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Health and Wellness of Royal Navy Personnel:
Trial of a Health & Wellness Programme for The Royal New Zealand Navy.

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Sport and Exercise
in
Endorsement of Exercise Prescription and Training

Massey University, Wellington, New Zealand.

Chance Rapheal Crawford-Mickleson

2019
Abstract

**Introduction:** It is essential for the Royal New Zealand Navy to ensure that all personnel are physically fit and maintain optimal physiological health for deployability. While access to health care and training facilities is provided, physiological health and physical fitness standard is up to the individual. This can potentially lead to sub-optimal health and wellness in military personnel. Therefore, the aim of this research is to trial a basic health and fitness screening programme among Royal New Zealand Navy personnel and compare results with healthy population data to ascertain any health and fitness issues that need to be addressed to ensure deployability of staff.

**Methods:** 91 male and female Royal New Zealand Navy participants (mean age of 34 years, 68.1% = male, 31.8% = female) volunteered for this study. Data was collected over two phases within the same day (between 0600 and 1500 hours). Phase one, participants arrived in a fasted state (12 hours) and blood cholesterol/glucose, resting heart rate and blood pressure, was obtained. On completion participants consumed breakfast. Phase two involved answering two questionnaires; (the AHA/ACSM health and fitness pre-participation screening questionnaire for general health and the Pittsburgh Sleep Quality Index questionnaire to measure sleep status over the past four weeks); and collection of anthropometric data (weight; height; waist circumference; hip circumference and right arm/leg length). Final assessment procedures involved the YMCA estimated VO$_{2\text{max}}$ test, Y-Balance and sit and reach test.

**Statistical analysis:** All data was first assessed for normal distribution and analysed using IBM SPSS Statistics 25. Data was grouped by age and/or gender and analysed using independent t-tests for first level comparisons, and univariate analyses for multi-level comparisons. Significance was set at p=0.05.

**Results:** Overall, results show that high density lipoprotein, estimated VO$_{2\text{max}}$, body mass index, Pittsburgh Sleep Quality Index and the AHA/ACSM health and fitness pre-participation screening questionnaire were near pre-published general population normal values. Analysis on age and gender showed that overall, females were healthier
than males but had lower VO$_{2\text{max}}$ and the <35 year age group performed better overall than the ≥35 year age group.

**Conclusion:** Those aged <35 years and who are female presented with less risk factors for cardiovascular disease than males and those aged ≥35 years, as a whole. Recommendations for a screening programme is provided.
Preface

This thesis has been written to fulfil the requirements of the Master of Sport and Exercise, Endorsement of Exercise Prescription and Training. Through 2017 to 2019, I (Chance Crawford-Mickleson) was the primary writer and researcher for this study. Supervision was provided by Dr Sally Lark and Dr Claire Badenhorst. While they supported my research by communicating how to format my writing, reduce errors in my methodology and present my results and discussion, physical writing was on my own accord.

This Master’s thesis is due to the collaboration between the Royal New Zealand Navy and Massey University. Major Jacques Rousseau, of the Royal New Zealand Army, approached Dr Lark, of Massey University, to see if it was possible to put together a short health and wellbeing screening programme for the Royal New Zealand Navy. The motivation behind the work was to provide the New Zealand Defence Force with a cost-effective health and wellness programme so they can ensure that all actively serving personnel are healthy and can be deployed.

Formation of research questions was via discussion between myself, Dr Lark and Major Rousseau. I researched each individual test to include in the screening programme and discussed each measure with both Dr Lark and Major Rousseau and providing sound reasoning on why it should be included.

Field testing was challenging, primarily due to Royal New Zealand Navy ships on deployment, delaying field testing time. Fortunately, Major Rousseau secured dates to commence testing. Although I had assistance in data collection, I coordinated all testing and persons, ensuring each tester was adequately trained. I was guided by Dr Lark on how to perform the statistical analysis. I completed all statistical tests, and interpretation of the results.

I feel privileged to have work with the New Zealand Defence Force on this project and understand that they also used it on battalions of the Royal New Zealand Army.
Acknowledgments

I would like to thank the Royal New Zealand Navy for the opportunity to devise a Health & Wellness programme, and their support and contribution in conducting study. Their willingness to accommodate the requirements of this research is really appreciated. Additionally, I would like to thank the participants of this study for taking the time out of their day to participate. I thoroughly enjoyed my time with each and every one and hope that the individual findings can be used in a positive manner.

I would also like to express my sincerer gratitude to my supervisor’s Dr Sally Lark and Dr Claire Badenhorst. Your guidance, expertise and attention to detail throughout this process has provide me with the core skills that can be transferred into many different areas of life.

To Major Jacques Rousseau of the Royal New Zealand Army. You were a vital part of this research of which would not be possible without your constant support and guidance both inside and outside of field testing. Thank you for everything you have done.

I would like to thank my mother, Leane, and my father, Stephen. Mum, thank you for teaching me that through perseverance, I can achieve anything I wish. Dad, thank you for teaching me the value of education and the self-discipline that is required to excel as a person.

Finally, I would like to thank my beautiful fiancée Sarah. Sarah, thank you for standing by me throughout this journey. You were a vital piece towards making my goal possible.
List of Abbreviations

RNZN: Royal New Zealand Navy
NZDF: New Zealand Defence Force
NZ: New Zealand
BP: Blood Pressure
BMI: Body Mass Index
WHR: Waist to Hip Ratio
PD: Premature Discharge
CVD: Cardiovascular Disease
US: United States
WHO: World Health Organisation
bpm: beats per minute
LDL: Low-Density Lipoproteins
HDL: High-Density Lipoproteins
UK: United Kingdom
AHA/ACSM: American Heart Association/American College of Sports Medicine
PSQI: Pittsburgh Sleep Quality Index
YBT: Y-Balance Test
LEYBT: Lower Extremity Y-Balance Test
UEYBT: Upper Extremity Y-Balance Test
rpm: revolutions per minute
ANOVA: Analysis of Variance
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CHAPTER 1. Introduction

The Royal New Zealand Navy (RNZN) is one of three branches of defence services which forms the New Zealand Defence Force (NZDF). Additional services are the Royal New Zealand Army and the Royal New Zealand Air Force. The primary objective of the RNZN is to protect the waters of New Zealand (NZ), performing rescue missions, disaster relief and maintaining international relations (RNZN, 2019). Secondary objectives reflect occupational and defence force obligations between the working hours of 0900 and 1700 hour (RNZN, 2018). Occupation tasks include performing tasks which relate to one’s profession within the military, such as mechanical work on ships. Additional NZDF obligations involve performing marching and combat drills (RNZN, 2019). Due to the sometimes high physical demand associated with these everyday occupational activities, it is important that both physiological health and physical fitness is maintained throughout an enlisted person contracted time, therefore ensuring all personnel are always ready for deployment.

The RNZN provides access to fitness facilities, healthy eating choices and free dental/medical check-ups (RNZN, 2018) as part of their responsibility to ensure a healthy work force and that their personnel are deployable. However, not all personnel take advantage of these facilities which, overtime, may mean a decline in physiological health and physical fitness. This implies that any declines in physiological health and physical fitness are linked with personal poor behavioural choices, which is suggested to be attributed to lack of education and/or motivation (Fryar, Herrick, Afful, & Ogden, 2016; Zinn et al., 2017).

Upon enlistment into the RNZN, all personnel are required to undergo a medical check and fitness test to ensure that they are not only physiologically healthy, but also physically fit (RNZN, 2019). For those who do not meet requirements, entry into the RNZN is not granted, and personnel are required to improve these standards upon their next enlistment attempt. However, while the RNZN have specific exclusion requirements (outlined in Factors Associated with Poor Health section of literature review – page 19), physical and physiological health standards are not always maintained (Eckart et al., 2004; Hoglin & Barton, 2015). Common health problems
experienced among NZDF personnel consist of, but are not limited to; high blood pressure (BP), weight gain (seen with increased body mass index (BMI) or waist to hip ratio (WHR)), type 2 diabetes, abnormal blood cholesterol and musculoskeletal injury which can increase the risk of premature discharge (PD) from their contracted time in the RNZN (Fryar et al., 2016; Iremonger, Atalag, Johnston, & Campbell, 2015; RNZN, 2018; Smith, Bono, & Slinger, 2017). This increases the NZDF financial expenditure, which has to balance the costs of enlistment into the NZDF and medical administration, which may not be equal to the duration spent in the NZDF (Hoglin & Barton, 2015).

Optimal health is associated with many benefits within a NZDF environment. Smith et al, (2017) suggested that those without health complications such as musculoskeletal injury, minor sickness or medical conditions have less days off from active duty and are more productive both inside and outside of working hours. However, when both physiological health and physical fitness decline below acceptable ‘healthy’ levels including changes to blood cholesterol, BMI, or required fitness levels, then there is an increased likelihood of developing health complications which may result in PD from the NZDF (Andersen, Grimshaw, Kelso, & Bentley, 2016; Iremonger et al., 2015; Neath & Quail, 2001). Nevertheless, while individuals may maintain health and fitness standards, duration within the NZDF is also associated with declining health which reflects the physiological effects of ageing (Baxi, Jackson, Ritter, & Sessums, 2011; RNZN, 2018).

For general populations, it is assumed that the physiological effects of ageing occur within the fifth decade of life, which can increase the likelihood of developing adverse health complications such as cardiovascular disease (CVD) (Mendoza-Nunez, 2016). The implications of ageing depend on many factors which include, but are not limited to; environmental, physiological, socio-economical, and psychological factors which if any of these or a combination are adverse, can promote the effects of ageing (Kenney, Wilmore, & Costill, 2015; Mendoza-Nunez, 2016). To help combat the effects of ageing, aerobic exercise (moderate intensity between 40-60% of one’s heart rate reserve at least 5 times a week) has been reported to have many positive effects on human physiology and is frequently used to improve one’s health status and lowering the risk of chronic disease (Kenney et al., 2015; ACSM, 2014). However, aerobic exercise
performance and capacity is reported to be different between males and females (Mosca, Barrett-Connor, & Kass Wenger, 2011). This is attributed to males having higher absolute levels of red blood cells and larger lung volume when compared to females which enhances the gas exchange during exercise and at rest (Sharma & Kailashiya, 2016). With regards to the NZDF, some professions (soldiers) are exposed to more physical activity than others (engineers, communications) throughout their years in service. However, the requirement to maintain physical fitness for service does not exclude personnel from participating in exercise outside of military working hours. According to the NZDF, (2017), within the RNZN, males represent 76.2% of the total population. Therefore, fitness requirements (see appendix 11) are scaled for females within the RNZN, meaning, males are required to attain higher fitness scores than females (RNZN, 2018). It should be noted that physically demanding occupations are not excluded from adverse health as increased time in the military often reflects increased rank which is associated with more administrative duties and hence more sedentary behaviour (Baxi et al., 2011).

Currently, minimal research has been conducted with regards to health and wellness of NZDF personnel and much less within the RNZN. While research has been conducted on musculoskeletal injuries (Iremonger et al., 2015), factors relating to PD (Hoglin & Barton, 2015) and the positive effects of exercise intervention/nutritional education (Zinn et al., 2017), to the researcher’s knowledge, no study exists which analyses physiological health, physical fitness and the susceptibility of musculoskeletal injury within the RNZN. Therefore, discussion of health and wellness within defence forces is extracted from sources outside of NZ such as; Australia, United States (US), United Kingdom (UK). In light of the lack of health and fitness information among RNZN staff, the NZDF required a short battery of tests that could capture this information and could be used annually to help individuals address health and/or fitness deficiencies. Therefore, the aim of this research is to conduct a pilot health and wellness programme as requested by the NZDF for physiological health and physical fitness among the RNZN. Data obtained will be compared to normal population data in order to provide further insight of health and wellness within the RNZN, and to help determine if the individual test prescribed are appropriate (i.e. valid and reliable in military personnel). Secondary
to the piloting of the programme, it will help develop an understanding of health and fitness by age and gender of RNZN personnel and identify the primary factors which contribute towards health declines. Due to the simplicity of the tests performed in this research, the testing protocol could be easily be applied to the NZDF as an annual or 6-month screening intervention to identify health status of NZDF personnel and to identify differences between defence forces (RNZN, Royal NZ Army, Royal NZ Air Force).

Hypothesis

1. The RNZN personnel would attain a VO$_{2\text{max}}$ score above 39-42 ml·kg$^{-1}$·min$^{-1}$ irrespective of age and gender.

2. The RNZN personnel physiological variables such as BMI, WHR, BP, resting heart rate, and blood cholesterol/glucose do not exceed values for normal healthy populations.

3. Persons within the RNZN who are ≥35 years and male are more at risk for CVD, musculoskeletal injury and have poor fitness standards when compared to females irrespective of age and those who are <35 years.
Development of testing procedure

Prior to testing, several complications were addressed to ensure proficiency of testing. Primary objectives were to ensure that all tests were completed within 45 minutes for a single person (see chapter 3 in methods for full break down of methods). Initial blood testing required participants to be fasted for 12 hours (measure blood profiles), which was then followed by physical activity. This posed a logistical problem as exercise performance may be impaired without consumption of food. Therefore, the timing and sequence of individual tests were carefully planned.

- **Testing time** – Preliminary testing was done to ensure that all researchers were proficient within their allocated health measure and could conduct tests in a timely fashion.

- **Part one and two of testing protocol** – to reduce elevations in blood lipids/cholesterol within part one of testing, participants were required to arrive in a 12-hour fasted state (excluding water intake). To reduce the error of physical performance after the 12-hour fast (part two), the schedule of testing involved completing necessary paper work first (see methods, chapter 3 for order of paperwork), followed by taking fasted blood samples, BP/resting heart rate prior to breakfast and then booking each person for the same day to complete part two of testing (physical activity).

- **Order of tests** – to prevent a bottle neck of participants, testing was done in order of most time required (first) and progressed into least time consuming, with each participant scheduled in 15 minute intervals.

- **Testing error** - Researchers were allocated to specific tests and did not deviate outside their assigned testing station throughout the researching process to eliminate inter-tester error.

- **Recording of data** – Participants were provided booklets with their recorded results. Researchers recorded measures on separate forms for analysis.

- **Feedback** - All participants were provided feedback via booklets and oral discussion on completion of all tests by a Clinical Exercise Physiologist.

- **Confidentiality** – All feedback was provided via one on one communication in a private room. All participants were individually coded to ensure confidentiality.
CHAPTER 2. Literature Review

Military life

Requirements of the defence forces

The primary objective of all RNZN is to stand alongside the Royal New Zealand Army and Royal Air Force to ensure that the people of NZ are kept safe (RNZN, 2019). Personnel within the RNZN and their ships respond to a wide array of situations, which include but are not limited to, combat operations, underwater rescue, recovery from water, search and rescue and peacekeeping while maintaining relations between other country’s (for principle roles of the RNZN see www.navy.mil.nz) (RNZN, 2019). In order to perform these roles and meet these objectives to aid readiness for deployment at any time, it is important to have personnel that are fit with adequate health at a physical, physiological and psychological level.

Life in the defence force

Approximately one third of RNZN personnel are at sea at a given time (NZDF, 2019). For those at sea, the RNZN must ensure that all daily requirements are met for personnel to maintain health and wellness standards. Facilities available include, but are not limited to; fitness centres, medical care, sleeping/nutrition and hygiene facilities. However, for those not at sea, military lifestyle is slightly different.

Located in Auckland, Devonport, the RNZN base has facilities to optimise health and wellbeing of Navy personnel including command centres, training grounds in addition to access medical care and fitness facilities (NZDF, 2019). Additionally, personnel can live on base or in allocated military housing. However, this is dependent of the individuals’ rank/position (enlist living on base versus officers living in housing). Throughout one’s time in the RNZN, personnel conduct medical check-ups every two years and undergo annual fitness assessments (NZDF, 2019). The importance of these are to ensure that personnel are ready for deployment at any given time. In addition, personnel are also required to undergo their military obligations which are in accordance to their career (NZDF, 2019). Furthermore, all personnel have access to fitness centres to upkeep their health care and fitness standards which can be accessed when needed (NZDF, 2019).
While younger populations are exposed to more physical fitness, those of senior rank may have a low exercise participation, likely due to managerial tasks. As such, it is up to the individual themselves to participate in their own physical activity with either a personal training instructor or via their own exercise regime (NZDF, 2018).

Definition of good health
Good health is defined as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 1948). However, in 1989 the WHO (1989) expanded on this definition;

“To reach a state of complete physical, mental and social well-being, an individual or group must be able to identify and to realise aspirations, to satisfy needs, and to change or cope with the environment. Health is, therefore, seen as a resource for everyday life, not the objective of living (retrieved from www.who.int).”

The WHO also explain that there are prerequisites for health which are; peace; shelter; education; food; income; a stable eco-system; sustainable resources; social justice and equity (WHO, 1989). These prerequisites serve as the foundation of health with the absence of pathological disease to enable an individual to live with optimal physiological and psychological health.

Factors associated with poor health
Cardiovascular disease (CVD)
Exclusion from military forces upon enlistment due to CVD can be multifactorial. Common diagnoses include; white coat syndrome; cardiac hypertrophy; heart valvular disease; coronary artery disease; second/third degree atrioventricular block; cardiomyopathy; persisting tachycardia at rest; left bundle branch block; history of heart failure; symptomatic arrhythmia and congenital abnormalities (excluding correction of patent ductus arteriosus and hypertension) (Eckart et al., 2004). This exclusion policy is due to an increased susceptibility for medical discharge and in service death of personnel (Bray et al., 2006). The exclusion of personnel from joining the military ensures that all personnel are ready for deployment at all times and are able to conduct
work in a safe manner which is not at risk to themselves or others around them (Iremonger et al., 2015).

Historically, infectious diseases were the primary threat for illness among military populations; however, as of 2008, CVD has surpassed infectious diseases for military hospitalisation (Obnibene & Barrett Jr, 1982; Sullenberger & Gentlesk, 2008). Common CVD pathologies experienced in both general and military populations are; ischemic heart disease, cerebrovascular disease, peripheral vascular disease, heart failure, rheumatic heart disease and congenital heart disease (Woodward et al., 2017). Worldwide, military forces experience many different CVD illnesses (see table 1 for CVD experienced in the military). Within the military environment, between 1994 and 2006, 10% of Hungarian military pilots were grounded which resulted in an inability to perform required tasks due to CVD complications (Grósz, Tóth, & Péter, 2007). Additionally, 15% of US military personnel (total of 163,627) were found to have ischemic heart disease between 2001 and 2006 and, of this 15%, 3% were diagnosed with cerebrovascular disease or transient ischemic attack (Baxi et al., 2011). The subsequent impact of these results are a decrease in deployability of military personnel, increased financial expenditure and in severe cases, death during active service time or when retired. There also appears to be a relationship between environmental influences which promote behavioural changes which may reflect this increase in CVD rates (Myers & Twenge, 2013). This implies that while military personnel are required to maintain physical fitness, over time, there is a progressively slow increase in CVD rates.
Table 1: CVD experienced within the military

<table>
<thead>
<tr>
<th>Study</th>
<th>Military force</th>
<th>Mean population number</th>
<th>Mean age</th>
<th>Duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 10 year follow up of ischemic heart disease in military pilots</td>
<td>Hungarian Air Force</td>
<td>250</td>
<td>33 (±6 years)</td>
<td>1994-1999-2004</td>
<td>Family history = 25.0% were at risk</td>
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<tr>
<td></td>
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<td></td>
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<td>Obesity = 40.8%</td>
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<td>Smoking = 31.7%</td>
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<td>Inactivity = 23.9%</td>
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<td>Elevated BP = 13.1%</td>
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<td></td>
<td>Total cholesterol (with low HDL) = 53.9%</td>
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<td></td>
<td></td>
<td></td>
<td>ECG requirement = 1.3%</td>
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<tr>
<td>Cardiovascular disease risk factor among male veterans U.S 2009-2012</td>
<td>US military</td>
<td>1107 veterans 3972 non-veterans</td>
<td>59.9 years 43.4 years</td>
<td>2014-2015</td>
<td>Increased age (veterans) associated with obesity (veterans = 42.6% versus non-veterans = 33.7%)</td>
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<td>(Fryar et al., 2016)</td>
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<tr>
<td>Prevalence of and risk factors for autopsy-determined atherosclerosis among US service members 2001-2011 (Webber, Seguin, Burnett, Clark, &amp; Otto, 2012)</td>
<td>US military</td>
<td>3832</td>
<td>25.9 (18-59 years)</td>
<td>2001-2011</td>
<td>Autopsy revealed that 8.5% of personnel had coronary atherosclerosis</td>
</tr>
<tr>
<td>When Military Fitness Standards No Longer Apply: The High Prevalence of Metabolic Syndrome in Recent Air Force Retirees</td>
<td>US Air Force</td>
<td>381</td>
<td>48.2 years</td>
<td>2011-2013</td>
<td>Metabolic syndrome = 37.2%</td>
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<td>Central obesity = 39.8%</td>
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<td>Elevated fasted glucose = 32.4%</td>
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<td></td>
<td>High BP = 56.8%</td>
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<td>Total cholesterol (with low HDL) = 33.3%</td>
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<td></td>
<td></td>
<td></td>
<td>Elevated triglycerides = 42.7%</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Sample Size</td>
<td>Age</td>
<td>Time Period</td>
<td>Key Findings</td>
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<td>---------------------------------------------------------------------</td>
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</tbody>
</table>
| Hypercholesterolemia and smoking habits of Lithuanian military personnel | Lithuania | 200         | 25-54 years | 2001-2002 | Total cholesterol (men versus women) = 6.21 mmol·L⁻¹ (±1.2 mmol·L⁻¹), 6.04 mmol·L⁻¹ (±1.09 mmol·L⁻¹)  
Highest rates of hypercholesterolemia in those of 25-34 years  
Smoking 2.6 times higher in males than females  
Hypercholesterolemia and smoking = 23.5% men and 7.5% in women |
| Obesity in the UK armed forces: Risk factors                         | UK        | 3759        | 17-55 years | 2006-2007 | Obese BMI males = 13.5%  
Obese females = 12.9%  
Waist circumference (94-101.9 cm males) = 14.8%  
Waist circumference males (+102 cm) = 8.7%  
Waist circumference females (80-87.9 cm) = 34.8%  
Waist circumference females (+88 cm) = 12.6% |
| Health-related quality of life in the Royal Norwegian Navy: Does rank matter? | Norway    | 1316        | 25-62 years | 2002      | When compared to the general public, Royal Navy officers had better quality of life and decreased risk of developing CVD. This was attributed to increased physical exertion experienced in the Royal Navy. |

*BP = Blood Pressure, HDL = High Density Lipoproteins, BMI = Body Mass Index, CVD = Cardiovascular Disease*
Known risk factors for CVD within a military environment are seen with, but not limited to; unhealthy diet (high sugar; high fat; low fruit and vegetables; low protein); harmful consumption of alcohol/drugs; smoking and sedentary lifestyle (Fryar et al., 2016; McGraw, Turner, Stotts, & Dracup, 2008). The effects of these, when left unaccounted for an extended period of time, may progress into hypertension, dyslipidaemia, elevated blood glucose and will likely result in over-weight/obesity (McGraw et al., 2008; Nangia, Singh, & Kaur, 2016). A review of CVD in active serving US military personnel found that hypertension and dyslipidaemia accounted for 1936 cases in 2005, while dyslipidaemia alone represented more than 2160 cases in 2002 (McGraw et al., 2008). However, according to Bray et al, (2003) personnel under the age of 25 years who actively serve in the US Navy were not required to have blood cholesterol assessed based on the assumption that younger populations do not present with the same risk for CVD as those aged between 25 and 49 years. It was not until 2002 that all age groups in the military were required to have blood cholesterol checked once every 2 years (McGraw et al., 2008). The implication of elevated blood lipids is the strong correlation with increased risk of overweight/obesity which increases stress of the internal organs.

