Activity Level

Thank you for submitting the above Low/Negligible risk (LNR) Application for review by the Human Research Ethics Committee (HREC). Based on the information you have provided and in accordance with the NHMRC guidelines [National Statement 2007 – Section 5 Institutional Responsibilities and “When does quality assurance in health care require independent ethical review?” (2003)], this project has been assessed as low risk and is therefore exempt from full HREC review.

The project was first considered by the LNR Committee on Tuesday 17 February 2015.

I am pleased to advise that ethical approval has been granted for this project to be conducted at the following site(s):

- NSW Ambulance Service

The following documentation has been approved:

- Low/negligible risk application, submission code AU/6/CBEC110, dated 2 February 2015
- Study 1 Background and Protocol, not dated
- Key Messaging Study, not dated
- Fit for Duty Survey, not dated

Conditions of approval

[Stamp: Prince of Wales Hospital Community Health Services]
[Stamp: Randwick NSW 2031]

2015.02.19. Approval of LNR  Page 1 of 2
1. This approval is valid for 5 years from the date of this letter.
2. Annual reports must be provided on the anniversary of approval.
3. A final report must be provided at the completion of the project.
4. Proposed changes to the research protocol, conduct of the research, or length of approval will be provided to the Committee.
5. The Principal Investigator will immediately report matters which might warrant review of ethical approval, including unforeseen events which might affect the ethical acceptability of the project and any complaints made by study participants.

For NSW Public Health sites only: You are reminded that this letter constitutes ethical approval only. You must not commence this research project until you have submitted your Site Specific Assessment (SSA) to the Research Governance Officer of the appropriate institution and have received a letter of authorisation from them.


Please quote HREC ref no: 15/031 in all correspondence.

We wish you every success in your research.

Yours sincerely

Amanda Iden
Acting Executive Officer, Human Research Ethics Committee

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007). NHMRC and Universities Australia/Australian Code for the Responsible Conduct of Research (2007) and the COmMACH Note for Guidance on Good Clinical Practice.

2016.02.10. Approval of LNFL  Page 2 of 2
Dear Alexander

Thank you for advising your project entitled Fit for Duty: Physical Demands of Paramedic Job Performance and Their Effect on Job Specific Skills - Study 2: Physical and Job Specific Demands in the Paramedic Workplace has been approved by the Southeast Sydney Local Health District Research Ethics Committee. The Charles Sturt University Human Research Ethics Committee operates in accordance with the National Health and Medical Research Council’s National Statement on Ethical Conduct in Research Involving Humans and as such accepts other fully constituted Human Research Ethics Committees determinations.

Consequently, I am pleased to advise the Charles Sturt University Human Research Ethics Committee has approved your project for a twelve-month period from the date of this email, and has been issued with the protocol number HS09/6. Please refer to this protocol number in all correspondence with the committee.

Please note the following conditions of approval:

- all consent forms and information sheets are to include the Charles Sturt University logo or letterhead, if possible - students should liaise with their supervisor to arrange to have these documents printed;
- you must notify the committee immediately in writing should your research differ in any way from that proposed - forms available at [http://www.csu.edu.au/research/ethical_safety/human/ethic_manager](http://www.csu.edu.au/research/ethical_safety/human/ethic_manager);
- you must notify the committee immediately if any serious and or unexpected adverse events or outcomes occur associated with your research, that might affect the participants and therefore ethical acceptability of the project – forms available from the link above;
- amendments to the research design must be reviewed and approved by the Human Research Ethics Committee before commencement – forms available from the link above;
- if an extension of the approval period is required, a request must be submitted to the Human Research Ethics Committee – forms available from the link above;
- you are required to complete a Report on Research Project annually, if your research has not been completed within the approval period – forms available from the link above;
- you are required to submit a final report at the completion of your research project – forms available at the link above.