Of interest is the finding of Ray, Kulkarni, and Sreenivas (2011) who found that of the 767 tri-service active serving personnel, 80% were found to have prehypertension despite regular participation in moderate to heavy exercise. Furthermore, newly diagnosed hypertension has also been reported to increase by 6.9% over a period of three years among military personnel (2004-2006) (Granado et al., 2009). Of importance are the young Pacific Island and Asian males serving in the US Army and Marine Corps who participated in smoking and regular consumption of alcohol which represented 25% of this ethnic population sampled. This is of particular interest since in 2012 males represented 77.6% of the total RNZN population with 24% classified as Maori, Pacific Island or Asian (NZDF, 2017). It should be noted, the population size of Granado, et al, (2009) was much larger than that of the total NZDF (36,061 persons versus 14,532 persons) therefore direct comparison may not be suitable (NZDF, 2017). However, there does appear to be a difference in health status between ethnic groups for military personnel suggesting that additional and ethnic specific factors are potentially linked to CVD complications.
Social economic status is a contributing factor for ethnicity differences in the health status of personnel. For example, Maori and Pacifica populations in NZ who reported to live in high deprivation areas were reported to be twice at risk of developing CVD complications when compared to European and Asian populations who lived in low deprivation areas (Pylypchuk et al., 2018). However, it is important to note that the NZDF provides free access to medical/dental check-ups, fitness facilities, healthy food choices and suitable housing both inside and outside of the NZDF base camp (RNZN, 2019). Therefore, health status among NZDF personnel should theoretically be equal among ethnicities. Nevertheless, while the NZDF provides access to facilities and services that aim to optimise an individual’s health, this does not exclude personnel from participating in choices which are not in line with the NZDF health objective for example; unhealthy eating or smoking.

Adverse effects of smoking include an increase in sympathetic drive and arterial stiffness, thus increasing the risk of hypertension (Granado et al., 2009). Smoking rates in Navy forces, Marines Corps and Navy Seals have increased from 15% to 24.1% from 2004 to 2017 (de Silva, Jayasekera, & Hanwell, 2012; Granado et al., 2009; Ray et al., 2011; Ulanday, Jeffery, Nebeling, & Srinivasan, 2017). Comparatively, additional studies have also shown decreases in smoking over time (Cronan, Conway, & Kaszas, 1991; Wedge & Bondurant, 2009). For example, Woodruff, Conway, and Edwards, (2000) decided to implement a single eight-week smoking ban within a military environment and found that smoking rates decreased from 41% to 25%. Despite this, if risk factors, such as smoking and the aforementioned behavioural risk factors, are left untreated, it can potentially lead to an increase mortality rates in military personnel (Bray et al., 2006).

In 2015, it was estimated that 17.7 million people died from CVD which accounted for 31% of all global deaths (WHO, 2017). While death among active serving young military individuals is very rare (~13 deaths per 100,000 recruited years), the most common cause of death in the military are cardiac abnormalities such as anomalous coronary artery from the sinus of valsalva, myocarditis or hypertrophic cardiomyopathy (Villacorta-Lyew, Laselle, Mazzoncini, Merchant, & Buckley, 2008). Between 1998 and
2013, the average age for noncombat death among active tri-serving US military personnel with disease was 30.1 years (Potter, Tremaine, & Gaydos, 2017). During the same time period, 16,192 noncombat-related deaths occurred of which 1.3% (~211) represented infectious processes (Potter et al., 2017). Of the 1.3%, myocarditis and pericarditis represented 18% (~38 deaths). Additionally, CVD was also responsible for 3.58% Bangladesh military deaths between 2013 and 2014 with ischemic heart disease and cerebrovascular disease being the primary cause (20% and 14.28%) (Alam, Haque, & Haque, 2017). While mortality due to CVD does occur, research has also pointed to the effects of ageing as a contributing factor for military personnel to develop CVD (McGraw et al., 2008).

Cardiovascular disease in young military populations

Previously published studies have shown that those returning from military deployment at approximately 28 years of age also return with at least one CVD risk factor (Burg et al., 2017; Haskell et al., 2017; Mullie, Clarys, Hulens, & Vansant, 2010). Contributing factors for this are seen with, but are not limited to; stressful environments, confined living space, poor sleeping status and not maintaining fitness standards (Haskell et al., 2017; Littman, Jacobson, Boyko, Powell, & Smith, 2013; Ulmer et al., 2015). Additionally, living on base (at home or on deployment) is also linked to poor behavioural changes. For example, Mullie et al., (2010) stated that the military provide high calorie foods which reflected the high energy expenditure experienced in young military populations and, throughout a working day, personnel are more inclined to consume unhealthy food choices or overeat. In other words, when excessive amounts of high calorific foods are consumed, over a prolonged period of time, and calorie expenditure does not match the calories consumed, subsequent increases in overweight/obesity, and associated co-morbidities, can occur (Brehm, Seeley, Daniels, & D’alessio, 2003). While this is of concern, research does suggest that obesity and the associated co-morbidities can be reversed via exercise interventions (Hagnäs et al., 2012).

The effects of eight weeks of basic training found that 1046 men, aged between 18-28 years, reduced; obesity (from 9% to 5%), body fat percentage; fat mass; waist circumference; lipid/glucose profiles and BP while significantly increasing fitness levels
(muscle fitness index, p-value = 0.016) (Hagnäs et al., 2012). In another study, Cederberg et al, (2011) studied the effect of exercise irrespective of dietary control on 1,112 men (between 19-28 years of age). They found that aerobic and muscular endurance exercise without dietary intake control reduced body weight; BMI; waist circumference; fat mass/percentage; visceral fat; BP and lipid profiles while it improved aerobic fitness and muscular endurance. The results from the aforementioned research would suggest that there is a decline in health status while on deployment and that when an individual is no longer deployed their health and fitness levels may decline. However, factors such as age and progression through military rank are also associated with the decline (or exacerbate) health status (Talbot, Weinstein, & Fleg, 2009).

**Cardiovascular disease in ≥35 year old populations**

Cardiovascular disease is more prominent in older (≥35 years of age) and sedentary military occupations (Baxi et al., 2011). According to Nangia et al, (2016), approximately one third of military personal over the age of 35 years are at high risk of developing CVD. In healthy non-military populations, CVD has previously been reported to occur at approximately 60 years of age (Dhingra, 2012). According to the WHO, the onset of CVD is progressively occurring at a younger age when compared to the early 2000’s (WHO, 2018). For military populations over the age of 35, there is often a decline in physical activity (frequently due to increased military rank, which increases the amount of time sitting at a desk as opposed to performing manual labour daily), and therefore personnel do not have the high rates of energy expenditure as they once did (Mullie et al., 2010; Nangia et al., 2016). Implementation of medical screening and encouragement of regular physical activity has resulted in a reduction of CVD and associated co-morbidities in personnel over 45 years (Grósz et al., 2007). In senior military ranked Royal Norwegian Navy officers (aged between 45 and 62 years) superior health and quality of life was noted to be of most importance when compared to non-military populations of the same age (Magerøy et al., 2007). It was concluded that those of senior rank considered physical activity to be the most important factor for improved health. Research in individuals serving in the military for 20 years that have maintained health and fitness requirements throughout their service time have demonstrated lower risk of developing CVD and accompanying risk factors when compared to age match peers of
the US population (23.4% vs. 39.0%) (Cranston et al., 2017). This suggests that the health of military populations tend to decline around 35-40 years of age and is linked to more sedentary behaviours/roles, though this can be reversed by an increase in self-health care. However, census data of CVD in the NZDF is scarce and therefore warrants further investigation.

**Blood Pressure (BP)**

Hypertension (>140/90mmHg – systolic/diastolic) and/or high BP (130-139/80-89mmHg) is known as ‘the silent killer’ as there are minimal symptoms (Sawicka et al., 2011). For this reason, high BP is commonly associated with CVD, peripheral artery disease, stroke, heart disease and kidney disease and therefore utilised as a primary health parameter to detect the likelihood or risk of CVD (ACSM, 2014; Kenney et al., 2015). In healthy individuals, normal BP is typically 120/80mmHg (ACSM, 2014). High or hypertensive values are generally due to large vascular resistance which increases ventricular contraction (Baxi et al., 2011). Latvala, Kuja-Halkola, and Ruck, (2016) suggest that the interconnected sympathetic and parasympathetic nervous systems also increase stress of the vascular system leading to increased BP (Latvala et al., 2016). This becomes problematic as those with high BP for a prolonged period of time are at increased risk of irreparable harm to vital organs such as kidneys, heart and brain which can result in additional complications (heart attacks, strokes and premature death) (Mensah, Croft, & Giles, 2002).

Blood pressure measurements in 15,391 US military personnel found that 13% of personnel were defined as hypertensive while 62% were pre-hypertensive with these values increasing with rank and age (Smoley, Smith, & Runkle, 2008). In a routine health risk assessment of military personnel, 360 active serving personnel were assessed, 10.7% were classified as hypertensive, with 6.9% identified as stage 1 hypertensive (140-159/90-99mmHg), and 8.3% as stage 2 hypertensive (>160-100mmHg) (Rinanty, Widodo, Setyasari, & Pujowaskito, 2017). One study compared BP between two living standards (living at sea versus living on base on land) within the armed forces and found that those who live at base had higher rates of hypertension than those at sea (36.1% verse 25.5%) (Hurd, Rockswold, & Westphal, 2013). It should be noted that there was a
difference in population size (shore-based living = 3330 (36.1% hypertensive) versus living at sea = 1305 (25.5% hypertensive)) and only those with no health concerns, such as hypertension, will be deployed.

Fluctuations in BP can occur within minutes and therefore one’s BP may not be a true representation of the values recorded (ACSM, 2014). In order to reduce inaccuracy in testing, BP should be measured in a relaxed environment at the same time of day, preferably morning, without stimulus, such as coffee or exercise. These measurements should be completed more than once and on three separate occasions (ACSM, 2014).

**Heart rate**

Normal resting heart rate, whilst lying supine or quietly seated, is generally 60 beats per minute (bpm) in healthy individuals (ACSM, 2014). However, if resting heart rate values increase to 100bpm for a prolonged time then this is referred to as tachycardia. Similarly, when values fall below 60bpm then this is termed bradycardia. Physically fit individuals may have heart rates that are significantly lower than 60bpm and are not considered to be bradycardic (Kenney et al., 2015). Diagnosed bradycardia and tachycardia have normal sinus rhythm however there is an inability to maintain cardiac output which can often cause symptoms of dizziness, syncope and fatigue, with these symptoms being exacerbated during physical activity (ACSM, 2014; Kenney et al., 2015).

Within the military, exposure to combat is a major contributor towards increased heart rates (Lieberman et al., 2016). Lieberman et al, (2016) used a controlled mock 3 week military environment to induce stress on 60 US Marines and found that not only did this increase heart rate values by 80% above baseline levels, but also affected cognition; memory; attention; salivary cortisol; epinephrine/norepinephrine; salivary neuro-peptide; prolactin and testosterone. The researchers explain that impaired cognition, memory and attention were attributed to increased hormonal levels which increased heart rate values. This suggests that for those with elevated resting heart rates who are then placed in a stressful combat situation, cognition/critical thinking may be impaired which can lead to injury to oneself or surrounding personnel. When US Marines who returned from deployment were assessed 2-months later, they were found to have high
variability in heart rate variance which was correlated (p-value = <0.001) with depression and post-traumatic stress disorder (Minassian et al., 2014). However, the research did not examine the environment that Marines were deployed to, but this was a likely contributor to the variance in heart rates. Therefore, further research is warranted to assess if pre-deployment heart rate variations can predict mental health outcomes.

**Obesity**

Obesity is associated with numerous physiological impairments such as CVD and diabetes that can be assessed using a variety of different procedures. To measure this among large scale populations, BMI and WHR (explained below) are commonly used to calculate overweight/obesity status and predict health outcome (McGraw et al., 2008). Incidence and prevalence rates using these methods are well validated for the identification of CVD, type 2 diabetes mellitus, cancers, metabolic syndrome, dyslipidaemia as well as identifying the susceptibility of musculoskeletal injury and premature death (ACSM, 2013; Bernritter, Johnson, & Woodard, 2011; Dong, Keum, Hu, & Orav, 2017). Therefore, the simplicity and cost effectiveness of these methods allow for simple administration among large populations such as military forces. While valid, these methods do have differences and limitations in predicting health outcomes (Dalton et al., 2003).

**Body Mass Index (BMI) and obesity**

The BMI is a practical tool to predict body mass-related metabolic risks in a population. The application of BMI places an individual into one of six weight classifications (see table 2) which are calculated by dividing one’s body mass (kg) by height squared (meters) (ACSM, 2014). Average population BMI values for each weight classification is shown in table 2 below (ACSM, 2014). Application of BMI enables the classification of normal, over weight and obesity status among large populations; countries; states; genders or ethnic groups allowing for effective comparisons for census data and epidemiological research (McConnell-Nzunga et al., 2017; Nickerson et al., 2018). Individuals with a normal BMI score have a low risk of CVD (ACSM, 2014). Increases in weight gain, primarily form fatty tissue, and increases the likelihood of CVD risk factors. Values that are above 25kg·m² are associated with not only advancements in CVD, but
also deaths (Chen et al., 2013; Dudina et al., 2011; Nickerson et al., 2018). Additionally, as one moves up in BMI scoring (for example: overweight to obese class 1 or class 1 obese to class 2 obese) CVD and irreparable harm is exacerbated (ACSM, 2014). However, there are a number of limitations associated with BMI use.

Age, ethnicity and muscle morphology are all factors which can lead to misinterpretation of BMI (Prentice & Jebb, 2001). Ageing is associated with a progressive increase in body fat and atrophy of lean muscle mass (Boutari & Mantzoros, 2017). Ethnicity and muscle morphology are both associated with bone and muscle mass differences (Heymsfeild, Peterson, Thomas, Heo, & Schuna, 2016). Within NZ, Maori and Pacifica populations are more susceptible to higher bone and muscle mass compared to Caucasians and Asian populations (Heymsfeild et al., 2016; Stoner et al., 2013). Consequently, the NZ Heart Foundation (2017) have modified BMI classification for Maori and Pacifica populations (New Zealand Heart Foundation, 2017) as seen in table 2 below. However, it must be noted that Taylor et al, (2010) examined BMI, waist circumference and waist to height to correctly identify metabolic comorbidities including; BP, elevated lipids and glucose. Their results suggested that anthropometric cut off points and metabolic conditions were similar irrespective of ethnicity. The importance of this is that indigenous NZ populations already have a high rate of CVD (Pylypchuk et al., 2018), therefore, if classification cut-off values are set at a higher level than Caucasians then underlying risk factors for CVD may go undetected (Gentles et al., 2007; Initiative, 1998; McAuley, Williams, Mann, Goulding, & Murphy, 2002; Tipene-Leach et al., 2004). Taylor et al, (2010) also noted that when increasing anthropometric values to the next cut-off point there was an associated increase in incorrectly classified metabolic conditions. Findings from the WHO (2004) demonstrate that standard BMI guidelines may not correctly classify individuals who are overweight and obese. Those with CVD risk factors were found to have BMI values between 22kg·m² - 25kg·m², while high-risk individuals had values between 26kg·m²-31kg·m². However, BMI does not provide a body fat percentage and is just an association of metabolic risk based on height and weight ratios, thus limits it application. For example, individuals can have a healthy BMI score but have low levels of lean muscle mass and a high body fat percentage which result in healthy BMI scores (Zhu, Hunter, James, Lim, & Walsh, 2015). Additionally, athletic individuals...
may be considered over weight due to high lean muscle mass and low body fat, despite
the fact that they are healthy, which can lead to misinterpretation (Prentice & Jebb,
2001). As such, additional anthropometric measurements should be used concurrently,
including WHR to assess central obesity among populations.

<table>
<thead>
<tr>
<th>Table 2: BMI for Europeans and Maori and Pacifica populations</th>
</tr>
</thead>
<tbody>
<tr>
<td>European (kg·m²)</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td><strong>Underweight</strong></td>
</tr>
<tr>
<td><strong>Normal</strong></td>
</tr>
<tr>
<td><strong>Overweight</strong></td>
</tr>
<tr>
<td><strong>Obese Class 1</strong></td>
</tr>
<tr>
<td><strong>Obese Class 2</strong></td>
</tr>
<tr>
<td><strong>Obese Class 3</strong></td>
</tr>
</tbody>
</table>


Permission for table 2 sought from ACSM and NZ Heart Foundation – awaiting response

Waist to Hip Ratio (WHR)

The WHR is an anthropometric measurement used to predict how susceptible one is to
develop CVD (ACSM, 2014). Due to differences in anthropometry and distribution of
fatty tissue between males and females, WHR ratio values are different for genders as
shown in table 3. The subsequent effects of high WHR include, but are not limited to;
hindering the removal of low-density lipoproteins (LDL) from the liver which
accelerates the build-up of cholesterol within arterial walls, reduced energy expenditure
and impaired release of hormones such as insulin, glucagon and epinephrine/non-
epinephrine (Bekkelund & Jorde, 2017; Simões et al., 2018; Zacharewicz, Hesselink, &
Schrauwen, 2018). This means central obesity not only causes impairment to
physiological processes but also increases lipogenesis, which can result in further weight
gain. Additionally, because the WHR is only an indicator of health, other cardiovascular
risk factors may go unnoticed. This is problematic for military forces as while active
serving personnel may participate in regular exercise, they may still be at risk for CVD
risk factors.

Cross-sectional studies of the Indian Army have found that those of ≥35 years of age
have an increased probability of a high WHR ratio (Verma, Bhalwar, & Sharma, 1998).
As WHR values increased beyond 0.91 so too did mean blood cholesterol/glucose and BP (Verma et al., 1998). Vaidya and Bhalwar, (2009) reported that CVD risk factors (mentioned above) increased with age in military populations. Additionally, Morkedal, Romundstad, and Vatten, (2011) reported that large WHR identified CVD risk factors among 60,731 active serving military male and females. Yet again, while WHR is a validated measurement, there are limitations to this measurement that must be considered.

Similar to BMI, WHR does not differentiate between free fat mass and lean muscle mass (Dalton et al., 2003), therefore, discussions on the applicability with regards to ethnicity has been previously questioned. Because the WHR is primarily derived from large percentage of Caucasian populations (Huxley, Mendis, Zheleznyakov, Reddy, & Chan, 2010), universal cut offs might not be applicable for various cultures due to differences in fat distribution observed in Pacific, Maori and Asian populations (Razi, Manish, Keshav, Sukriti, & Gupta, 2016; WHO, 2011). Recently the site of measurement has also gained interest. The WHO, (2011) stated that measurement sites should be taken from the lowest palpated rib for waist measurements and the widest circumference around the buttocks. However, the ACSM (2013; 2014) guidelines state that waist measurements should be taken from the narrowest circumference and the hips around the widest circumference. Table 3 shows the population normal values for WHR by gender and age as stated in the ACSM (2014). Comparatively, the NHLBI (2000) state that waist circumference should be taken from the top of the iliac crest and hips should be taken from the greater trochanter. Therefore, it is important for researchers to select one method and to not deviate outside of this throughout field testing as this will provide inconsistent results. It is important to note that a large proportion of studies conduct assessments which are in accordance with the WHO (2011) and ACSM (2014) and have found valid results (Dalton et al., 2003; Huxley et al., 2010; McGee, 2016; Savva & Kourides, 2000; Sullenberger & Gentlesk, 2008; Verma et al., 1998). More recently the height to waist and waist circumference alone, has gained attention for methods to assess body fatness (Dong et al., 2017; Wu et al., 2014).
Table 3: Waist to Hip Ratio values for males and females

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Low (cm)</th>
<th>Moderate (cm)</th>
<th>High (cm)</th>
<th>Very high (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29</td>
<td>&lt;0.83</td>
<td>0.83-0.88</td>
<td>0.89-0.94</td>
<td>&gt;0.94</td>
</tr>
<tr>
<td>30-39</td>
<td>&lt;0.84</td>
<td>0.84-0.91</td>
<td>0.92-0.96</td>
<td>&gt;0.96</td>
</tr>
<tr>
<td>40-49</td>
<td>&lt;0.88</td>
<td>0.88-0.95</td>
<td>0.96-1.00</td>
<td>&gt;1.00</td>
</tr>
<tr>
<td>50-59</td>
<td>&lt;0.90</td>
<td>0.90-0.96</td>
<td>0.97-1.02</td>
<td>&gt;1.02</td>
</tr>
<tr>
<td>60-69</td>
<td>&lt;0.91</td>
<td>0.91-0.98</td>
<td>0.99-1.03</td>
<td>&gt;1.03</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29</td>
<td>&lt;0.71</td>
<td>0.71-0.77</td>
<td>0.78-0.82</td>
<td>&gt;0.82</td>
</tr>
<tr>
<td>30-39</td>
<td>&lt;0.72</td>
<td>0.72-0.78</td>
<td>0.79-0.84</td>
<td>&gt;0.84</td>
</tr>
<tr>
<td>40-49</td>
<td>&lt;0.73</td>
<td>0.73-0.79</td>
<td>0.80-0.87</td>
<td>&gt;0.87</td>
</tr>
<tr>
<td>50-59</td>
<td>&lt;0.74</td>
<td>0.74-0.81</td>
<td>0.82-0.88</td>
<td>&gt;0.88</td>
</tr>
<tr>
<td>60-69</td>
<td>&lt;0.76</td>
<td>0.76-0.83</td>
<td>0.84-0.90</td>
<td>&gt;0.90</td>
</tr>
</tbody>
</table>

(ACSM, 2014)
Permission for table 3 sought from ACSM – awaiting response

Waist to height ratio and waist circumference

Waist to height measures the distribution of body fat mass over one’s body and follows a similar calculation as the WHR (ACSM, 2014). Waist measurements that are less than half of and individuals’ height reduces the risk for CVD (Browning, Hsieh, & Ashwell, 2010). Comparatively, waist circumference is the total circumference of the waist only (Taylor et al., 2010). While both measure obesity in relation to the risk of CVD development, research shows differences in outcome. Analysis of cardiovascular risk factors have shown that the waist to height is a suitable measure for screening CVD risk factors among men and women, when compared to BMI, body fat percentage, waist circumference and WHR (Caminha et al., 2017; Swainson, Batterham, Tsakirides, Rutherford, & Hind, 2017). In a study of 6355 participants a positive association was shown between waist to height and predicting CVD and death (Schneider et al., 2010). Waist circumference and waist to height ratio have similar health predictions among males and female populations (Barreira et al., 2014; Savva & Kourides, 2000). The main limitation of anthropometric measurements are the aforementioned differences in site location. Therefore, when conducting anthropometric assessments, landmarks should be clearly established to ensure validity and reliability (Bernritter et al., 2011). Additionally, conducting waist circumference only may over or under estimate health outcomes for both tall and short individuals with similar waist circumferences. Therefore, when conducting anthropometric measures, they should be done concurrently with other measures (Bernritter et al., 2011; Browning et al., 2010).
Furthermore, to the researcher’s knowledge, there are no direct validation studies for waist to height ratio and waist circumference within the military.

**Smoking**

A high prevalence rates of habitual smoking is reported in military forces (Siddall et al., 2017). Habitual smoking increases endothelial dysfunction and can advance into atherosclerosis and thrombogenesis (Ambrose & Barua, 2004; Elbejjani et al., 2018). Endothelial dysfunction, due to smoking, is attributed to vasoconstriction of the vascular system which increases mean arterial pressure (Manddela, 2016). This is also attributed to the decreased nitric oxide available to dilate blood vessels, increased adhesion molecules and macrophages available, thus, increasing the risk of thrombogenesis (Ambrose & Barua, 2004; Messner & Bernhard, 2014). Despite the importance of macrophages oxidizing lipids, there is also an increase of foam cells accumulation in smokers which are a key factor in atherogenesis (Kenney et al., 2015).

Smoking is also associated with decreasing high density lipoprotein (HDL) cholesterol levels which are important for removing LDL (Forey, Fry, Lee, Thornton, & Coombs, 2013). A reduced HDL level increases adhesion molecules, macrophages and platelets, which not only increasing endothelium dysfunction, but also the risk of atherosclerosis and thrombogenesis. This increases the risk of a cardiac event and infectious diseases in habitual smokers (Manddela, 2016; Messner & Bernhard, 2014).

Diseases experienced among habitual smokers are linked to, but are not limited to; CVD progression; respiratory disease; cancers; bone health; type 2 diabetes mellitus; decrease immune function; visual impairment; decrease fitness levels and overweight/obesity (ACSM, 2014; Andersen et al., 2016; Elbejjani et al., 2018; Nance et al., 2017; Rom, Reznick, Keidar, Karkabi, & Aizenbud, 2015; Samet, 2016). Statistics show that, between 1950 and 2010, 1 in 5 NZ citizens were reported to smoke which was linked to 160,000 premature deaths (Laugesen, Glover, Fraser, McCormick, & Scott, 2010). The smoking prevalence survey conducted by the NZ Ministry of Health (2014) reported that between 2007 and 2013, a decline of 18% occurred with a large decline in those aged 15-19 years (36%) while those aged between 25-27 years and 65-74 years
declined by 13% and 27% respectively (Ministry of Health., 2014). Since 2013 smoking has decreased from 626,000 to 610,000 and as of 2016 a further reduction in those ages 15-17 years (6%) (Ministry of Health., 2014, 2016). This suggests that smoking within NZ is slowly decreasing especially in younger groups. In the NZDF, during 2017, between 10-12% of personnel were reported to engage in habitual smoking (Navy: 14%, Army: 12% Air Force: 15%) (ASH, 2017). While there is a decrease in the NZ population who participate in habitual smoking, the NZDF is to become the first smoke free defence force by 2020, which is in line with the NZ governments goal of making NZ smoke free by 2025 (Ministry of Health., 2018).

Metabolic diseases

Diabetes

An equally important factor contributing to poor health in the military is the implications of type 2 diabetes mellitus. Diabetes involves two separate classifications; type 1 diabetes mellitus and type 2 diabetes mellitus (Kim et al., 2017). Type 1 diabetes mellitus is characterised as hyperglycaemia and the inability to produce insulin from β-cells located in the pancreases, while type 2 diabetes mellitus is an inability to produce insulin and the inability to transport glucose into cells due to insulin resistance (Kenney et al., 2015). Type 2 diabetes mellitus has increased in incidence due to changes in behavioural and environmental factors such as, diet and lifestyle over time. However, genetics also increases the susceptibility for its progression (Chen, Magliano, & Zimmet, 2012; DeFronzo, 2004).

Diabetes complications include an elevated blood plasma glucose level that reduces the nitric oxide facilitated vasodilation of blood vessels (Leahy, 2005). The inability to dilate blood vessels also increases the risk of hypertension and numerous pathologies such as, CVD; kidney damage; visual impairment; neuropathy and cerebrovascular disease (Kenney et al., 2015). While diabetes is growing in the general population, there is also concern within military populations (Mathers & Loncar, 2006; Paris, Bedno, Krauss, Keep, & Rubertone, 2001).
Diabetes in military forces upon enlistment is an exclusion criteria for enlistment, however, developing diabetes throughout service time is not always discharge worthy (Boyko et al., 2010). Those who develop diabetes while actively serving are generally considered overweight (Boyko et al., 2010). Therefore, health interventions involving weight management are generally prescribed to improve biochemical profiles (Naghii, 2006). However, if one does not take the required steps then PD or demotion of position/rank may occur (Williams, Stahlman, & Hu, 2017). While this may be considered excessive, it is important due to the nature of deployment which is highly stressful, and mental health disorders such as depression and post-traumatic stress can exacerbate in those with diabetes due to increased inflammation and insulin resistance (Boyko et al., 2010).

A study which comprised of 500 US Army and Navy active serving personnel (with type 2 diabetes) was compared against 2000 random control subjects of active serving tri-services (Paris et al., 2001). Researchers reported that increases in BMI (+25kg·m²), and individuals of African American or Hispanic decent were commonly associated with type 2 diabetes.

Between 1990 and 2005 the over-all rate of insulin required diabetes among the US military accounted for 2,918 new cases of diabetes among males and 414 cases in females (17.5 per 100,000 person years and 13.6 per 100,000 person years) (Gorham et al., 2009). Incidences rates were double in African American males and females which supports the study by Paris et al, (2001) whereby differences in ethnicity contributed towards diabetes. Prevalence rates of diagnosed diabetes in tri-service military personnel ranged from 7.26% to 11.22% in 2006 and 8.29% to 13.55% in 2010 (Chao et al., 2013). This trend also increased with age and BMI (Boyko et al., 2010). Similar trends are also reported in militaries outside of the US such as Australia, Europe and Asian countries (Ceppa, Merens, Burnat, Mayaundont, & Bauduceant, 2008; King, Nancarrow, Grace, & Borthwick, 2017; Williams et al., 2017). Finger prick analysis (in a fasted state) is a widely used tool to measure blood sugar levels for diabetes susceptibility, however, limitations do exist (Bruen, Delaney, Florea, & Diamond, 2017). Difference in monitors used may not differentiate between glucose, maltose, galactose and/or xylose which
may increase blood glucose levels to prediabetic values (Erbach et al., 2016; Saxena & Mittal, 2009). For this reason, clinical blood testing should be confirmed by a medical professional (using an accredited laboratory), so an individual’s true level of susceptibility of diabetes can be established.

Metabolic syndrome

Metabolic syndrome is defined as a wide range of abnormal physiological and biochemical progressions which can ultimately cause CVD (ACSM, 2014). Generally, this consists of having at least three of the following; abdominal obesity; hypertension/high BP; hyperglycaemia and dyslipidaemia (Kenney et al., 2015). Environmental stress is one of the most important contributors to advance metabolic syndrome, which is due to the increase inflammatory cytokines (Liu, Wang, & Jiang, 2017; Payab et al., 2017).

Investigations of body composition on metabolic syndrome susceptibility show that among 2,200 Iranian active military participants, 11.1% presented with metabolic syndrome (Payab et al., 2017). Between 1999- 2000 and 1999 - 2006, metabolic syndrome increased from 27% to 34.2% respectively across all US military forces (Herzog, Chao, Eilerman, Luce, & Carnahan, 2015). In 2016, prevalence rates of metabolic syndrome among Air Force personnel found that 21.3% of Air Force mechanics and 12.6% of Air Force pilots were at risk of developing metabolic syndrome (Kim et al., 2017). Gentles et al, (2007) reported that Maori had twice the risk of metabolic syndrome compared to Europeans while Pacifica people are 2.5 times more at risk. These findings suggest that those of Maori and Pacifica descent are more likely to develop metabolic syndrome in NZ and those personnel who are actively serving in the military, and are overweight, they may have an exacerbated risk for metabolic syndrome.

Cholesterol

There are five different types of lipids in the body; HDL, LDL, intermediate density lipoproteins, very LDL and triglycerides and when excessive can increase total cholesterol levels (ACSM, 2014). Although high levels of HDL contribute to an increase in total cholesterol levels, they decrease the risk of metabolic disease and/or CVD by
aiding the removal of the remaining four lipids from the blood stream (reverse transportation) (Kenney et al., 2015). The implications of the accumulation of LDL, intermediate density lipoproteins and, very LDL are fatty deposits within systemic blood vessels causing stenosis and in severe cases promoting plaque formation and atherosclerosis or hardening of the blood vessels (arteriosclerosis) (Nayor & Vasan, 2016). When excessive, atherosclerosis or arteriosclerosis inhibit dilation and constriction of blood vessels, an increase in peripheral resistance is observed (Kenney et al., 2015).

Elevated lipid levels have previously been found to increase the risk of the aforementioned pathologies among military populations (Alam et al., 2017; Bray et al., 2006; Kim et al., 2017; Ray et al., 2011; Villacorta-Lyew et al., 2008). In 1991 the US Navy reported that of the 5,487 active serving males and females, 36.9% had elevated fasted blood cholesterol above the recommendations for those aged between 18-24 (200mg·dL⁻¹) and for those aged >25 years (220mg·dL⁻¹) (Trent, 1991). In 659 active US Army personnel, 30% of males and 16% of females had fasted cholesterol levels above 200mg·dL⁻¹ with 69% classified as obese (via BMI) (Funderburk & Arsenault, 2013). With respect to the RNZN, Zinn et al, (2017) found, at baseline testing, four out of five blood lipid profiles among 41 overweight active serving RNZN personnel (BMI = 31.5kg·m², age = 39 years) were outside normal values when compared to the Ministry of Health recommendations, excluding LDL cholesterol (3.05mmol·L⁻¹). Over a six-year period, the Swiss military lowered consumed cholesterol foods available and found that 174,872 Swiss conscripts reduced mean total cholesterol significantly (0.125mmol·L⁻¹) (Bruggisser, Burki, Haeusler, Rühl, & Staub, 2016). Additionally, for conscripts with total cholesterol values >5.17mmol·L⁻¹, reductions of total cholesterol were achieved by >10.2% in 2011 and a further 8.2% in 2012. Adding to findings by Zinn et al, (2017) significant changes in cholesterol levels can be achieved through consuming a healthy high fat/low carbohydrate diet over a period of 12 weeks. However, specific fats such as polyunsaturated/monosaturated were not specified within Zinn et al, (2017) rather participants were provided education of healthy fat choices (nuts, avocado and healthy oils). While this suggests that decreases are achieved through dietary intervention, it is important to note that conscripts within the Swiss military had a mean age of 19 years
and highly active. This raises the question on whether the same decreases may be achieved in senior ranked individuals.

Sleep

Importance of sleep

It is advised that between 7-9 hours of sleep is needed by adults to ensure that both physiological and psychological recuperation is achieved (Marshall & Turner, 2016). Despite knowing the importance of sleep and recovery, it is often over looked as a health initiative (Fullagar et al., 2015). Adequate sleep allows hormones (human growth hormone, testosterone, prolactin, glucagon, insulin, cortisol) to be released throughout the body which repair damaged muscle tissue, build muscle, promote bone growth, relax the sympathetic nervous system, promote fat oxidation and storage of glycogen (Marshall & Turner, 2016).

Sleep is controlled by the of the hormone melatonin, which is released from the pineal gland found in the centre of the brain and, regulated by the suprachiasmatic nuclei located in the hypothalamus (Reilly, 2009). This process is also known as the circadian rhythm. The circadian rhythm is influenced by both internal cues, metabolism of food, and external cues such as light (Reilly, 1997). The circadian rhythm is a predetermined biological clock which is synchronised with different body processes, shown in table 4 below. These body functions and processes should be considered as they can impact sleeping patterns.
<table>
<thead>
<tr>
<th>Table 4: Peak times of the circadian rhythm</th>
</tr>
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<tbody>
<tr>
<td>Physiological Variable</td>
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<tr>
<td>--------------------------------------------</td>
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<tr>
<td>Increased metabolic process - recovery (lipid oxidation, glucose stored, protein synthesis)</td>
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<tr>
<td>Deep sleep</td>
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<tr>
<td>Lowest body temperature</td>
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<tr>
<td>Sharp rise in BP</td>
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<tr>
<td>Decrease in melatonin secretion</td>
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<tr>
<td>Highest testosterone levels</td>
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<tr>
<td>High alertness</td>
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<tr>
<td>Increased metabolic process (increases fat uptake from muscles, high glycogen used, elevated insulin levels, increased lipogenesis)</td>
</tr>
<tr>
<td>Best coordination</td>
</tr>
<tr>
<td>Highest reaction time</td>
</tr>
<tr>
<td>Highest peak of muscle strength</td>
</tr>
<tr>
<td>Highest BP</td>
</tr>
<tr>
<td>Highest temperature</td>
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<tr>
<td>Melatonin secretion starts</td>
</tr>
</tbody>
</table>

Table 4 created from information provided by Rosa et al, (2016)

Inadequate sleep often results from late night/early morning functioning or psychological factors such as stress and anxiety (Fullagar et al., 2015). Changes in sleep patterns include, sleep deprivation (the complete absence of sleep over a duration of time i.e., 24 hours or more), and sleep restriction (the reduced number of hours slept in one night or more) (HajSalem, Chtourou, Aloui, Hammouda, & Souissi, 2013). Sleep restriction can manifest in waking earlier than usual or falling asleep later than usual (Fullagar et al., 2015). Inadequate sleep may compromise mental alertness and physical functioning (Reilly, 2009), and, within a military setting sleep restriction is more prevalent (Troxel et al., 2015).

Sleep restriction in military forces are seen with insomnia, stress, ingestion of stimulants (caffeine), major life events, (death of friend/family and divorce), environmental conditions (weather/sleeping in encapsulated spaces), use of medication, illnesses, anxiety, poor mental wellbeing and obstructive sleep apnoea (Troxel et al., 2015). The Pittsburgh Sleep Quality Index (PSQI) found, in tri-services, that 46% of individuals in the
military reported scores of ≥5 which represents a poor sleep (Mysliwiec, Matsangas, & Baxter, 2016). This is similar to results seen in Troxel et al, (2015) who not only found sleep restriction among all four services (48.6% of US Army, Navy, Air Force and Marines reported score of ≥5) but reported the US Navy averaged only 5.9 hours of sleep which impacted daily functioning. Within the Royal Norwegian Navy, increased movement while sleeping (due to loud noise when living on a ship) is linked to impair sleep by 36.9% (Sunde, Bråtveit, Pallesen, & Moen, 2016). Tri-service US soldiers reported that just over 50% (928 participants) suffered from some form of sleep restriction but primary findings were ‘trouble falling asleep’ and ‘staying asleep for the night’ (Lincoln, Moore, & Ames, 2018). This suggests that sleep restriction in the military is highly reflective of external factors such as the environment.

The ability to sleep uninterrupted within field operations is often not possible. According to Naitoh, Englund, and Ryman (1983) US Marines historically have previously had to work 20 hour shifts separated by only 4 hours of sleep. Furthermore, while they stated that napping improved performance, it was not effective for restoring full cognitive performance. However, it is important to note that Marine forces are considered to be elite forces, and this is often a requirement within field operations which is different to additional military services. Tri-services military forces are reported to sleep approximately 6.5 (Peterson, Goodie, Satterfield, & Brim, 2008) and 6.7 hours per night (Mysliwiec et al., 2016). While this is not the recommended sleep duration of 7-8 hours of sleep per night for young to older adults, this is still significantly more than those of elite forces (Hirshkowitz et al., 2015). Young aged individuals of junior rank are at increased risk for suffering from sleep restriction which is linked to the stress/requirements of the military in addition to traumatic experiences (Troxel et al., 2015). Among the UK armed forces (marine and army), 23% reported sleep restriction with an additional 11% reporting mental disorders which impacted habitual sleep throughout a duration of six months (Troxel et al., 2015). This suggested that while there are differences among military services, young individuals within the Navy, and especially the Marines, are at increased risk of sleep restriction when within field operations and at base. However, not only are personnel exposed to impaired sleeping
environments within the field, it appears that impaired sleep is present when living on base.