Your are reminded that approval from the Charles Sturt University Human Research Ethics Committee constitutes ethical approval only. If your research involves the use of radiation, biological materials, chemicals or animals a separate approval is required from the appropriate committee.

If you have any questions please do not hesitate to contact me.

All the best with your research.

Kind regards

Regan

Regan McIntosh
Dear Mr MacQuarrie,

HREC ref no: 15/328 (HREC/15/POWH/584)
Project title: Fit for Duty: Physical Demands of Paramedic Job Performance and Their Effect on Job Specific Skills Study 2 (Physical and Job Specific Demands in the Paramedic Workplace)

Thank you for submitting the above application for ethical and scientific review and for your correspondence dated 19 May 2016 to the Executive Officer responding to questions which arose at the Executive Committee meeting on 20 April 2016. Authority to grant final approval was delegated to the Executive Officer and I am pleased to advise that ethical approval has been given for the following:

- NEAF application submission code AU/1/SA82210, dated 16 November 2015
- Participant Information Sheet & Consent Form [Version 4 dated 17 March 2016]
- Paramedic Log Book dated 23 January 2016
- Study 2 Protocol [Version 2 dated 23 January 2016]

Ethical approval is valid for the following site(s):

- New South Wales Ambulance

Conditions of approval:

1. This approval is valid for 5 years from the date of this letter.
2. Annual reports must be provided on the anniversary of approval.
3. A final report must be provided at the completion of the project.
4. Proposed changes to the research protocol, conduct of the research, or length of approval will be provided to the Committee.

5. The Principal Investigator will immediately report matters which might warrant review of ethical approval, including unforeseen events which might affect the ethical acceptability of the project and any complaints made by study participants.


Please quote 15/328 in all correspondence.

We wish you every success in your research.

Yours sincerely,

Andrew Baldwin
Executive Officer, Research Support Office

This PReS is constituted and operates in accordance with the National Health and Medical Research Council (NHMRC) National Statement on Ethical Conduct in Human Research (2007), NHMRC and Universities Australia, Associated Code for the Responsible Conduct of Research (2007) and the PReS Code (2009) for Guidance on Good Clinical Practice.
Dear Alexander,

Thank you for advising your project entitled 'fit for duty: physical demands of Paramedic Job Performance and Their Effect on Job Specific Skills - Study 2: Physical and Job Specific Demands in the Paramedic Workplace' has been approved by the Southeast Sydney Local Health District Research Ethics Committee. The Charles Sturt University Human Research Ethics Committee operates in accordance with the National Health and Medical Research Council's National Statement on Ethical Conduct in Research Involving Humans and as such accepts other fully constituted Human Research Ethics Committee determinations.

Consequently, I am pleased to advise the Charles Sturt University Human Research Ethics Committee has approved your project for a twelve-month period from the date of this email, and has been issued with the protocol number 1660/16. Please refer to this protocol number in all correspondence with the committee.

Please note the following conditions of approval:

- all consent forms and information sheets are to include the Charles Sturt University logo or letterhead, if possible - students should liaise with their supervisor to arrange to have these documents printed;
- you must notify the committee immediately in writing should your research differ in any way from that proposed - forms available at [http://www.csu.edu.au/research/ethics_safety/humanresearch_managing](http://www.csu.edu.au/research/ethics_safety/humanresearch_managing);
- you must notify the committee immediately if any serious and/or unexpected adverse events or outcomes occur associated with your research, that might affect the participants and therefore ethical acceptability of the project – forms available from the link above;
- amendments to the research design must be reviewed and approved by the Human Research Ethics Committee before commencement – forms available from the link above;
- if an extension of the approval period is required, a request must be submitted to the Human Research Ethics Committee – forms available from the link above;
- you are required to complete a Report on Research Project annually, if your research has not been completed within the approval period – forms available from the link above;
- you are required to submit a final report at the completion of your research project – forms available at the link above.