Environmental stimulus (temperature, noise and light exposure), over training, stress of pre-deployment is all linked to impaired sleep while on base (Brown, Berry, & Schmidt, 2013; Troxel et al., 2015). Sleep is also impacted by new recruits who bring poor habitual sleeping practices into the military. These practices include, drinking alcohol, smoking, electronic device use at night (phone/laptop) and substance abuse which impacts sleep-wake cycles (Brown et al., 2013). Furthermore, within the military, emphasis is placed on increasing and maintaining physical fitness. When this becomes excessive it can cause overtraining, which is linked to declining or broken sleep cycles. For example, Booth, Probert, Forbes-Ewan, and Coad (2006) found that over a period of 45 days, recruits slept on average of 6.4 hours which reflected the increase in training intensity and volume. There was also a substantial reduction of hours slept when the first seven nights of sleep were compared to the last seven nights of sleep. Increased training is linked to impaired sleep through suppression of the immune response, increased autonomic signalling and increased free radicals which are linked to cognitive decline, impaired mood and reduced physical performance (Driver & Taylor, 2000; Fullagar et al., 2015; Kreher & Schwartz, 2012; Lastella et al., 2018). Secondary to the factors causing impaired sleep while living within military environments, are the effects of individuals snoring who share the same room.

A total of 19.5% of individuals who snore are reported to not wake up feeling refreshed, and have difficulty with breathing (Okpala, Walker, & Hosni, 2011). As such, they will take medication to aid in sleep (Okpala et al., 2011). This is not only problematic for the individual sleeping, but because military lifestyle requires living in confined spaces, personnel who share the same sleeping arrangements are also affected. Lettieri et al, (2005) report that 45.7% of individuals with high or excessive body weight are more likely to snore while asleep. This suggests that impaired sleep is more than just limited to the aforementioned factors but can also be due to individual aspects such as body composition and recruitment of new staff with poor sleeping habits. Although the effects of positional sleep therapy (sleeping on one’s side versus their back) has not been
assessed within a military setting, it may serve as a solution for combatting not only people who snore but also those who suffer from impaired sleep due to shared accommodation.

Other factors (diet, mental health and hormones)
Factors such diet, mental health and effects of hormones on health are outside the scope of this research and therefore are not included within the literature review. However, I do acknowledge that they play a role in overall health. These particular factors required multi-testing and sometimes quite complex measures which were outside the parameters of the required study. Factors such as dietary and mental health analysis are multi factorial (for example; diet changes through the year due to changes in season) and are therefore are considered limitations within this study.

Discharge
Over the duration of one’s military career, enlistees are obliged to sign contracts which state their duration of service (Gebicke, 1998). This contracted time is classified as a personnel’s first term and is generally between 2-6 years, typically four years, of service but varies from defence force and profession (Sackett & Mavor, 2006). The duration of time that is served is in accordance with the time and money that is invested into military personnel to develop the required skills to contribute to their defence force (Hoglin & Barton, 2015). On completion of the first term, personnel can either choose to sign another contract for a specified duration or, be released from their military obligations (Braithwaite et al., 2009). While most enlisted persons complete their contracted service time, there is still a high proportion of personnel who do not (Hoglin & Barton, 2015).

Premature discharge (PD)
Globally, PD is of growing concern within all defence force and is defined as an inability of defence force personnel to perform their required duties safely and are therefore discharged from their contracted time (Reis, Trone, Macera, & Rauh, 2007). Within the military, PD accounts for one third of discharge rates while a further one-third are said to have an existing medical condition (musculoskeletal injury, high BP) before entering
the defence force (Niebuhr, Powers, Krauss, Cuda, & Johnson, 2006). However, because PD must be related to a single primary cause, it does not address the underlying cause(s) of poor health nor does it access contributing factors (Pollack, Boyer, Betsinger, & Shafer, 2009; Reis et al., 2007).

**Primary factors**

Premature discharge rates vary from each defence force and nation-state (Larsson, Tegern, & Harms-Ringdahl, 2012). Primary causes include; medical conditions such as CVD, low fitness levels, obesity, musculoskeletal conditions, behavioural factors including personality disorder, substandard performance, substance abuse and various misconduct such as unauthorized absences and illegal offences. Further factors in administrative discharge involve the failure to meet educational standards, preservice psychological problems, criminal history, parental hardship and finally, inappropriate sexual misconduct may be a cause for PD (Booth-Kewley, Larson, & Ryan, 2001). Some factors such as being female, smoking status, training history, age, living in confined space and marriage status (divorced or widowed) are associated with PD (Pollack et al., 2009) but are not the primary cause.

**Medical discharge**

Currently, there is only one study which addresses the epidemiology of medical discharge within the NZDF (Iremonger et al., 2015). This study showed that between 2006 and 2013 a total of 7,511 (9.2%) personnel left the NZDF and 402 (0.5%) were released due to medical related conditions. A comparison of tri-services show that the Royal New Zealand Army have the highest percentage of permanent disability (Iremonger et al., 2015). Interestingly, the RNZN had the lowest rate of permanent disability but the highest rate of medical discharge (Army total = 20.5% vs Navy total 4.2%, Army medical = 5.32 per 1000 personnel, Navy medical = 13.2 per 1000 personnel, Air Force 1.6 per 1000 personnel) (Iremonger et al., 2015). Furthermore, both acute and long-term musculoskeletal injuries were shown to be the leading cause of medical discharge, which represented 32.6% of the total discharged population. While this was the first epidemiological study of medical discharge within NZDF, it failed to capture current medical discharge rates.
Musculoskeletal medical discharge

A musculoskeletal injury is defined as (1) pain, inflammation or a disorder that involves the musculoskeletal system and/or soft tissue, (2) serious enough to seek or obtain medical consultation and (3) could have occurred entirely or in part as a consequence of an external trauma or strain sustained during a training period (Heir, 1998). Studies that have sought to explain the risk factors for injury suggest that a sudden and rapid onset of physical activity; low physical activity before commencing basic training; pre-existing injuries; a high BMI; smoking; low flexibility and age all contribute to injury in military personnel (Booth-Kewley et al., 2001; Iremonger et al., 2015; Knapik, Jones, Hauret, Darakjy, & Piskator, 2004; Larsson et al., 2009; Reis et al., 2007).

In 1997, studies on the Australian Defence Force addressed the location and type of injury among new Amy recruits. Rudzki (1997b) randomly allocated 350 new recruits into either a running group or substituted weighted walking/marching and found that normal running groups resulted in 79.8% of lower-limb injuries while walking/marching resulted in 61.1% of injuries to the lower limbs. Injury locations were predominately the foot (18.9%); knee (16.7%); ankle (13.3%) and shoulder (8.9%) for the walking/marching group (Rudzki, 1997b). Normal running group injury locations were the knee (32.1%); ankle (18.3%); foot (11.9%); and shin (7.3%). Rudzki (1997a) initial study found that 10 discharges reflected lower limb injuries suggesting a possible link between training demand and risk of injury. Reducing both running and walking distance decreased injury rates from 46.6% to 37.6% (Rudzki, 1997). Regarding the NZDF, Davidson, Chalmers, Wilson, and McBride (2008) found that of the 2,575 total injuries reported between 2002 and 2003, via Accident Compensation Claims, approximately 24.5% were from the NZDF. Primary injuries were sprains and strains located in the lower limbs including the ankle (35%); knee (16%); upper leg (15%); lower leg (10%); suggesting that over training may be a possible leading mechanism of injury (Davidson et al., 2008). However, the study by Davidson et al, (2008) was 12 months in duration and therefore may not detect any underlying conditions such as the effects of environmental terrain, poor gait or running technique which also acknowledge to increase the likelihood in musculoskeletal injury (Molloy, 2016; Nindl, Jones, Van Arsdale, Kelly, & Kraemer, 2016; Reis et al., 2007).
Epidemiological findings conducted by Rousseau, Morton, and Lark (currently unpublished) for lower-limb musculoskeletal injuries indicate that between 2005 and 2012 the Royal New Zealand Army had the highest rate of lower limb injuries across the NZDF. In addition, Rousseau reports that, annually, 40% of total injury rates are experienced within the Royal New Zealand Army, with 47% occurring in the ankle joint. Further follow-up research by Rousseau and Lark on the aetiology of the high number of ankle injuries (yet unpublished) show that the long-term effects of wearing military issued boots decrease proprioception and ankle range of motion. This suggests that when military boots are removed, and casual footwear is worn, there is an increased likelihood of musculoskeletal injury which reflects the inability to maintain ankle stability provided by military issued boots. Andersen et al, (2016) also supports the finding of Rousseau and Lark by explaining that while acute increases in training load and overtraining is linked to musculoskeletal injury, so too are the effects of footwear used within the military which can occur in field, sporting events and personal training (Nindl, Williams, Butler, & Jones, 2013). Over-training and inadequate footwear have previously been linked to tibial stress syndrome; patellofemoral syndrome; lower back pain; tendinitis and iliotibial syndrome. With all of the previously mentioned injuries readily occurring in military forces, subsequently resulting in discharge (Andersen et al., 2016). Research from the Australian Defence Force and NZDF propose that there is an increased risk for lower body injury when active military personnel participate in high training loads which is exacerbated due to wearing military issued boots. This suggests that there is a protective effect while wearing military boots which cause maladaptation’s, due to long-term boot wear, which exacerbates the risk of injury when not wearing the boot.

Several studies have also addressed how musculoskeletal injuries which existed prior to entering military services and the subsequent impact on military discharge (Cox, Clark, Li, Powers, & Krauss, 2000; Knapik et al., 2004; Swedler, Knapik, Williams, Grier, & Jones, 2011). Waiving injuries to allow enlistment is done on a case by case basis and depends on the injury classification/location and history of symptoms, nevertheless, this can cause complications for military service (Knapik et al., 2004). A loss of financial income for the associated defence force and a long rehabilitation process for those injured are
the primary implications seen with waiving injuries (Taanila et al., 2009). For those who receive a waiver for musculoskeletal condition, there is an increased risk of injury due to the physical requirements of the military. Cox et al, (2000) examined the number of knee injuries among entry level military populations against non-injured military in order to examine discharge rates over 6 to 30 months post enlistment. Results found that those who suffered an injury prior to military service were 2.1 times more likely to be discharged from their military service and 14 times more likely to be discharged compared to those who were injury free. Similar findings are seen in the Knapik et al, (2004) review of military attrition, whereby waived groups of military personnel with back injuries (281) were compared against a control group and results indicate that waived personnel had a higher probability of time off from active duty (600 days). There was no difference in Navy and Marines, due to limited research in this domain.

In 2012, musculoskeletal injuries were the leading cause of hospital visits and ultimately resulted in 2,200,000 medical encounters in the US (Cox et al., 2000). The prevalence of orthopaedic injuries among 18,651 soldiers resulted in 3.44% (641) discharged and of those 43% (274) were discharged due directly to orthopaedic injuries (Schwartz, Libenson, Astman, & Haim, 2014). However, to understand military discharge rates based on medical discharge and musculoskeletal injuries additional factors may need to be considered.

**Body Mass Index and injury**

Between 1978 and 2000, the US military have progressively increased in obesity/high BMI status (Krauss, Garvin, Cowan, & Boivin, 2017). Previous studies have found that a BMI score >30kg·m² and <18.5kg·m² was related with high rates of musculoskeletal injury and ultimately PD (Larsson et al., 2009; Pollack, Boyer, Betsinger, & Shafer, 2009). A 12 month cohort study found that musculoskeletal injuries of the lower and upper extremity (lower and upper legs/arms) occurred in overweight populations (Viester et al., 2013). Obese populations were found to have significantly more musculoskeletal injuries in the upper and lower extremities, lower back, neck and shoulders (Viester et al., 2013). The increase in BMI (particularly in central obesity) contributes to an anterior shift in the body centre of mass, which increases torque developed at the ankle, knee
and hip joints to maintain an upright position (Nunns et al., 2016). Underlying mechanisms for non-weight-bearing joints (such as the neck, shoulders and wrists) causing musculoskeletal injuries have previously been demonstrated to stem from daily activities such as sit-to-standing as overweight individuals. These individuals will use their upper extremities to assist in standing which increases force on the shoulder capsule, therefore increasing injury risk (Viester et al., 2013). Obesity has also been attributed to nerve compression due to increased adipose tissue (Becker et al., 2002). Compression of the median nerve has shown to be linked to carpal tunnel syndrome in those who have a BMI of >30kg·m$^2$ which leads to pain, and in severe cases paraesthesia, in the hand (Becker et al., 2002). Over 12 months, researchers found that there was a linear relationship between increased BMI, workload and musculoskeletal injuries among a population of 44,793 (Viester et al., 2013). It was concluded that increased loading on the body (due to BMI and physical work) caused more stress on joints such as the ankles; knees; hips and compression of nerves (upper and lower legs), which subsequently caused pain, weakness and reduced work productivity (Viester et al., 2013). While the study was not conducted on military personnel, these findings are applicable to military personnel due to the physically demanding nature of the military requirements.

Underweight, overweight and obese individuals have previously been compared to normal BMI standards and found that those either underweight and obese were at the greatest risk for musculoskeletal injury (Flegal, Graubard, Williamson, & Gail, 2005). This is also consistent with Finestone et al., (2008) who found that a low BMI increases the likelihood of stress fractures among females. Furthermore, researchers also stated that that when low BMI standards was coupled with low physical activity prior to joining the military, there is a significant increase of musculoskeletal injury susceptibility. This suggests that those with BMI standards outside of normal values are exposed to increase the chance of musculoskeletal injury within a military environment.

Low fitness levels and musculoskeletal injury

Military forces have fitness standards that are to be maintained throughout their contract duration. While each military force has their own specific fitness requirements,
they all have the objective of ensuring that personnel are deployable and can conduct military objectives (Bridger, Munnoch, Dew, & Brasher, 2009). When fitness levels fall below military requirements standards, there is an increased risk for musculoskeletal injury (Booth-Kewley et al., 2001). More specifically, if fitness levels are not maintained throughout the year and high training volume loads are subsequently commenced for preparation of fitness tests or field work, then this can lead to increase the risk for musculoskeletal injury (Larsson et al., 2009). While an increased volume/intensity of training can cause positive training adaptations, when recovery from this training is inadequate or disrupted then declines in performance occur (Zinner & Sperlich, 2016). For example, inadequate recovery from exercise can cause imbalances in the testosterone:cortisol ratio. A high testosterone:cortisol ratio reflects a state of anabolism (30% decrease in cortisol which decreases catabolism) while a low testosterone:cortisol ratio indicates a lack of adaptation to the exercise stimulus applied, which impairs performance and is correlated to injury (Joyce & Lewindon, 2014). Those with low fitness levels who suddenly increase physical activity stress on the musculoskeletal system are said to increase the risk of stress fractures, weaken connective tissue and present with a blunted immune response (due to increased inflammation) and decreased leukocytes and cytokines concentrations, which increase not only the risk of illness but musculoskeletal injury also (Gleeson & Walsh, 2012; Joyce & Lewindon, 2014; Mackinnon, 1997).

Discharge rates for males versus females

It is estimated that the US recruitment training consists of approximately 30,000 males and 8,000 females per year (Trone et al., 2013). Evidence has previously compared male and female discharge rates and causations of discharge (Bray, Camlin, Fairbank, Dunteman, & Wheeless, 2001; Gebicke, 1998; Jones & Bovee, 1993; Lappe, Stegman, & Recker, 2001; Trone et al., 2013). Factors that expose males and females to higher PD rates are multifactorial and complex but primarily consist of, musculoskeletal injuries, physical inactivity prior to joining the military, anthropometrics, low/high BMI standards, smoking status, depression/mental health symptoms and being a female in the military (discussed below) (Bray et al., 2001; Ezzati et al., 2013; Geary, & Croff, 2002; Jones & Bovee, 1993; Trone et al., 2013). Research shows that there is a separation
between males and females, with females having higher PD rates, particularly due to high musculoskeletal injury (Geary et al., 2002).

Males and females are required to undergo the same style and format of military training and as a result female are often at a physical disadvantage (Trone et al., 2013). A 15 year overview of injuries among UK military forces found a significant change of trends for musculoskeletal injury between each sex (see figure 1) (Geary et al., 2002). This research identified that between 1985-1993 there was a low prevalence of musculoskeletal injury among female military personnel, however, between 1993-2000 there was a dramatic rise in musculoskeletal injury rates (Geary et al., 2002). While this can be related to an increase in female recruits among military forces, it was also reflective of a dramatic increase in musculoskeletal injury which is suggested to arise from anthropometric limitation (Krupenevich, Rider, Domire, & DeVita, 2015).

A shorter stature and stride length were shown to increase the risk of musculoskeletal injury in females when performing physical activity (Neely, 1998). The effect of carrying heavy backpacks (22kgs) requires females to produce more force through the lower body which increases fatigue rates and decrease their stride length, therefore creating a potential source for injury (Krupenevich et al., 2015). In comparison, a study which assessed the effects of self-reported training and injury history prior to joining the US Navy found that low physical activity and a history of musculoskeletal injury prior to joining resulted in 17% of males and 21% of females not completing their first recruitment training (Trone et al., 2013). This low participation of exercise prior to joining the military suggests a lack of musculoskeletal adaptations to meet the high physical demands of exercise experienced in the military which increases the susceptibility of injury (Burton, Stokes, & Hall, 2004).
**Figure 1**: Medical discharge rates for musculoskeletal disease and injury by gender between 1985 and 2000 (Geary et al., 2002).

Permission for figure 1 sought from Occupational Medicine – awaiting response

**Economic cost of early discharge**

Between 1978-1998 an estimated cost of US$1.6 billion was spent on enlistment training and recruitment (Gebicke, 1998). By 2006, it was projected that the Department of Defence would spend US$2.1 billion annually as a result of poor health among all military forces and an additional US$965 million on paid medical leave and replacement training (Naito & Higgins, 2012). The US military spends approximately US$22,000 on recruiting and medically clearing a single person, and a further US$18,000 spent on basic training per annum (Swedler et al., 2011). It is estimated that a reduction of 10% in the US military would save US$12 million per annum (Booth-Kewley, Larson, & Ryan, 2001). In 2008, US citizens paid more than US$8.6 billion which benefited US$8.5 million physically/mentally disabled retirees and the Department of Defence spent a further US$1.3 billion which benefited 86,000 physically/mentally disabled retirees (Sikorski, Emerson, Cowan, & Niebuhr, 2012).

While the NZDF only totals 14,532 personnel inclusive of regular, reserve force and civilians, it stills faces excessive expenditure based medical discharge and time off from active duty (NZDF, 2018). Total costs of discharge between 2002 and 2003 for the
Australian Defence Force was reported to be $15 million (Australian Defence Force, 2014). The financial expenditure of discharge rates among the NZDF is currently unknown.

Importance of premature discharge
Discharge of military personnel is essential and necessary as injured and/or medical complaints are associated with unnecessary financial expenditure and place individuals and associated individuals at risk of harm (Iremonger, Atalag, Johnston, & Campbell, 2015). Nevertheless, the NZDF must act in accordance with the NZ Human Rights Act 1993, which states that employers must take specific steps to accommodate for disabilities (The Human Rights Act 1993: guidelines for Government policy advisers, 2000), therefore, the NZDF can only discharge personnel deemed inadequate to perform the required duties.

Procedures to measure health
The following sections review potential health measurements available that would be suitable for the health screening required.

General health
AHA/ACSM health and fitness pre-participation screening questionnaire
Application of the American Heart Association/American College of Sports Medicine health and fitness pre-participation screening questionnaire (AHA/ACSM questionnaire) allows for CVD risk factors to be identified and also contain cardiac pathologies which are exclusion worthy within the NZDF (NZDF, 2018). This questionnaire has 37 questions which assess an individual’s risk of a cardiac event while exercising (ACSM., 2014). The questions asked pertain to cardiovascular/pulmonary/metabolic disease history, symptoms experienced at rest/exercising and CVD risk factors (see appendix 1 for full questionnaire) (Maron et al., 1996). Completion of the questionnaire allows health and exercise professionals to identify any contraindications for exercise (see appendix 2), therefore decreasing the risk of a cardiac event such as an acute myocardial infarction while participating in exercise (Riebe et al., 2015). Individuals who answer with two or
more positive risk factors are assigned one of three categories via an algorithm named the "logic model for classification of risk for of cardiovascular disease and risk classification table" (see appendix 3 and 4) (ACSM., 2014).

Because the AHA/ACSM questionnaire is self-administered, it is important that results are interpreted and reviewed by qualified health care professional to determine if individuals are at risk (ACSM., 2014). This is due to the undisclosed information and cardioprotective questions asked, which may be misinterpreted by lay people such as blood cholesterol and glucose levels (Whitfeild, Pettee- Gabriel, Rahbar, & Kohl, 2014). For example, HDL levels of ≥60mg·dL⁻¹ (1.55mmol·L⁻¹) are considered a protective mechanism of cardiovascular and metabolic disease, therefore, results in the reduction of one total risk factor score (ACSM., 2014; Assmann & Gotto, 2004).