Your are reminded that approval from the Charles Sturt University Human Research Ethics Committee constitutes ethical approval only, if your research involves the use of radiation, biological materials, chemicals or animals a separate approval is required from the appropriate committee.

If you have any questions please do not hesitate to contact me.

All the best with your research.

Kind regards,

Regan McIntosh
Amendment to Study 2 Ethics for Study 3 Charles Sturt University Ethics Committee

18 August 2016

Mr Alexander MacQuarie
Charles Sturt University
Paramedic Program
Panorama Avenue
BATHURST NSW 2795

Dear Mr MacQuarie,

The Charles Sturt University (CSU) Human Research Ethics Committee (HREC) operates in accordance with the National Health and Medical Research Council’s National Statement on Ethical Conduct in Research Involving Humans.

The CSU HREC has reviewed your report requesting a variation for your research project “Examining Physical and Job Specific Demands of Paramedicine Students in Simulation”, protocol number H10066 and I am pleased to advise that this request for a variation meets the requirements of the National Statement, and variation for this research is granted for a twelve month period from the date of this letter.

Please note the following conditions of approval:

- all Consent Forms and Information Sheets are to be printed on Charles Sturt University letterhead. Students should liaise with their Supervisor to arrange to have these documents printed;
- you must notify the Committee immediately in writing should your research differ in any way from that proposed. Forms are available at [http://www.csu.edu.au/...](http://www.csu.edu.au/...);
- you must notify the Committee immediately if any serious and/or unexpected adverse events or outcomes occur associated with your research, that might affect the participants and therefore ethical acceptability of the project. An Adverse Incident form is available from the website as above;
- amendments to the research design must be reviewed and approved by the Human Research Ethics Committee before commencement. Forms are available at the website above;
- if an extension of the approval period is required, a request must be submitted to the Human Research Ethics Committee. Forms are available at the website above;
- if your research has not been completed by that date, you are required to submit a final report, the form is available from the website above.

You are reminded that an approval letter from the CSU HREC constitutes ethical approval only.

If your research involves the use of radiation, biological materials or chemicals separate approval is required from the appropriate University Committee.
Please don’t hesitate to contact the Governance Officer, telephone (02) 6338 4620 or email ethics@csu.edu.au if you have any enquiries about this matter.

Yours sincerely,

Regan McIntosh
Governance Officer
Human Research Ethics Committee
Direct Telephone: (02) 6338 4620
Emails: ethics@csu.edu.au

Cc: Dr James Wockham

This Charles Sturt University Human Research Ethics Committee is constituted and operates in accordance with the National Health and Medical Research Council’s (NHMRC) National Statement on Ethical Conduct in Human Research (2007)
Amendment to Study 2 Ethics for Study 3 Southeast Sydney Local Health District Ethics Committee

27 September 2016

Alexander MacQuarrie  
Charles Sturt University Paramedic Program  
Panoa Street Avenue  
BATHURST NSW 2795

Dear Mr MacQuarrie,

HREC ref no: 15/338 (HREC/15/POWH/564)  
Project title: Fit for Duty: Physical Demands of Paramedic Job Performance and Their Effect on Job Specific Skills Study 2 (Physical and Job Specific Demands in the Paramedic Workplace)

Thank you for your correspondence dated 5 September 2016 to the Human Research Ethics Committee (HREC) requesting an amendment to the above stated ethics approval. Your amendment request was reviewed at the Executive Committee meeting on 23 September 2016.

I am pleased to advise that the following documentation has been approved:
- Amendment Form, dated 05 September 2016
- Participant Information & Consent Form Amendment (Version 3 dated 27.09.16)
- Study 2 Amendment Beep Test Protocol Version 1 dated 28.08.16
- Study 2 Amendment Survey Version 1 dated 28.08.16
- Pre-Test Screening tool dated 28.08.16

Ethical approval is valid for the following site(s):
- New South Wales Ambulance

This amendment has also been reviewed by the Research Governance Officer at SESLHD. Further authorisation of the above approved documents is not required for any site that has the Research Governance conducted by the SESLHD Research Support Office. Implementation of this amendment can now proceed.