A limitation of the AHA/ACSM questionnaire is if an individual is classified as moderate or severe risk then medical referral examination before exercise may be required. This can lead to timely and unnecessary referral to health care professionals (Thompson, Arena, Riebe, & Pescatello, 2013). Consequently, a consensus was established that medical clearance is only sought when individuals present with at least one of the four characteristics. See appendix 5 for the full classification table. Joy and Pescatello (2016) also suggests that reducing medical referral increases exercise adherence which is of importance to both asymptomatic and symptomatic individuals. This suggest that decreasing medial referral rate will increase exercise participation and decrease not only signs and symptoms experienced, but also fear from exercise participation. Individuals who have a history of CVD require general practitioners or medically qualified staff to stay through exercise sessions that are in accordance with the previously mentioned classifications (Magal & Riebe, 2016; Neath & Quail, 2001; Riebe et al., 2015).

While the AHA/ASCM questionnaire has been recently updated to decrease physician referral, peer-reviewed literature is scarce with regards to its usage among military populations. However, Whitfeild et al, (2014) applied the ACSM/AHA questionnaire to the National Health and Nutrition Examination Survey which surveyed 6,785 US personnel aged 40 years and over. The objective was to quantify what proportion of
people surveyed would receive recommendations based on the AHA/ACSM questionnaire. Results found that between 2001 and 2004, of the 3,459 females and 3,326 males, 95.5% of female and 93.5% of males would be recommended to see a physician based on their results. It is important to note that while these rates are high, the updated AHA/ACSM questionnaire was developed one year later to decrease these numbers. Currently, to the researcher’s knowledge, there is no up to date data with regards to referral rates based on the updated AHA/ACSM questionnaire.

**Pittsburgh Sleep Quality Index (PSQI)**

The PSQI contains 19 individual self-rated questions which examine seven different aspects of sleep. These include; sleep quality; latency; duration; disturbance; habitual sleep efficiency; use of sleep medication and day time dysfunction (see appendix 6 for full questionnaire, appendix 7 for scoring) (Grandner, Kripke, Yoon, & Youngstedt, 2006). Originally developed in 1988 by Buysse and colleagues, the objective of the PSQI was used to produce a standard and quantifiable measures of sleep status in order for both clinicians and health professionals to have the ability to assess factors which impaired sleep (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989; Mollayeva et al., 2015). It has been used on a wide array of diverse populations including military populations (Manzar et al., 2018; Mollayeva et al., 2015).

Validation studies of the PSQI are seen in a variety of populations (Cole et al., 2006; Grandner et al., 2006; Nishiyama et al., 2014). Recently the PSQI was validated among 311 healthy non-military participants (men age = 25.5 years ±6 years, BMI = 22.1 ±2.3kg·m²) for insomnia (Salahuddin et al., 2017). Results found that the global score of the PSQI was 7.0 and did not have a floor or ceiling effect. In other words, no participant had maximum (21) or minimum (0) scores. However, results did show ceiling effect among individual components of sleep duration and efficiency (Salahuddin et al., 2017). Of importance is that the PSQI showed consistency among the population sampled (Cronbach’s alpha = 0.59). Additional validation studies of the PSQI in both clinical and non-clinical populations have also shown that while global score are valid, three component questions are significantly important when assessing scores (sleep efficiency, perceived sleep quality and disturbances) (Cole et al., 2006). This suggest
that while the total global score is both valid are reliable, careful analysis of questions, such as those mentioned above, should be considered when analysing findings as total global score may not equal of ≥5, however, individual component questions may show ceiling effects.

Additional studies have also compared the PSQI to other sleep questionnaires and sleep diaries which have shown favourable results for the PSQI. Fichtenberg, Putnam, Mann, Zafonte, and Millard, (2001) validated the PSQI against the Epworth sleepiness scale and a seven-day sleep diary among 50 participants with traumatic brain injury (15 with insomnia and 35 without insomnia) (total mean age = 33.8 years, male = 59%, female = 41%). Results found that mean data obtained from the PSQI including sleep latency (31.9 minutes ±40.9 minutes, $r = 0.796$) sleep duration (7.6 hours, ±1.6 hours, $r = 0.633$) and sleep efficiency (84.9% ±18.0%, $r = 0.641$) were not statistically different from sleep diary data. Fichtenberg et al, (2001) concluded that the PSQI is a valid screening method to assess insomnia in traumatic brain injured patients. Additional studies have found that the PSQI also show high test-retest reliability and validity among those with primary insomnia (Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002). Test-retest was applied to 80 primary insomnia patients (46.3 years ±15 years) and 45 control subjects (43.3 years ±9.5 years). The study was applied over a period of two nights of polysomnography laboratory testing, a seven to fourteen-day sleep diary and two applications of the PSQI over a 45 day period (±18 days). Results found the PSQI global score to be 12.5 (±3.8) for insomnia patients and 3.3 (±1.8) for controls (p-value = 0.000) with 98.7% for sensitivity (Backhaus et al., 2002). Primary sleep components highlighted were sleep quality and sleep disturbance. Strong correlations between the sleep diary and the PSQI were found within total hours slept and sleep latency ($r. = 0.71$ and $r. = 0.81$). Furthermore, while correlation between the PSQI and polysomnographic were lower than highlighted components mentioned above, results were still significant (sleep duration; $r. = -0.32$, p-value = 0.034, sleep efficiency; $r. = 0.28$, p-value = 0.063) (Backhaus et al., 2002). Therefore, findings from Fichtenberg et al, (2001) and Beckhaus et al, (2002) suggest that increases in total global scores can result from a single individual component. However, Backhaus et al, (2002) suggested that individuals tend to focus on nights when sleep is impaired (especially insomnia populations) and
therefore may present a bias in results. Nevertheless, application of the PSQI within military populations has found sleep restriction to be a leading cause of impaired sleep in military settings (Troxel et al., 2015). Despite this, it is important to note that to the researchers’ knowledge, no direct validation studies of the PSQI has been conducted within military populations (Mysliwiec et al., 2016).

*Injury – The Y-Balance test (YBT)*

The Y-Balance test (YBT) is a dynamic balance and stability test performed on a single limb and is used to provide information about left and right symmetry of the upper and lower extremities (Cosio-Lima et al., 2016). The foundation of this assessment is based on the Star Excursion Balance Test which was formally used to assess lower limb injuries through eight multi-directional motions on both left and right lower limbs (appendix 8) (Gray, 1995). However, research has found that left and right lower extremity reach directions (anterior, posteromedial and posterolateral) predicted injuries, thus, additional reach directions were considered redundant (Hertel, Braham, Hale, & Olmsted-Kramer, 2006; Plisky et al., 2009). Therefore, because it is easy to apply and low-cost, the YBT includes both lower extremity YBT (LEYBT) and the upper extremity YBT (UEYBT).

The objective of the UEYBT is similar to the LEYBT (assess symmetry and injury susceptibility of left and right arms), however, core rotation and stability is also required (Gorman, Butler, Plisky, & Kiesel, 2012). Westrick, Miller, Carow, and Gerber (2012) validation study of the UEYBT, found that the UEYBT is not only a reliable unilateral assessment for upper extremity closed chain performance but was well associated with the other measures such as the closed kinetic chain upper extremity stability test, lateral trunk endurance test and the push up test.

The closed kinetic chain upper extremity stability test is a well validated measure of upper extremity stability (Goldbeck & Davies, 2000), however, results do not discriminate between left and right limbs as both limbs are working simultaneously to attain stability (see appendix 9) (Tucci, Martins, de Carvalho Sposito, Camarini, & de Oliveira, 2014). Therefore, because the UEYBT does dissociate between left and right
limbs, it is a reliable choice of apparatus to use within assessments analysing asymmetry and balance/stability for the upper body. Additionally, both the UEYBT and LEYBT have individual cut-off values for injury risk according to gender. This is important as, previously mentioned, males and female are reported to have differences in musculoskeletal injuries within the military due to anthropometric limitations.

The YBT is increasing in popularity for musculoskeletal assessments for injury within the military. Unilateral limb dominance (reflective of poor biomechanical alignment resulting from external forces causing unilateral limbs to become overactive and cause malalignment within the muscular system) can often increase the risk of injury within military forces (Gorman et al., 2012). Asymmetry greater that 4cm in the YBT is reported to increase the likelihood of injury (Shaffer et al., 2013). With regards to military populations, males and/or females who have a composite score of ≤88% and ≤85% for their UEYBT and ≤92% and ≤89% for their LEYBT are at increased risk for injury (Teyhen et al., 2014). Comparatively, composite reach scores of <94% in female basketball players have previously been reported to be 6.5 times more likely to be at risk for injury (Plisky, Rauh, Kaminski, & Underwood, 2006). However, the lower composite scores in the military are likely to reflect the physical activity requirements in the military such as pack marching. Differences in symmetry, composite scores (i.e., asymmetry) may increase throughout an individual’s duration in the military. For example, Teyhen et al, (2014) applied the YBT to assess the influence of age and gender on balance and stability among 247 US active serving military personnel (males = 140; females = 107; <30 years = 143; ≥30 years = 104). Results are displayed in table 5.

<table>
<thead>
<tr>
<th>Table 5: Comparison of upper and lower YBT scores adjusted for gender and age among active serving US military personal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper YBT mean</strong></td>
</tr>
<tr>
<td>Overall</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>&lt;30 years of age</td>
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<tr>
<td>≥30 years of age</td>
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</tbody>
</table>

Table 5 created from information extracted from Teyhen et al, (2014)
The results suggest that males aged >30 years have better LEYBT and UEYBT. However, this may be attributed to the fact that the population size of males aged <30 years was larger than their aged match opposite sex peers. Follow-up study by Teyhen et al, (2016) reinforced that not only are there differences based on gender but also with age. Interestingly, Teyhen et al, (2016) observed significant correlations with the Army physical fitness test and the YBT suggesting that better symmetry between left/right and upper/lower body is linked to increased physical performance. While these findings do show differences in age and gender within a military setting, maximal age of participants was 45 years with increased numbers in those of lower ages which may skew results. Cosio-Lima et al, (2016) suggested that those over 29 years are at greater risk for musculoskeletal injury. Nevertheless, it is still important to address balance and stability in order to improve not only physical fitness but reduce increasing musculoskeletal injuries.

**Sit and reach test**

Validation studies of the sit and reach test conducted by Lemmink, Kemper, Greef, Rispens, and Stevens, (2003) concluded that the sit and reach test positively identified hamstring flexibility in middle aged (55 years) males and females but not the lower back. Similarly, Mayorga-Vega, Merino-Marban, and Viciana, (2014) meta-analysis also found valid hamstring flexibility results via the sit and reach test. While low, Mayorga-Vega et al, (2014) found validation in lumbar extensibility (lumbar tightness causing limited lumbar flexion) suggesting a relationship between posterior tightness and injury susceptibility. Within the military, a mean score of 41.6cm was attained among 25 actively serving military males and females performing the sit and reach test (Zupan et al., 2018). According to the ACSM, (2014) this is considered excellent for males and females (see appendix 10). Within the military, research has found that those with increased flexibility present with less injuries, lower WHR, body fat percentage, less sedentary behaviour/fatigue and more time spent exercising (Kennedy-Armbruster, Evans, Sexauer, Peterson, & Wyatt, 2013). This suggest that those who are more flexible are less likely to be injured and may present with adequate or optimal health parameters.
**Fitness - VO2max**

The RNZN entry requirements and annual fitness tests are shown in appendix 11. All fitness tests within the RNZN are graded on a scale from 0 (minimal pass) to 5 (highest pass) with the highest scores achieved increasing the likelihood of entry into the RNZN (NZDF, 2018). For those who are active within the RNZN and then fail fitness tests, personnel are required to consult with a personal training instructor until required fitness levels are achieved (NZDF, 2018). A multi-stage fitness test (beep test) is currently performed by all personnel and is then followed by a body drag, body lift/carry (with a dummy), an entry level swim (50 meters – not timed) and a in water float for 3 minutes while wearing standard gym/running shoes and RNZN overalls (NZDF, 2018). There are varying ages and genders in the RNZN, therefore, fitness tests are scaled according to gender and age groups (see appendix 11). It is important to note that there are differences between each defence force and their aligned country. For example, differences exist between the Royal New Zealand Army/Air Force/Navy and the Royal Australian Army/Air Force/Navy. Furthermore, swimming is not assessed within the Royal NZ Army nor the Royal NZ Air Force as it is not required within their defence force (see appendix 11, 12 and 13 for additional differences between NZDF fitness tests) (NZDF 2018).

**Measuring fitness**

A large proportion of military forces use running assessments such as shuttle tests or timed distance run to measure aerobic fitness (Hauschild et al., 2014; Knapik, 1989; Panichkul, Hatthachote, Napradit, Khunphasee, & Nathalang, 2007), including the NZDF. While these tests are valid and reliable, and can be applied to a large group of individuals at a single time, they require large open space that is not always accessible (Bandyopadhyay, 2015; Mayorga-Vega, Aguilar-Soto, & Viciana, 2015). Additionally, to produce valid and reliable results, environmental factors including weather and surface conditions (i.e. grass, concrete wooden floors) need to be consistent (Hauschild et al., 2014; Mayorga-Vega et al., 2015). Any variation in environmental conditions may increase the inaccuracy of the results. However, to reduce errors testing, cycling tests have previously been compared to running tests which provide valid and reliable results (Mays, Boér, Mealey, Kim, & Goss, 2010).
YMCA estimated VO$_{2\text{max}}$

The YMCA cycle test (ACSM, 2014) is also used to measure aerobic fitness and has been well validated in many different populations including the military (Beekley et al., 2004; Pollock et al., 1994; Travensolo et al., 2018). This test is designed to progressively increase the steady state heart rate over a 6 to 12 minute period and record values between 110bpm and 85% of an individual’s age predicted heart rate (ACSM, 2014). Within the military, mean results for those aged between 18 and 54 years were 48.3ml·kg$^{-1}$·min$^{-1}$ (males and females), male mean value (38.1 years) was 51.9ml·kg$^{-1}$·min$^{-1}$ while females mean value (38.7 years) was 32.8ml·kg$^{-1}$·min$^{-1}$ (Beekley et al., 2004). According to the ACSM (2014) this is considered “good” for males and “below average/average” for females – depending on age classification (see appendix 14 for full table of fitness values based on age and gender). In comparison to data by Beekly et al, (2004), the Finish defence force reported that male VO$_{2\text{max}}$ values were between 44.8ml·kg$^{-1}$·min$^{-1}$ and 47.4ml·kg$^{-1}$·min$^{-1}$ (Santtila, Hakkinen, Pihlainen, & Kyrolainen, 2013). However, the Finish defence force has a conscription process, therefore female data is currently unknown. The Royal Australian Air Force reported that pilots mean VO$_{2\text{max}}$ score was 50ml·kg$^{-1}$·min$^{-1}$ (Newman, White, & Callister, 1999). It is important to note that VO$_{2\text{max}}$ values in Newman et al, (1999) and Santtila et al, (2013) are estimated values and not measured directly via gas analysis.

Direct gas analysis of VO$_{2\text{max}}$ is considered the gold standard of VO$_{2\text{max}}$ testing, however, due to the high costs of equipment and process of setting up, it is not often conducted in field research, especially with large numbers (ACSM, 2014). However, Beekley et al, (2004) estimated measurements of VO$_{2\text{max}}$ were well correlated with direct gas analysis measures and were reported to predict VO$_{2\text{max}}$ analysis accurately in male participants. Females were found to have a 2.2ml·kg$^{-1}$·min$^{-1}$ difference between direct and estimated values of VO$_{2\text{max}}$. This suggests there may be differences between genders seen with over/under prediction which is not uncommon for VO$_{2\text{max}}$ results (ACSM, 2014).

**Summary**

From the research gathered, there appears to be a high requirement for not only physical fitness but general health and wellness. While annual fitness tests are required
within military populations, not all personnel maintain these standards. Furthermore, because medical examination of one’s general health is conducted once every 2 years, this may not capture CVD risk factors in the early stages. Cardiovascular complications are suggested to be exacerbated for those who progress into high ranked positions (officers) due to increased sedentary time performing administrative tasks. This can reflect an increased body weight, BMI and WHR which is typically more prevalent in males and those aged ≥35 years. This increases not only the risk for cardiovascular complications such as high BP or abnormal blood lipids/glucose but the risk of injury and, in the worst-case scenario, medically discharged. Implementation of valid and reliable tests have shown favourable results in improving health and wellness of military populations irrespective of their age or gender, therefore providing justification for the requirement of this thesis’s research.

Ultimately, the importance of this research will be to provide better insight into how to reduce the cardiovascular complications such as high BP and the number musculoskeletal injuries in military forces in addition to reducing medical discharge and overall financial expenditure through valid, reliable and effective health and wellbeing assessments.
CHAPTER 3. Materials and methods

Participants

One hundred and twenty-two volunteers (84 male, 37 females and one not disclosed; mean age 36.2 years ±12.1 years) participated in this study between September 6th, 2017 through to April 27th, 2018. Volunteers were recruited through the RNZN based in Devonport, Auckland, New Zealand. Human ethics was approved by the Massey Human Ethic committee Southern A, (application 17/35) and the NZDF Headquarters Organisational Research (number 5000/PB/5/3, dated 9/6/2017). Recruitment involved visits to the RNZN base in Devonport handing out flyers about the study and how to contact the primary researcher. Participants that were recruited were provided with written information about the study and informed of exclusion criteria based on the following elements; civilian, (defence force outside of the RNZN (Royal New Zealand Air Force/Army), non-active serving in the RNZN.

Protocol

All tests were completed on the same day for an individual. However, testing occurred in two separate phases between 0600 – 0730 hours (phase one) and 0830 – 1500 hours (phase two) as blood cholesterol/glucose was required to be collected in a fasted state (≥12 hours). Upon arrival, informed consent was obtained, and participants were asked to rest for 10 minutes to establish resting heart rate and BP. Following this, fasted blood cholesterol and glucose was obtained via finger prick blood sample. On completion of phase one, participants requested a time they could return for phase two.

Phase two testing involved answering two questionnaires, collection of anthropometric data, implementation of the YMCA cycle fitness tests, YBT for upper and lower extremities and the sit and reach test for flexibility. Questionnaires included the AHA/ACSM questionnaire to measure general health and the PSQI questionnaire to measure sleep status over the past four weeks. Anthropometric data collected included weight (kgs), height (m), waist circumference (cm), hip circumference (cm) and right arm/leg length (cm). The YMCA (ACSM, 2014) estimated VO2max test was used as a measure of fitness. On completion of all tests, participants were given their personal
results and feedback, via a Clinical Exercise Physiologist which would enable them to interpret all information provided.

Confidentiality
All research assistants outside of Massey University were required to sign a Confidentiality and Transcriber’s agreement (see appendix 15 and 16). Additionally, to prevent identification of participants, all participants were coded alphanumerically and were only known to the primary researcher.

Tests
All tests were conducted by a team of exercise professionals. Tests were conducted in a conveyer belt process with time consuming test conducted first to prevent bottle necking of participants. Phase one of testing involved BP, resting heart rate, fasted cholesterol and glucose. Duration of time to complete part one for a single participant was 17 minutes, inclusive of 10 minute rest prior to BP recording. Part two testing commenced at 0830 hours and took approximately 35 minutes to complete.

Questionnaires were examined by an exercise professional to determine if the participant was free of any known signs and symptoms of cardiovascular, metabolic and pulmonary disease. If the participants were identified as presenting with signs and symptoms, then they were referred to a medical professional to conduct an exercise graded electrocardiogram. This did not exclude the participant from all tests in this programme except for the YMCA estimated VO$_{2\max}$ test. On completion of the YMCA estimated VO$_{2\max}$ test, participants conducted the YBT, followed by the sit and reach test. Tests where evaluated and interpreted by an exercise professional and participants were informed of all results.

Blood pressure and resting heart rate
Both BP and resting heart rate were both measured via an Omron® automatic BP monitor (Company: Omron®, Model: HEM7130 Deluxe, Japan). The BP cuff was placed on the left arm with the artery mark placed over the left brachial artery. Participants were seated and rested for 10 minutes prior to measurement.
**Fasted cholesterol**

Blood cholesterol was measured in a fasted state ($\geq 12$ hours). Participants were instructed to not consume any food or beverages, excluding water, which could increase blood sugar or blood lipid levels. Institutional standard operating procedures were applied for finger prick blood sampling and disposal (see appendix 17 for standard operating procedures details). To draw blood, an Accu-chek®, three depth setting, finger prick lancet was used. Approximately 40-35 μL of blood was collected using pipette/capillary blood collectors. Blood was analysed using a CardioChek® blood lipid panel test strips (Company: People Technology and Service® (PTS®) diagnostics, Indianapolis) in a portable CardioChek® home cholesterol test system monitor Company: PTS®, Indianapolis). Total cholesterol (mmol·L⁻¹); HDL (mmol·L⁻¹); triglycerides (mmol·L⁻¹); LDL (mmol·L⁻¹) and total cholesterol/HDL ratio were all recorded. In the event that LDL and total cholesterol/HDL ratio were too low and were not displayed, calculations outlined in the PTS® lipid panel standard operation procedures provided by the manufacturer were used (see calculation below). All blood samples were disposed via bio-hazard waste bags and sharps bins as per standard operating procedures.