For multi-site projects reviewed by the HREC after 1 January 2011, a copy of this letter must be forwarded to all Principal Investigators at every site approved by the SESLHD.

Prince of Wales Hospital  
Community Health Services  
Barker Street  
Randwick NSW 2031

2015.08.27 Ethics Amendment Approval 15-338  
Page 1 of 2 11/11/2015
HREC for submission to the relevant Research Governance Officer along with a copy of the approved documents.

Should you have any queries, please contact the Research Support Office on (02) 9382 3387. The HREC Terms of Reference, Standard Operating Procedures, membership and standard forms are available from the Research Support Office website:

Please quote HREC ref no 15/328 in all correspondence.

We wish you every success in your research.

Yours sincerely,

Andrew Bonjke
Executive Officer, Human Research Ethics Committee

This HREC is constituted and operates in accordance with the National Health and Medical Research Council (NHMRC) National Statement on Ethical Conduct in Human Research (2007), NHMRC and University of Sydney Human Research Ethical Approval Guidelines and the International Ethical Guidelines for Pharmacological Research on Humans.
Amendment to ethics for Hexoskin® validation study

CSU Ethics committee

13 April 2016

Mr Pranee Titheradge
C/- Professor Rob Roberts
School of Human Movement Studies
BATHURST CAMPUS

Dear Mr Titheradge,

The CSU Human Research Ethics Committee (HREC) operates in accordance with the National Health and Medical Research Council’s National Statement on Ethical Conduct in Research Involving Humans.

The HREC has reviewed your report requesting an extension and variation for your research project “Validation of a Venturi tube for airflow and volume: Suitability for physiological applications”, protocol number 2014/182 and I am pleased to advise that this request for a variation meets the requirements of the National Statement and a variation for this research is granted for a twelve month period from 13/4/2016 subject to receipt of an updated Participant Information Sheet (also needs to identify the Researcher as a PhD student) as well as confirmation that nothing else has changed with the move to PhD.

Please note the following conditions of approval:

- subject to the receipt of information requested above;
- all Consent Forms and Information Sheets are to be printed on Charles Sturt University letterhead. Students should liaise with their Supervisor to arrange to have these documents printed;
- you must notify the Committee immediately in writing should your research differ in any way from that proposed. Forms are available at http://www.csu.edu.au/research/ethics_safety/human/hrec_managing you must notify the Committee immediately if any serious and/or unexpected adverse events or outcomes occur associated with your research, that might affect the participants and therefore ethical acceptability of the project. An Adverse Incident form is available from the website as above;
- amendments to the research design must be reviewed and approved by the Human Research Ethics Committee before commencement. Forms are available at the website above;
- if an extension of the approval period is required, a request must be submitted to the Human Research Ethics Committee. Forms are available at the website above;

www.csu.edu.au
• you are required to complete a Report On Research Project, which can be
downloaded as above, by 20/1/2017 if your research has not been completed by
that date;
• you are required to submit a final report; the form is available from the website
above.

You are reminded that an approval letter from the CSU HREC constitutes ethical
approval only.

If your research involves the use of radiation, biological materials or chemicals separate
approval is required from the appropriate University Committee.

Please don’t hesitate to contact the Executive Officer: telephone (02) 6538 4628 or
e-mail ethics@csu.edu.au if you have any enquiries about this matter.

Yours sincerely,

Regan McIntosh
Executive Officer
Human Research Ethics Committee
Direct Telephone: (02) 6538 4628
Email: ethics@csu.edu.au

Cc: Professor Rob Robins

This HREC is constituted and operates in accordance with the National Health and
Medical Research Council’s (NHMRC) National Statement on Ethical Conduct in
Human Research (2007)