Calculation for LDL cholesterol

\[
\text{LDL cholesterol} = \text{total cholesterol} - \text{HDL} - (\text{triglycerides}/5)
\]

**Fasted glucose**

All SensoCard© PLUS monitors (Company: Point of Care Diagnostics©, Model: Sendocard PLUS, NZ) were calibrated to SensoCard© blood glucose testing strips (Company: Point of Care Diagnostics©, Model: Sendocard© PLUS, NZ) prior to testing each day. Fasted blood glucose was taken from the same site as fasted blood cholesterol. Approximately 0.5μL of blood was placed on SensoCard© blood glucose testing strips and, fasted blood glucose levels were displayed and recorded.

**AHA/ACSM health and fitness pre-participation screening questionnaire**

The AHA/ACSM questionnaire (ACSM, 2014) was self-administered via hard copy. Participants were asked to answer yes or no to all questions (see appendix 1 for full questionnaire used). The research team entered values for blood cholesterol, glucose
and BP where applicable to prevent incorrect and inflated total scores and misinterpretation of information. If individuals were unsure of questions asked in the questionnaire, then their results were considered as a positive risk factor (+1 score) for CVD. This applied for all variables except blood glucose, where a +1 scores indicates prediabetes (Magal & Riebe, 2016). Prediabetes is only classified as a positive risk factor when age is >45 years or when age is >45 years and their BMI exceeds 25kg·m² (ACSM., 2014).

**Pittsburgh Sleep Quality Index questionnaire**

On completion of the AHA/ACSM questionnaire (ACSM, 2014), the PSQI questionnaire (Buysse et al, 1989) was self-administered via hard copy (see appendix 6 for full questionnaire used). Participants were asked to recall the previous four weeks of habitual sleep and to be as specific as possible. Once completed, the researching team calculated total composite scores (see appendix 7 for calculations/scoring).

**YMCA estimated VO\textsubscript{2max}**

The YMCA VO\textsubscript{2max} test (ACSM, 2014) was conducted on a stationary Monark® 828E cycle ergometer (Company: Monark®, Model: 828E, Washington). Target heart rate values were between 110bpm and 85% of the participant’s age predicted heart rate. Heart rate was monitored with a Polar® FT1 watch and chest strap (Company: Polar®, Model: FT1, Australia). The cycle ergometer set up ensured that the participant could cycle for the maximum duration of 15-minutes with a 3 minute warm up and 3 minute cool down period included and with a minimum of two stages completed to perform calculations. Once familiarised with all procedures, participants cycled the baseline value of 150kgm·min\textsuperscript{-1}, with 0.5kg, and were required to maintain 50 revolutions per minute (rpm). Participant’s heart rate values were recorded at 3 minutes intervals and values were then used to dictate subsequent workload (see table 6 for workload/heart rate values). Termination of the test occurred when either; the test was fully completed; heart rate values increased beyond 85% of the participants age predicted heart rate; the participant asked to stop, or the 50 rpm could not be maintained. On completion, participants cooled down for approximately 3 minutes by cycling slowly at baseline.
values (150kg·min⁻¹, with 0.5kg). Estimated VO₂max was calculated using the equations below:

\[
VO_21 \text{ (ml·kg}^{-1}·\text{min}^{-1}) = \frac{(1.8 \times \text{work rate})}{\text{Body weight in kg}} + 7
\]
\[
VO_22 \text{ (ml·kg}^{-1}·\text{min}^{-1}) = \frac{(1.8 \times \text{work rate})}{\text{Body weight in kg}} + 7
\]

To find the slope, the following calculation was used

\[
\text{Slope (m)} = \frac{VO_2 (VO_22 - VO_21)}{(HR2 - HR1)}
\]

To find the estimated VO₂max

\[
VO_{2\text{max}} \text{ (ml·kg}^{-1}·\text{min}^{-1}) = m (HR_{\text{max}} - HR2) + VO_22
\]

| Table 6: Workload and heart rate values for YMCA estimated VO₂max |
|-----------------------------|-----------------|-----------------|-----------------|-----------------|
| Stage 1                     | 150 kg·min⁻¹    | (0.5 kg)        |                 |                 |
| Heart rate                  | <80 bpm         | 80-89 bpm       | 90-100 bpm      | >100 bpm        |
| Stage 2                     | 750 kg·min⁻¹    | (2.5 kg)        | 600 kg·min⁻¹    | (2.0 kg)        |
| Stage 3                     | 900 kg·min⁻¹    | (3.0 kg)        | 750 kg·min⁻¹    | (2.5 kg)        |
| Stage 4                     | 1050 kg·min⁻¹   | (3.5 kg)        | 900 kg·min⁻¹    | (3.0 kg)        |

(ACSM, 2014)

Permission for table 6 sought from ACSM – awaiting response

**Y-Balance test**

Right lower leg length was measured from the anterior superior iliac spine down to the medial malleolus. Right arm length was measured from spinoius process of the 7th cervical vertebrae to the tip of the middle finger of an abducted (90 degrees) supinated arm/hand. The YBT apparatus used was in accordance with Plinsky et al, (2009). The test was conducted barefoot, with the big toe touching the front of the moveable gauge on the corresponding line for the YBT (see figure 2). Instructions included maintenance of the support limb heel in contact with the surface, and produce a smooth movement i.e., no kicking for additional distance. All participants commenced the test with their left lower leg as the support limb, the movements performed in order were anterior, posteromedial and posterolateral directions. Once complete, data was recorded, and the right lower limb was performed following the same procedure.
Instructions for a successful upper limb YBT were for the thumb to be in contact with central line on YBT (see blue line on figure 2); their balance to be maintained, and three points of contact to the floor at all times i.e., both feet and supporting arm/hand. Participants feet needed to be shoulder width apart and they could not use the moving platform for stability. Once completed, distance achieved in each direction was recorded.

Figure 2: The YBT. Blue line indicates (as highlighted) where the big toe and thumb must be touching throughout the test (Plisky et al., 2009). See appendix 8 for reach directions. Presented with permission from Major Jacques Rousseau

Calculation for Y-Balance test – left lower extremity only

Anterior left and right variance = \( \text{anterior left} - \text{anterior right} \)

Posteromedial left and right variance = \( \text{posteromedial left} - \text{posteromedial right} \)

Posterolateral left and right variance = \( \text{posterolateral left} - \text{posterolateral right} \)

Composite score

Composite score = \( \frac{\text{Anterior} + \text{posteromedial} + \text{posterolateral}}{3 \times \text{length of limb}} \)

Sit and reach

Sit and reach box (Company: Acuflex®, United States of America) zero point was set 26cm. Participants were instructed to be seated in front of the box with their legs outstretched; knees extended; and shoes removed. All participants were instructed to breathe normally, place the soles of their feet up against the platform (see appendix 18 below for positioning). They had to complete a smooth forward motion, with their right hand over their left and ensure that they maintained their knees in the locked extended
position. At the end point of the forward motion, participants had to hold their stretch position for 2 seconds while distance was read at the finger-tip level. Their two best attempts out of three scores were recorded (see appendix 10 for normal values).

Body Mass Index

Height was measured with a stadiometer (Company: Seca®, Model: 217, Deutschland). Participants were instructed to maintain heel, gluteus maximus, upper back and head contact with the stadiometer. The participant’s head was placed in the Frankfort position, (see appendix 19) and were instructed to inhale and hold their breath while the stadiometer level was lowered onto the head. Height was measure to the closet 0.1 cm.

Weight was measured using digital scales (Company: Seca®, Model: 813, Deutschland). Participants were instructed to remove shoes and all items in pockets. BMI was calculated from height and weight via the calculation seen below:

\[
BMI = \frac{weight \ (kg)}{height^2 \ (m)}
\]

Waist to Hip Ratio

Waist and hip circumference (cm) were measured using an anthropometric tape (Company: Lufkin®, Model: W606pm, Australia). Waist measures were taken at the umbilicus level, while the hips were measured at the widest gluteal region that corresponded with the greater trochanter of each leg. When taking measurements, participants were asked to relax, not draw in their abdomen and to breathe normally. The WHR was calculated as below:

\[
WHR = \frac{waist \ circumference \ (cm)}{hip \ circumference \ (cm)}
\]

Statistical analysis

All data was assessed for normal distribution before statistical analyses using frequency distribution plots, skewness and kurtosis. All statistical analysis were carried out using IBM SPSS Statistics 25. Data was grouped by age, gender, ethnicity, and analysed for
main effects between male and female, and also age groups for each variable using one-way analysis of variance (ANOVA). When a between group difference was indicated, then comparisons using independent t-tests were conducted. Univariate analyses for multi-level comparisons was conducted when analysing for a specific group effect and controlling for confounding factors, e.g., comparing age differences while controlling for gender. Effect sizes were calculated and standard Cohen’s d (Cohen, 1988) cut-offs used; 0-0.2 small; 0.21-0.599 moderate; >0.8 large. A partial correlation of fitness (VO₂max) to age was conducted to highlight any gender differences. Significance was set at p=0.05 and all mean ±SD are reported.
CHAPTER 4.0 Results

Results

Participants

A total of one hundred and twenty two participants (84 males, 37 females, 1 unspecified) from the Devonport RNZN base volunteered in this study. Thirty-one of the participants were excluded due to missing data or enrolment within a defence force outside of the RNZN (Royal New Zealand Air Force and Royal New Zealand Army). The final total for analysis were ninety one participants (see table 7 for total participant breakdown).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total participants</td>
<td>91</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>&lt;35 years</td>
<td>52</td>
</tr>
<tr>
<td>≥35 years</td>
<td>39</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>62</td>
</tr>
<tr>
<td>Female</td>
<td>29</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
</tr>
<tr>
<td>European</td>
<td>70</td>
</tr>
<tr>
<td>Maori</td>
<td>21</td>
</tr>
<tr>
<td>Age and gender</td>
<td></td>
</tr>
<tr>
<td>Males aged &lt;35 years</td>
<td>29</td>
</tr>
<tr>
<td>Males aged ≥35 years</td>
<td>33</td>
</tr>
<tr>
<td>Females aged &lt;35 years</td>
<td>23</td>
</tr>
<tr>
<td>Females aged ≥35 years</td>
<td>6</td>
</tr>
<tr>
<td>Mean age</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>34 years</td>
</tr>
<tr>
<td></td>
<td>(±10.6 years)</td>
</tr>
<tr>
<td>Males</td>
<td>36.7 years</td>
</tr>
<tr>
<td></td>
<td>(±10.5 years)</td>
</tr>
<tr>
<td>Females</td>
<td>28.3 years</td>
</tr>
<tr>
<td></td>
<td>(±8.2 years)</td>
</tr>
</tbody>
</table>

Cardiovascular measures

Results of cardiovascular parameters (seen in table 8) show that 3 out of the total 15 measures assessed were considered to be outside of normal population values. These values were; HDL cholesterol (1.31mmol·L⁻¹); estimated VO₂max (32.74ml·L⁻¹·min⁻¹) (figure 3) and the PSQI (5.6) (see table 10 for PSQI results).
<table>
<thead>
<tr>
<th>Measure</th>
<th>Total mean (n=91) (±SD)</th>
<th>Male (n=62) (±SD)</th>
<th>Female (n=29) (±SD)</th>
<th>P-value (0.05)</th>
<th>Effect size (men vs women)</th>
<th>&lt;35 years (n=52) (±SD)</th>
<th>≥35 years (n=39) (±SD)</th>
<th>P-value (0.05)</th>
<th>Effect size (&lt;35 years vs ≥35 years)</th>
<th>Normal value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood lipids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total chol (mmol·L⁻¹)</td>
<td>4.41 (0.80)</td>
<td>4.58 (0.88)</td>
<td>4.04 (0.75)</td>
<td>0.005</td>
<td>0.84</td>
<td>4.04 (0.84)</td>
<td>4.89 (0.67)</td>
<td>0.000</td>
<td>-1.06</td>
<td>&lt;5.18</td>
</tr>
<tr>
<td>HDL (mmol·L⁻¹)</td>
<td>1.31 (0.38)</td>
<td>1.22 (0.34)</td>
<td>1.51 (0.39)</td>
<td>0.001</td>
<td>-1.09</td>
<td>1.29 (0.35)</td>
<td>1.34 (0.42)</td>
<td>0.564</td>
<td>-0.09</td>
<td>≥1.55</td>
</tr>
<tr>
<td>Triglyceride (mmol·L⁻¹)</td>
<td>1.21 (0.78)</td>
<td>1.31 (0.69)</td>
<td>1.00 (0.42)</td>
<td>0.079</td>
<td>0.53</td>
<td>1.13 (0.58)</td>
<td>1.31 (0.98)</td>
<td>0.293</td>
<td>-0.33</td>
<td>&lt;1.70</td>
</tr>
<tr>
<td>LDL (mmol·L⁻¹)</td>
<td>2.57 (0.81)</td>
<td>2.79 (0.80)</td>
<td>2.11 (0.62)</td>
<td>0.000</td>
<td>1.23</td>
<td>2.25 (0.72)</td>
<td>3.00 (0.72)</td>
<td>0.000</td>
<td>-1.32</td>
<td>&lt;2.59</td>
</tr>
<tr>
<td>Ratio</td>
<td>3.6 (0.18)</td>
<td>4.00 (1.20)</td>
<td>2.78 (0.58)</td>
<td>0.000</td>
<td>1.65</td>
<td>3.29 (0.99)</td>
<td>4.03 (1.29)</td>
<td>0.003</td>
<td>-0.93</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Fasted blood glucose (mmol·L⁻¹)</td>
<td>5.10 (0.57)</td>
<td>5.22 (0.59)</td>
<td>4.86 (0.43)</td>
<td>0.004</td>
<td>0.88</td>
<td>5.00 (0.51)</td>
<td>5.25 (0.62)</td>
<td>0.042</td>
<td>-0.66</td>
<td>&lt;5.55</td>
</tr>
<tr>
<td>Resting heart rate (bpm)</td>
<td>65.37 (11.59)</td>
<td>64.58 (11.06)</td>
<td>67.06 (12.69)</td>
<td>0.343</td>
<td>-0.30</td>
<td>65.82 (10.56)</td>
<td>64.76 (12.96)</td>
<td>0.669</td>
<td>-0.06</td>
<td>60-80</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>124.20 (13.39)</td>
<td>127.62 (13.18)</td>
<td>117.10 (10.97)</td>
<td>0.000</td>
<td>1.10</td>
<td>121.46 (12.08)</td>
<td>128.02 (14.28)</td>
<td>0.020</td>
<td>-0.70</td>
<td>120-130</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>78.6 (12.23)</td>
<td>80.56 (13.16)</td>
<td>74.55 (9.21)</td>
<td>0.029</td>
<td>0.66</td>
<td>74.42 (10.91)</td>
<td>84.28 (11.94)</td>
<td>&lt;0.000</td>
<td>-1.18</td>
<td>&lt;85</td>
</tr>
<tr>
<td>Mean arterial pressure</td>
<td>93.85 (11.23)</td>
<td>96.25 (11.68)</td>
<td>88.73 (8.26)</td>
<td>0.002</td>
<td>0.93</td>
<td>90.10 (9.42)</td>
<td>98.8 (8.97)</td>
<td>&lt;0.000</td>
<td>-1.17</td>
<td>70-100</td>
</tr>
<tr>
<td>VO₂max (ml·kg⁻¹·min⁻¹)</td>
<td>32.74 (10.15)</td>
<td>33.63 (11.16)</td>
<td>30.85 (7.38)</td>
<td>0.226</td>
<td>0.41</td>
<td>33.57 (9.76)</td>
<td>31.65 (10.67)</td>
<td>0.374</td>
<td>0.37</td>
<td>See appendix 14</td>
</tr>
</tbody>
</table>
Gender differences

One-way ANOVA (seen in table 8) reveal that RNZN males have significantly higher total cholesterol; LDL; blood cholesterol ratio; fasted blood glucose and mean arterial pressure (which reflect higher systolic/diastolic BP) when compared to total females. However, females have higher HDL when compared to males.

Age differences

One-way ANOVA (seen in table 8) reveal that those ≥35 years have significantly higher total blood cholesterol; LDL; blood cholesterol ratio; fasted blood glucose and mean arterial pressure.

Figure 3: Estimated VO\textsubscript{2max} (ml·kg\textsuperscript{-1}·min\textsuperscript{-1}) for males and females according to age, and best line fit with R\textsuperscript{2} values. Correlated fitness values to age (shown in figure 3) show a slight decline for males with increasing age (R\textsuperscript{2} = 0.039), while female fitness levels are more stable with age (R\textsuperscript{2} = 0.0007).
**Anthropometric, flexibility and balance**

All anthropometric, flexibility and balance data are presented in table 9.

**Gender differences**

One-way ANOVA reveal that males have significantly greater body mass; height; BMI and WHR compared to females. However, sit and reach test was significantly greater in female populations. Collected means for YBT (table 9) reveal that male upper and lower YBT scores are below normal values. However, female scores for the YBT were above required normal values.

**Age differences**

One-way ANOVA indicated that the WHR was significantly higher in those ≥35 years. However, sit and reach test and YBT (left and right lower extremity and right upper extremity) were significantly greater among those who are <35 years.

**AHA/ACSM and PSQI questionnaire**

Table 10 provides the total responses for the AHA/ACSM and PSQI questionnaires. AHA/ACSM questionnaire results suggest that all RNZN mean scores (excluding those aged ≥35 years) were below the normal population score of ≤2. PSQI questionnaire results demonstrated that total RNZN population have scores higher than 5. The primary component to increase total scores was habitual sleep efficiency for the total population. Age and gender differences suggested that sleep quality and sleep latency were the primary areas to increase total PSQI questionnaire scores for all military personnel in this study.
Table 9: Results for anthropometric, balance and flexibility for all RNZN participants.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Total population (n=91) (±SD)</th>
<th>Male (n=62) (±SD)</th>
<th>Female (n=29) (±SD)</th>
<th>P-value (0.05)</th>
<th>Effect size (male vs female)</th>
<th>&lt;35 years (n=52) (±SD)</th>
<th>≥35 years (n=39) (±SD)</th>
<th>P-value (0.05)</th>
<th>Effect size (&lt;35 years vs ≥35 years)</th>
<th>Normal values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kgs)</td>
<td>84.99 (16.57)</td>
<td>90.88 (15.77)</td>
<td>72.40 (10.00)</td>
<td><strong>0.000</strong></td>
<td>-</td>
<td>82.47 (16.12)</td>
<td>88.30 (16.79)</td>
<td>0.100</td>
<td>-</td>
<td>≤125</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.74 (0.08)</td>
<td>1.78 (0.08)</td>
<td>1.67 (0.05)</td>
<td><strong>0.000</strong></td>
<td>-</td>
<td>1.73 (0.08)</td>
<td>1.76 (0.08)</td>
<td>0.228</td>
<td>-</td>
<td>≥1.52</td>
</tr>
<tr>
<td>BMI (kg·m⁻²)</td>
<td>27.64 (4.36)</td>
<td>28.44 (4.56)</td>
<td>25.92 (3.35)</td>
<td><strong>0.009</strong></td>
<td>0.82</td>
<td>27.11 (4.11)</td>
<td>28.34 (4.62)</td>
<td>0.184</td>
<td>-0.42</td>
<td>European = 18.6-24.5 Maori/Pacifica = 18.5-25.9 *NZDF = 36</td>
</tr>
<tr>
<td>Waist to hip ratio</td>
<td>0.87 (0.09)</td>
<td>0.91 (0.07)</td>
<td>0.79 (0.67)</td>
<td><strong>0.000</strong></td>
<td>2.25</td>
<td>0.84 (0.08)</td>
<td>0.90 (0.09)</td>
<td><strong>0.002</strong></td>
<td>-0.98</td>
<td>See table 3 - page 33</td>
</tr>
<tr>
<td>Sit and reach (cm)</td>
<td>28.9 (9.09)</td>
<td>25.45 (7.69)</td>
<td>36.44 (7.16)</td>
<td><strong>0.000</strong></td>
<td>-2.09</td>
<td>31.16 (9.18)</td>
<td>26.27 (8.34)</td>
<td><strong>0.041</strong></td>
<td>0.60</td>
<td>See appendix 10</td>
</tr>
<tr>
<td>Y-balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper body right (%)</td>
<td>87.02 (10.47)</td>
<td>86.86 (10.66)</td>
<td>87.36 (10.22)</td>
<td>0.836</td>
<td>-0.09</td>
<td>89.0 (10.76)</td>
<td>84.34 (9.54)</td>
<td><strong>0.033</strong></td>
<td>0.63</td>
<td>Male ≥88</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Female ≥85</td>
</tr>
<tr>
<td>Upper body left (%)</td>
<td>86.81 (10.69)</td>
<td>86.43 (11.19)</td>
<td>87.61 (9.68)</td>
<td>0.624</td>
<td>-0.18</td>
<td>88.4 (10.93)</td>
<td>84.68 (10.11)</td>
<td><strong>0.101</strong></td>
<td>0.49</td>
<td>Male ≥88</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Female ≥85</td>
</tr>
<tr>
<td>Lower body right (%)</td>
<td>89.59 (11.23)</td>
<td>91.02 (12.08)</td>
<td>91.01 (9.18)</td>
<td>0.413</td>
<td>-0.12</td>
<td>91.8 (8.07)</td>
<td>86.59 (13.97)</td>
<td><strong>0.027</strong></td>
<td>0.69</td>
<td>≥88 ≥89</td>
</tr>
<tr>
<td>Lower body left (%)</td>
<td>89.23 (11.60)</td>
<td>88.60 (12.25)</td>
<td>89.69 (10.27)</td>
<td><strong>0.798</strong></td>
<td>0.29</td>
<td>91.3 (8.89)</td>
<td>86.40 (14.09)</td>
<td><strong>0.043</strong></td>
<td>0.60</td>
<td>≥88 ≥89</td>
</tr>
</tbody>
</table>

*A BMI of ≥36kg·m⁻² can still be enrolled into the NZDF upon consideration of a health professionals at initial enrolment or at annual required fitness tests. For normal population BMI classifications, please see table 2 in “factors associated with poor health – BMI and obesity page: 29*
Table 10: Response for both the AHA/ACSM and PSQI questionnaire within RNZN participants.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Total population n=91</th>
<th>Men n=62</th>
<th>Women n=29</th>
<th>&lt;35 years n=52</th>
<th>≥35 years n=39</th>
<th>Normal values</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHA/ACSM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤2</td>
</tr>
<tr>
<td>Total score</td>
<td>152</td>
<td>125</td>
<td>27</td>
<td>56</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>History (9 questions)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Symptoms experience (6 questions)</td>
<td>17</td>
<td>14</td>
<td>3</td>
<td>6</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Other health issues (7 questions)</td>
<td>23</td>
<td>17</td>
<td>6</td>
<td>8</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular risk factors (11 questions)</td>
<td>112</td>
<td>94</td>
<td>18</td>
<td>42</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Total with high HDL (-1 risk factor)</td>
<td>140</td>
<td>119</td>
<td>21</td>
<td>53</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>Mean score of participants</td>
<td>1.5</td>
<td>1.9</td>
<td>0.7</td>
<td>1</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>PSQI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤5</td>
</tr>
<tr>
<td>Mean total score</td>
<td>5.6</td>
<td>5.7</td>
<td>5.4</td>
<td>5.6</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>Sleep quality</td>
<td>1.1</td>
<td>1.1</td>
<td>1.3</td>
<td>1.2</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Sleep latency</td>
<td>1.2</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Sleep duration</td>
<td>0.5</td>
<td>0.6</td>
<td>0.3</td>
<td>0.4</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Habitual sleep efficiency</td>
<td>1.3</td>
<td>0.4</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Sleep disturbances</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.0</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Use of medication</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Daytime dysfunction</td>
<td>0.8</td>
<td>0.9</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
<td></td>
</tr>
</tbody>
</table>

Note: AHA/ACSM questionnaire (see appendix 1) total score is calculated from the 33 questions asked in a single questionnaire meaning that a single participant can answer applicable questions positively more than once within each subsection. A total score of 2 or more following the AHA/ACSM questionnaire should consult with a physician about exercise participation.
'History' examines medical conditions such as heart pathologies via congenital or behavioural factors. ‘Symptoms’ examines medical symptoms experienced through physical activity and heart medication. ‘Other health issues’ examine metabolic; respiratory; musculoskeletal conditions; medication usage and pregnancy status. ‘Cardiovascular risk factors’ examine; age; smoking status; BP; cholesterol/glucose; anthropometric data and family history. Those with HDL ≥1.55 mmol·L⁻¹ have a reduction of 1 (see AHA/ACSM questionnaire section of literature review – page 52) from their total AHA/ACSM questionnaire due to the cardioprotective effects of high HDL cholesterol. The PSQI (see appendix 6) contains 19 questions which are combined into seven categories which range from 0-3 points. Each category is added together to form one total score. A total score of 5 or more following competition of the PSQI is suggestive of poor sleep over the past 4 weeks. Total scores are displayed as each question answered yes within a given population.
CHAPTER 5. Discussion

The hypothesis of the RNZN personnel being healthier than the normal population (civilian) was supported by the results of this study. Males ≥35 years were found to have the highest risk of CVD when compared to males <35 years and all females included in the participant cohort. While males aged ≥35 years presented with an increased risk, majority of their physiological health values indicated good health when compared to published normal values.

Due to scant data and literature on health and wellness conducted in the RNZN, this cross-sectional study which trialled a concise and applicable battery of health tests demonstrates that overall, personnel of the RNZN are considered healthy when compared to the general population. Of the 15 health and fitness measures chosen to assess health and wellbeing only HDL, estimated VO$_{2\text{max}}$ and the PSQI were considered to be not within healthy normal values. These were further disseminated by age and gender.

Personnel <35 years and/or females, were considered to be the healthiest population groups within the RNZN. Cholesterol (excluding HDL) blood glucose, BP, estimated VO$_{2\text{max}}$, WHR, YBT scores, AHA/ACSM and PSQI questionnaire scores for those aged <35 years were well within healthy normal population values and better than those aged ≥35 years. Likewise, female cholesterol, blood glucose, BP, BMI, WHR, sit and reach, YBT score, AHA/ACSM and PSQI questionnaire scores (global scores) were well within normal population values and were considered to indicate better health when compared to males. It is perhaps not surprising that female personnel, as a group, appear to have healthier outcomes as there were less females within this study (see table 7). This limitation will skew age related comparisons in favour of the female sex, indicating that perhaps age has a greater effect than gender on health overall, albeit there were less females ≥35 years. Larger military population studies may be required to determine if this is the case. Nevertheless, the variables measured appeared to be good health indicators and provided discriminatory results.
Gender difference in balance and flexibility found in this study may be due to the fact that males have a narrower pelvis and thick/longer arms and legs when compared to females (Lewis, Laudicina, Khuu, & Loverro, 2017). A narrower pelvis means that males have a reduced range of motion at the hip joint when performing exercises such as hip flexion and abduction (Sahrmann, 2010). Similarly, longer bones (for example femur, tibia and fibula) mean that men are required to move through a larger range of motion when compared to females (for example lumbar flexion) (Kendall, McCreary, Provance, Rodgers, & Romani, 2005). While there were slight differences in YBT scores among males and female within this study, significant differences only existed among those analysed by age (table 9), which may be attributed to increased age-related muscle stiffness which contributes to decreases in flexibility and proprioception (Liutsko, Muiños, & Tous-Ral, 2014).

Those with low sit and reach scores often reflect muscle tightness within the posterior chain have increased likelihood of developing musculoskeletal injuries such as lumbar syndrome when performing movements such as lumbar flexion (Myer et al., 2014). Unfortunately, it was beyond the scope of this study to assess injury data, particularly back pain, and correlate it with the sit and reach flexibility results. Nonetheless, females and those <35 years had significantly greater extensibility of muscle and non-contractile tissues as evidenced by the sit and reach result, and large effect sizes (table 9). While women are at an advantage due to anthropometric structure, restriction within the lower extremity (hamstrings, gluteus maximus and paraspinal muscles) can still occur irrespective of age and gender (Sahrmann, 2010). This suggests that without specifically addressing problems, such as posterior chain tightness, the risk of injury is enhanced. However, because the military population perform movements that go beyond moving in the sagittal plane, it is important to address the potential of injury in other planes and within the upper body.

Results in this study show that females and those <35 years performed better at the YBT than males and those ≥35 years (see table 9) indicating better stability in both the upper and lower body. Significant differences were found between age groups for both left and right upper and lower body, excluding the upper left side of the body which may
reflect right upper extremity dominance. Limb dominance and decreased proprioception have previously been linked to increased musculoskeletal injuries which may be a contributing factor towards why left upper extremity did not perform as well as the right upper extremity (Andersen et al., 2016). However, the difference in age groups suggests that the process of ageing is a key factor for musculoskeletal injury among military populations irrespective of gender. In fact, recent studies found that those who have actively served for 11 to 15 years who are aged between 30 - 34 years and present with low fitness levels and increased body mass, are at increased risk for increased musculoskeletal injury (Abt et al., 2016).

Anthropometric measures in this study show that males have significantly higher BMI and WHR scores compared to females. With regards to age, those ≥35 years were found to have significantly higher WHR than those <35 years, which was a similar result to Vaidya, Bhalwar, and Bobdey (2009). Additionally, the magnitude of these differences between gender and age for BMI and WHR are reinforced by their effect size as shown in table 9. This suggests that males ≥35 years are at more risk for CVD complications when compared to females. However, it is important to note that BMI values obtained in this study are well within the required 18-33kg·m² range for the NZDF (NZDF, 2018). Males are traditionally reported to have larger WHR, body mass, height and overall BMI scores which is reflective of lipid (storage of adipose tissue round the abdomen), musculoskeletal (muscle fibre composition and density) and hormonal (testosterone, estrogen and cortisol) differences when compared to females (Kenney et al., 2015). For example, male populations have greater visceral fat distributed around the stomach, while females tend to have more fatty tissue deposited around the hips and buttocks (ACSM., 2014; Kenney et al., 2015). This can be problematic as leptin, tumour necrosis factor alpha, interleukin-6, oestrogen, resistin and acetylation-stimulating proteins are all secreted from adipose tissue which can impair the delivery of nutrition to central organs and lead to inflammation and damage to internal organs within male populations (Prentice & Jebb, 2001). Additionally, body fat distribution and central obesity are also linked to impaired vascular health which may increase the risk for presenting with high BP, cholesterol and blood glucose levels (Nishizawa et al., 2017).
Overall, blood glucose measured in this study was well within acceptable levels when compared to normal population data (overall = 5.10mmol·L⁻¹; normal = ≤5.55mmol·L⁻¹). However, while within healthy levels, when analysed by gender and age, significant differences presented. Those ≥35 years and male display higher blood glucose when compared to those <35 years and/or female (≥35 years = 5.20mmol·L⁻¹; males = 5.22mmol·L⁻¹; <35 years = 5.00 mmol·L⁻¹; female = 4.86mmol·L⁻¹). In addition, with an effect size of 0.88 based on gender differences, this reinforces that there are clinical differences between genders for blood glucose profile. These findings are similar to the previous research conducted by Zinn et al, (2017) who found that the mean fasted blood glucose in RNZN personnel was 5.20mmol·L⁻¹ at base line testing. However, blood glucose measured in Zinn et al, (2017) was a mean value which comprised of both males and females and did not dissociate between genders.

Within this study, results show that overall mean BP values were well within acceptable levels (124/78 mmHg). Significant differences existed between gender and age (males = 127/80mmHg; females = 117/74mmHg; <35 years = 121/74mmHg; ≥35 years = 128/84mmHg). Therefore, based on these results, males who are ≥35 years are likely to be at risk for high BP. Mean arterial pressure provides further support for differences between gender and age and suggest that ageing (effect size = -1.17) is more likely to influence BP rather than gender (effect size = 0.93). Reasons for lower BP in this study among those <35 years, may be attributed to a large sample size of personnel aged between 18 and 34 years which may skew results in favour of the <35 year olds (n=52 versus 39). One study in the US military found that longer deployment duration increased C-reactive proteins which was attributed to inflammation of the arteries causing vascular stiffness and subsequently increasing BP (Holliday et al., 2017). The mean age of females within Holliday et al, (2013) was 29.91 years and presented with a mean arterial pressure of 88.34, which is similar to the findings of our study. While there is a difference in the mean age of males in Holliday et al, (2013) and values within this study, mean arterial pressure was higher when compared to females irrespective of age, suggesting that males are at increased risk for high BP. Alternatively, this can also be attributed to differences in fitness levels which is known to influence BP (Crump, Sundquist, Winkleby, & Sundquist, 2016).
If fitness standards are below optimal levels, then health parameters such as BP, cholesterol and body weight can increase (Regitz-Zagrosek, 2012). Results from our study show that the mean age and VO\textsubscript{2max} of participants was 34 years and 32.74ml·kg\textsuperscript{-1}·min\textsuperscript{-1}. According to the ACSM (2014) guidelines for exercise testing and prescription, this was considered to be a poor VO\textsubscript{2max} score when compared to healthy populations. For healthy populations aged 34 years, a score between 39-42ml·kg\textsuperscript{-1}·min\textsuperscript{-1} is considered to be average (ACSM, 2014). The limitation in this study was the applicability and comparison of a cycling test to the multistage running (beep test) which reflected the limited space provided to conduct our research. According to the RNZN website (NZDF, 2018), the minimum entry fitness requirement for a male is a beep test score of 7.10, 5 push ups and 35 sit ups. For females the minimum entry fitness requirement is a beep test score of 5.9, 1 push up and 25 curl ups (NZDF, 2018). While this study did not implement tests which are in accordance with the NZDF fitness requirements, when a beep test score is converted to VO\textsubscript{2max}, parity with our current study, clarity of a low VO\textsubscript{2max} is seen. A beep test score of 7.10 for males and 5.9 for females is equivalent to a VO\textsubscript{2max} score of 36.8ml·kg\textsuperscript{-1}·min\textsuperscript{-1} and 32.9ml·kg\textsuperscript{-1}·min\textsuperscript{-1} respectively (see Ramsbottom, Brewer, and Williams, 1988 for conversion table – Appendix 20) (Ramsbottom, Brewer, & Williams, 1988). However, because a score of 32.74ml·kg\textsuperscript{-1}·min\textsuperscript{-1} was the mean overall score, we speculated that there was a difference in VO\textsubscript{2max} between gender and age. This was attributed to the fact that female VO\textsubscript{2max} is reported to be 70-75% of males VO\textsubscript{2max} (after puberty among normal healthy populations). In older age group cohorts, people tend to become more sedentary and are reported to lose 1.6% of VO\textsubscript{2max} values a year (Baur, Christophi, Cook, & Kales, 2012; Sharma & Kailashiya, 2016). However, with regards to the current study, when VO\textsubscript{2max} was analysed by gender, a difference of 2.78ml·kg\textsuperscript{-1}·min\textsuperscript{-1} was found in favour of males. When further adjusted for age, there was a 1.92ml·kg\textsuperscript{-1}·min\textsuperscript{-1} in favour of those aged >35 years. Therefore, males who were >35 years were slightly fitter than females and those ≥35 years. However, anecdotal evidence from participants indicated that cessation of the beep test is applied once minimum requirements were achieved. This means RNZN personnel are not aware of their potential maximal fitness test level or score for comparative purposes.
Due to increased testosterone levels in males, they are at an advantage for increasing muscle mass, promoting protein synthesis, increasing bone density and increasing lipid oxidation (Goymann & Wingfield, 2014; Kenney et al., 2015). However, testosterone begins to decline at approximately 30 years of age and therefore, if exercise is not continued on a regular basis, positive adaptations resulting from exercise may decline which may contribute to the decline in VO_{2\text{max}} scores in the ≥35 year age group (Goymann & Wingfield, 2014; Harridge & Lazarus, 2017). Time within the military can involve more sedentary behaviours (such as officers sitting at a desk) and are associated with health declines (Schulze et al., 2015) including; reductions in aerobic capacity; lean muscle mass, absolute strength and increase visual fat gain (Joyce & Lewindon, 2014). Trank, Ryman, Minagawa, Trone, and Shaffer (2001) explored this further and found regular exercise regimes can reverse deconditioning in military populations. Similar results were observed in Vickers Jr and Barnard (2010); Haddock, Poston, Heinrich, Jahnke, and Jitnarin (2016) and Nindl, et al, (2016) irrespective of age and gender.

The RNZN personnel in our study were considered to have healthy lipid profiles when compared to normal population values (see table 8). In particular, LDL and triglyceride were within normal population values. However, HDL were below general population values (1.31mmol·L^{-1} versus 1.55mmol·L^{-1}). When HDL are below the recommended level of ≥1.55mmol·L^{-1}, then reverse cholesterol transportation is inefficient and LDL and triglycerides begin to rise within the systemic system which increases the risk for atherosclerotic plaque formation. When gender was considered, significant differences were also found. This was seen between male HLD cholesterol (1.22mmol·L^{-1}); female HDL cholesterol (1.51mmol·L^{-1}); male LDL cholesterol (2.57mmol·L^{-1}) and female LDL cholesterol (2.11mmol·L^{-1}) which are supported by their large effect sizes as see in table 8. While female HDL cholesterol is slightly lower than the desired 1.55mmol·L^{-1}, reverse transportation can occur among females more efficiently that males. When age was considered, significant differences in LDL were found with the <35 years group presenting with lower LDL cholesterol (2.25mmol·L^{-1} versus 3.00mmol·L^{-1}). When blood lipids results from this cross-sectional study were compared to previous published findings, similar results were observed. Previous research among military forces noted elevations in LDL and triglycerides in addition to low HDL (Ray, Sreenivas, 2011; Saely et
al., 2009; Whitney et al., 2005). Of particular interest is the findings of Goncalves (2014) and Funderburk and Arsenault (2013) who found that 100% of personnel had HDL below normal values.

With regards to the RNZN, Zinn et al, (2017) reported that the adoption of a low carbohydrate and high healthy fat intake in addition to a healthy eating education programme provided significant reductions in body weight, WHR with additional improvements to blood triglycerides, HDL and blood glucose. Our results for lower LDL and triglycerides suggest that there is a lower risk of CVD within the RNZN and that personnel are possibly selecting healthy food choices. However, a limitation of our study is that no dietary analysis was conducted due to time constraints, and those who live on-base (or on-board at sea) have meals pre-determined for nutritional value, while those who live off-base do not. Nevertheless, this does not exclude personnel living on-base from consuming food outside of the RNZN food choices. Therefore, it may be prudent for the RNZN to include a dietary analysis in future studies (see recommendations). While research shows that high HDL cholesterol increases overall cholesterol and therefore while one may present with high total cholesterol, however, this may actually be due to high HDL cholesterol (Zhou, Li, Gao, & Wang, 2015). For this reason questionnaires which assess overall health and dissociate true risk factors for CVD (LDL/triglycerides) from the cardio-protective effects (HDL) are important to conduct concurrently within screening protocols (ACSM., 2014).

Implementation of the AHA/ACSM questionnaire show that males scored higher than females for general health as did those ≥35 years, highlighting some health concerns in males. Among both population groups, risk factors for CVD were the primary areas to increase total score (see appendix 1 for the full questionnaire). It is known that males and ageing populations are at a higher risk of cardiovascular complications (ACSM., 2014). More specifically, ageing males are more at risk when compared to ageing females (see literature review – procedures to measure health – AHA/ACSM health and fitness pre-participation screening questionnaire, page 52) (Mosca et al., 2011). However, it is important to note that no personnel stated that they had a previous history of cardiovascular complications (see appendix 1 for questions asked in history of
cardiovascular complications). The importance of this is that all 9 questions asked in this portion of the AHA/ACSM questionnaire are primary factors for medical discharge (Iremonger et al., 2015). Questions asked in the remaining portions are of importance as they can record lifestyle and behavioural modification adjustments (increasing exercise participation, improving diet, eliminating smoking) in order to improve overall physiological health (Funderburk & Arsenault, 2013; Iremonger et al., 2015; Zinn et al., 2017). In addition, application of the AHA/ACSM questionnaire has shown to reduce medical check-up (see procedures to measure health, AHA/ACSM questionnaire -page 52) therefore both time and financial expenditure is improved (Beauchamp et al., 2017). While the AHA/ACSM questionnaire analyses many different risk factors for CVD, it does not assess the implications of restricted sleep, which also has a bearing on cardiovascular health (Wang et al., 2016).

Results from the PSQI show a very minor level of sleep restriction in the RNZN with a mean score of 5.6, where a score below 5 indicates no significant sleep restrictions. Primary areas which increased the mean global score were; habitual sleep efficiency (mean score of 1.3); sleep latency (mean score of 1.2); sleep quality (mean score of 1.1) and sleep disturbance (mean score of 1.1). Unfortunately, normal values for each component score are currently not available, nevertheless, these primary factors are similar to those identified previously (Brown et al., 2013; Sunde et al., 2016; Troxel et al., 2015). Factors to cause sleep restriction have previously been attributed to excessive physical training (Joyce & Lewindon, 2014). However, when fitness was adjusted as a covariant there was no significant difference, which reinforces the findings that sleep restriction is linked to the primary factors mentioned above. Restricted sleep is associated with increased cortisol stress reactivity (Massar, Liu, Mohammad, & Chee, 2017), hardening of the coronary arteries via calcification within the tunica media which increases the risk of heart disease (Kuehn, 2017; Nagai, Hoshide, & Kario, 2010), impairments in metabolic function (Charles et al., 2011), increased strain on the cardiovascular system (Guo et al., 2013) and declines in the immune system (Wang et al., 2016).
The PSQI score of 5.6 was the mean global score for all participants in this study and one may speculate that there is a difference between gender and age. However, both global scores and primary factors were not significantly different (see table 10). There were five additional questions in the PQSI which are to be answered by someone who shares the same sleeping arrangements (partner, roommate) and were not included in this study. However, they do not contribute to the total sleep restriction scoring. Because not all participants in this study shared accommodation (people living alone versus people living in dorm rooms versus those who are in relationships which are not at the RNZN base), and they did not contribute to the scoring, we considered these additional questions as unnecessary in this trial.
CHAPTER 6. Conclusion

In conclusion, the battery of tests chosen within the RNZN guideline parameters for the health and wellness check appear to be appropriate for assessing physiological health. The test selected for the measurement of physical health (fitness test) did not provide reliable results. Despite this, all results were discriminatory, and individualised feedback was able to given to all participants.

The RNZN cohort that participated in this investigation were considered relatively healthy when compared to non-military populations. With younger and female personnel considered the healthiest from the accumulated data. Fitness was considered to be the major factor which was outside of desired levels irrespective of gender and age. However, because the method used to measure fitness within this study was not reflective of activities conducted within military populations (cycling versus running) it may be considered that more applicable fitness measures be used in the future. Cardiovascular risk factors measured by anthropometric variables, lipid profiles, and blood-sugar levels were deemed at healthy levels compared to normal population values, and when aligned to gender and age, then males who are ≥35 years were suggested to be at more at risk for adverse health, while females and those <35 years were at least risk. Health parameters within this study are important to address as they are linked to common progressive cardiovascular and metabolic pathologies. A list of recommendations for the RNZN has arisen from this research.

Recommendations for the Royal New Zealand Navy:

- Use the Beep test for fitness assessments.
- Allow RNZN personnel to achieve their potential maximal fitness level or score in annual fitness assessments.
- Undertake dietary assessments, for example 3-day or 7-day recall diaries.
- Involve partners and family in evaluations e.g., sleep quality.
- Provide follow-up dietary advice and education.
- Provide follow-up individualised training programmes for fitness, flexibility and core stability where deficiencies are identified.
- Annual health check for over 35 years.
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Appendix

Appendix 1

AHA/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire

Name ____________________________________________________________
Rank ____________________________________________________________
Defence Force ____________________________________________________
ID Number _______________________________________________________

Assess your health status by marking yes (Y) for all true statements or no (N) for false/not applicable statements

History
You have had:

A heart attack(s).
Heart surgery.
Cardiac catheterization.
Coronary angioplasty (PTCA).
Pacemaker/implantable cardiac defibrillator/rhythm disturbance.
Heart valve disease.
Heart failure.
Heart transplantation.
Congenital heart disease.

Symptoms:
You experience chest discomfort with exercise.
You experience unreasonable breathlessness.
You experience dizziness, fainting, or blackouts.
You experience ankle swelling.
You experience unpleasant awareness of a forceful or rapid heart rate.
You take heart medications.

Other health issues
You have diabetes.
You have asthma or other lung disease.
You have burning or cramping sensation in your lower legs when walking short distances.
You have musculoskeletal problems that limit your physical activity.
You have concerns about the safety of exercise.
You take prescription medication(s).
You are pregnant.

If you marked any of these statements in this section, consult your physician or other appropriate health care provider before engaging in exercise. You may need to use a facility with a medically qualified staff.
Cardiovascular risk factors

You are a man older than 45 years.

You are a woman older than 55 years.

You smoke or quit smoking within the previous 6 months.

Your blood pressure is >140/90 mm Hg.

Please enter your recorded blood pressure take today.

You take blood pressure medication.

Your blood cholesterol level is >200 mg/dl or 5.18mmol/L.

Please enter your cholesterol levels recorded today.

You have a close blood relative who had a heart attack or heart surgery before age 55 (father or brother) or age 65 (mother or sister).

You are physically inactive (i.e., you get <30 minutes of physical activity on at least 3 days per week).

Your BMI is ≥30 kg/m².

You have prediabetes.

Please enter your glucose levels recorded this morning.

You have none of the above

ACSM (2014)

Permission for questionnaire sought – awaiting response from ACSM.
### Appendix 2

**Absolute and relative contraindications to exercise**

<table>
<thead>
<tr>
<th>Contraindications to exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Absolute</strong></td>
</tr>
<tr>
<td>A recent significant change in the resting electrocardiogram suggesting significant ischemia, recent myocardial infarction (within 2 days), or other acute cardiac event</td>
</tr>
<tr>
<td>Unstable angina</td>
</tr>
<tr>
<td>Uncontrolled cardiac dysrhythmia causing symptoms or hemodynamic compromise</td>
</tr>
<tr>
<td>Symptomatic severe aortic stenosis</td>
</tr>
<tr>
<td>Acute pulmonary embolus or pulmonary infarction</td>
</tr>
<tr>
<td>Acute systemic infection, accompanied by fever, body aches, or swollen lymph glands</td>
</tr>
<tr>
<td><strong>Relative</strong></td>
</tr>
<tr>
<td>Left main coronary stenosis</td>
</tr>
<tr>
<td>Moderate stenotic valvular heart disease</td>
</tr>
<tr>
<td>Electrolyte abnormalities (e.g., hypokalaemia or hypomagnesemia)</td>
</tr>
<tr>
<td>Severe arterial hypertension (i.e., systolic blood pressure of &gt;200mmHg and/or diastolic blood pressure of &gt;110mmHg) at rest.</td>
</tr>
<tr>
<td>Tachydysrhythmia or bradydysrhythmia</td>
</tr>
<tr>
<td>Hypertrophic cardiomyopathy and other forms of outflow tract obstruction</td>
</tr>
<tr>
<td>Neuromotor, musculoskeletal, or rheumatoid disorders that are exacerbated by exercise</td>
</tr>
<tr>
<td>High degree of atrioventricular block</td>
</tr>
<tr>
<td>Ventricular aneurysm</td>
</tr>
<tr>
<td>Uncontrolled metabolic disease (e.g., diabetes, thyrotoxicosis, or myxedema)</td>
</tr>
<tr>
<td>Chronic infectious disease (e.g., HIV)</td>
</tr>
<tr>
<td>Mental or physical impairment leading to inability to exercise adequately</td>
</tr>
</tbody>
</table>

(ACSM., 2014)

**Note:** Asymptomatic individuals who score ≥2 are at moderate risk while asymptomatic individuals who score <2 are at low risk (Maiorana et al., 2018). Asymptomatic individuals do not require medical supervision but do require medical clearance (Riebe et al., 2015).

ACSM (2014)

Permission for contraindications to exercise sought – awaiting response from ACSM.
Appendix 3

The logic model for classification of risk for CVD

Permission for the logic model for classification of risk for CVD sought – awaiting response from ACSM.

ACSM (2014)
Appendix 4
The risk classification table for CVD

ACSM (2014)
Permission for the risk classification table for CVD sought– awaiting response from ACSM.
Appendix 5
Updated risk classification table for cardiovascular disease

<table>
<thead>
<tr>
<th>Participants in Regular Exercise</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>No CV, Metabolic\textsuperscript{11}, or Renal Disease AND No Signs or Symptoms\textsuperscript{11} Suggestive of CV, Metabolic\textsuperscript{2}, or Renal Disease</td>
<td>Medical Clearance\textsuperscript{111} Not Necessary</td>
<td>Medical Clearance\textsuperscript{111} Recommended</td>
</tr>
<tr>
<td>Known CV\textsuperscript{11}, Metabolic\textsuperscript{2}, or Renal Disease AND Asymptomatic</td>
<td>Medical Clearance\textsuperscript{111} Recommended</td>
<td>Medical Clearance\textsuperscript{111} Not Necessary</td>
</tr>
<tr>
<td>Any Signs or Symptoms\textsuperscript{11} Suggestive of CV, Metabolic\textsuperscript{2}, or Renal Disease (Regardless of disease status)</td>
<td>Medical Clearance\textsuperscript{111} for Moderate Intensity Exercise Not Necessary</td>
<td>Discontinue Exercise and Seek Medical Clearance</td>
</tr>
<tr>
<td>Known CV\textsuperscript{11}, Metabolic\textsuperscript{2}, or Renal Disease AND Asymptomatic</td>
<td>Medical Clearance\textsuperscript{111} for Moderate Intensity Exercise Not Necessary</td>
<td>Discontinue Exercise and Seek Medical Clearance</td>
</tr>
<tr>
<td>Any Signs or Symptoms\textsuperscript{11} Suggestive of CV, Metabolic\textsuperscript{2}, or Renal Disease (Regardless of disease status)</td>
<td>Medical Clearance\textsuperscript{111} for Moderate Intensity Exercise Not Necessary</td>
<td>Discontinue Exercise and Seek Medical Clearance</td>
</tr>
</tbody>
</table>

Note: Pre-existing medical conditions which have been diagnosed by a physician such as cardiovascular, metabolic and renal diseases which are symptomatic are considered be at high risk for cardiac events and require medical supervision while exercising (ACSM, 2014). Additionally, for those who experience symptoms when exercising or at rest (syncope, ankle oedema, shortness of breath and pain which is suggestive of ischemia) then medical clearance is required before participation in exercise regimen (ACSM, 2014).

ACSM (2014)
Permission for updated risk classification table for CVD sought—awaiting response from ACSM
Appendix 6

PITTSBURGH SLEEP QUALITY INDEX (PSQI)

Name ________________________________________________
Rank ________________________________________________
Defence Force _________________________________________
Your researcher ID Number_________________________________

Instructions
The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days/ nights in the past month. Please answer all questions on page one and two.

1. During the past month, what time have you usually gone to bed at night?
   USUAL BED TIME_____________________________________

2. During the past month, how long (in minutes) has it taken you to fall asleep each night?
   NUMBER OF MINUTES_________________________________

3. During the past month, when have you usually gotten up in the morning?
   USUAL GETTING UP TIME______________________________

4. During the past month, how many hours of actual sleep did you get at night? (this may be different than the number of hours you spend in bed)
   HOURS OF SLEEP PER NIGHT___________________________

Instructions
For each of the remaining questions, check the one best response.
Please answer all questions.

5. During the past month, how often have you had trouble with sleeping because you…

<table>
<thead>
<tr>
<th></th>
<th>Not during the last month</th>
<th>Less than once a week</th>
<th>Once or twice a week</th>
<th>Three or more times a week</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) cannot get to sleep within 30 minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) wake up in the middle of the night or early morning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) have to get up to use the bathroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) cannot breathe comfortably</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) cough or snore loudly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) feel too cold</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) feel too hot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(h) have bad dreams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) have pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(j) other reasons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. During the past month, how would you rate your sleep quality overall?

- Very good
- Fairly good
- Fairly bad
- Very bad

7. During the past month, how often have you taken medicine (prescribed or “over the counter) to help you sleep?

- Not during the past month.
- Less than once a week.
- Once or twice a week.
- Three or more times a week.

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

- Not during the past month.
- Less than once a week.
- Once or twice a week.
- Three or more times a week.

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

- No problem at all.
- Only a very slight problem.
- Somewhat of a problem.
- A very big problem.

Permission for PSQI questionnaire sought—awaiting response from the National Center for Biotechnology Information
Appendix 7
Scoring the PSQI

**Component 1: Subjective sleep Quality**
1. Examine question 6, and assign score as follows:
   
<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good</td>
<td>0</td>
</tr>
<tr>
<td>Fairly good</td>
<td>1</td>
</tr>
<tr>
<td>Fairly bad</td>
<td>2</td>
</tr>
<tr>
<td>Very bad</td>
<td>3</td>
</tr>
</tbody>
</table>

   *Component 1 score: ________*

---

**Component 2: Sleep latency**
1. Examine question 2, and assign score as follows:
   
<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15 minutes</td>
<td>0</td>
</tr>
<tr>
<td>16-30 minutes</td>
<td>1</td>
</tr>
<tr>
<td>31-60 minutes</td>
<td>2</td>
</tr>
<tr>
<td>&gt;60 minutes</td>
<td>3</td>
</tr>
</tbody>
</table>

   *Question 2 score ________*

2. Examine question 5a, and assign score as follows:
   
<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not during the last month</td>
<td>0</td>
</tr>
<tr>
<td>Less than once a week</td>
<td>1</td>
</tr>
<tr>
<td>Once or twice a week</td>
<td>2</td>
</tr>
<tr>
<td>Three or more times a week</td>
<td>3</td>
</tr>
</tbody>
</table>

   *Question 5a score ________*

3. Add 2 and 5a scores together ____________
4. Assign component score as follows:
   
<table>
<thead>
<tr>
<th>Sum of 2 and 5a</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

   *Component 2 score: ________*

---

**Component 3: Sleep duration**
1. Examine question 4, and assign score as follows:
   
<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;7 hours</td>
<td>0</td>
</tr>
<tr>
<td>6-7 hours</td>
<td>1</td>
</tr>
<tr>
<td>5-6 hours</td>
<td>2</td>
</tr>
<tr>
<td>&lt;5 hours</td>
<td>3</td>
</tr>
</tbody>
</table>

   *Component 3 score: ________*
Components 4: Habitual sleep efficiency

1. Write the number of hours slept (question 4) here: _______
2. Calculate the number hours spent in bed:
   a. Getting up time (question 3): _______________________
   b. Bed time (question 1): _____________________________
      Number of hours spent in bed: ___________________
3. Calculate habitual sleep efficiency as follows:
   (number of hours slept/number of hours spent in bed) X 100 = Habitual sleep
   efficiency (%)
   (___________ / __________) X 100 = %
4. Assign component score as follows:
   Response | Score
   >85%      | 0
   75-84%    | 1
   65-74%    | 2
   <65       | 3

Component 4 score: _______

Component 5: Sleep disturbances

1. Examine question 5b-5j, and assign scores for each question as follows:
   Response | Score
   Not during the last month | 0
   Less than once a week      | 1
   Once or twice a week       | 2
   Three or more times a week | 3
      5b score _____
      5c score _____
      5d score _____
      5e score _____
      5f score _____
      5g score _____
      5h score _____
      5i score _____
      5j score _____
2. Add the scores for questions 5b-5j: _______
3. Assign component 5 score as follows
   Sum of 5b-5j | Score
   0            | 0
   1-9          | 1
   10-18        | 2
   19-27        | 3

Component 5 score: _______
Component: Use of sleeping medication

1. Examine question 7 and assign scores as follows:

<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not during the last month</td>
<td>0</td>
</tr>
<tr>
<td>Less than once a week</td>
<td>1</td>
</tr>
<tr>
<td>Once or twice a week</td>
<td>2</td>
</tr>
<tr>
<td>Three or more times a week</td>
<td>3</td>
</tr>
</tbody>
</table>

Component 6 score: ______

Component 7: Daytime dysfunction

1. Examine question 8 and assign scores as follows:

<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not during the last month</td>
<td>0</td>
</tr>
<tr>
<td>Less than once a week</td>
<td>1</td>
</tr>
<tr>
<td>Once or twice a week</td>
<td>2</td>
</tr>
<tr>
<td>Three or more times a week</td>
<td>3</td>
</tr>
</tbody>
</table>

Question 8 score: ______

2. Examine question 9, and assign scores as follows:

<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>No problem at all</td>
<td>0</td>
</tr>
<tr>
<td>Only a very slight problem</td>
<td>1</td>
</tr>
<tr>
<td>Somewhat of a problem</td>
<td>2</td>
</tr>
<tr>
<td>A very big problem</td>
<td>3</td>
</tr>
</tbody>
</table>

3. Add the scores for question 8 and 9:

Sum of 8 and 9: ______

4. Assign component 7 score as follows

<table>
<thead>
<tr>
<th>Sum of 8 and 9</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1-2</td>
<td>1</td>
</tr>
<tr>
<td>2-4</td>
<td>2</td>
</tr>
<tr>
<td>5-6</td>
<td>3</td>
</tr>
</tbody>
</table>

Component 7 score: ______

Global PSQI score

Add the seven component scores together

Global PSQI score: ______

Note: The application of this questionnaire is based on a four week recall of sleep and each questions asked is scored on a 0-3 Likert scale which correspond to one of the 7 categories above (Buysse et al., 1989). These seven categories are also scaled on a 0-3 Likert scale and, when added together, provide an overall global score between 0-21 (Nishiyama et al., 2014). Sleep scores of 0-4 represent adequate sleep while scores of ≥5 indicate impaired sleep patterns (Grandner et al., 2006). There are an additional five questions that are answered by a significant other (spouse/room-mate or someone who shares sleeping arrangements with an individual), however, these scores do not effect global scoring (Manzar et al., 2018). The purpose of this is to assess the components of
sleep that may impair sleep quality/quantity (such as snoring or sleep apnea) in order to provide information about how to improve sleep status.

Permission for PSQI questionnaire sought—awaiting response from the National Center for Biotechnology information
Appendix 8

Comparison of the Star Excursion Balance Test and the Y-Balance Test

Figure 4: Reach directions for the Star Excursion Balance Test and the Y-Balance test (left leg) and the upper extremity Y-Balance test (left arm).

Presented with permission by Chance Crawford-Mickleson
Appendix 9

The closed kinetic chain upper extremity stability test

Figure 5: Starting position for the closed kinetic chain upper extremity stability test. Participant is instructed to touch left and right shoulders with the opposite hand as many times as possible for 15 seconds.

Presented with permission by Chance Crawford-Mickleson
## Appendix 10

### Sit and reach values

<table>
<thead>
<tr>
<th>Categories (age)</th>
<th>20-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50-59</th>
<th>60-69</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>W</td>
<td>M</td>
<td>W</td>
<td>M</td>
</tr>
<tr>
<td>Excellent</td>
<td>40</td>
<td>41</td>
<td>38</td>
<td>41</td>
<td>35</td>
</tr>
<tr>
<td>Very good</td>
<td>39</td>
<td>40</td>
<td>37</td>
<td>40</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>37</td>
<td>33</td>
<td>36</td>
<td>29</td>
</tr>
<tr>
<td>Good</td>
<td>33</td>
<td>36</td>
<td>32</td>
<td>35</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>33</td>
<td>28</td>
<td>32</td>
<td>24</td>
</tr>
<tr>
<td>Fair</td>
<td>29</td>
<td>32</td>
<td>27</td>
<td>31</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>28</td>
<td>23</td>
<td>27</td>
<td>18</td>
</tr>
<tr>
<td>Needs improvement</td>
<td>24</td>
<td>27</td>
<td>22</td>
<td>26</td>
<td>17</td>
</tr>
</tbody>
</table>

**Note:** These norms are based on a sit and reach box which the "zero" point is set at 26cm. When using a box in which the zero point is set at 23cm, subtract 3cm from each value in this table.

ACSM (2014)

Permission for values for sit and reach sought– awaiting response from ACSM.
Appendix 11
RNZN fitness tests

<table>
<thead>
<tr>
<th>MINIMUM FITNESS LEVEL</th>
<th>MSFT</th>
<th>LIFT &amp; CARRY 20KG WEIGHT</th>
<th>BODY DRAG A DUMMY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male under 30 years old</td>
<td>7.10</td>
<td>4x 15m shuttles in under 45 seconds</td>
<td>15 m in under 30 seconds</td>
</tr>
<tr>
<td>Male 30-39 years old</td>
<td>6.10</td>
<td>4x 15m shuttles in under 45 seconds</td>
<td>15 m in under 30 seconds</td>
</tr>
<tr>
<td>Male 40+ years old</td>
<td>5.9</td>
<td>4x 15m shuttles in under 45 seconds</td>
<td>15 m in under 30 seconds</td>
</tr>
<tr>
<td>Female under 30 years old</td>
<td>5.9</td>
<td>4x 15m shuttles in under 45 seconds</td>
<td>15 m in under 30 seconds</td>
</tr>
<tr>
<td>Female 30-39 years old</td>
<td>4.9</td>
<td>4x 15m shuttles in under 45 seconds</td>
<td>15 m in under 30 seconds</td>
</tr>
<tr>
<td>Female 40+ years old</td>
<td>4.1</td>
<td>4x 15m shuttles in under 45 seconds</td>
<td>15 m in under 30 seconds</td>
</tr>
</tbody>
</table>

*Multi-Stage Fitness Test (beep test).*

<table>
<thead>
<tr>
<th>MSFT (BEEP TEST)</th>
<th>CURL-UPS (NOT GRADED)</th>
<th>PRESS-UPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.10 (Grade 2, Minimum Pass)</td>
<td>35</td>
<td>5  (Grade 2, Minimum Pass)</td>
</tr>
<tr>
<td>&gt;10.5 (Grade 7, Strong Pass)</td>
<td>&gt;65</td>
<td>&gt;29 (Grade 7, Strong Pass)</td>
</tr>
<tr>
<td><strong>FEMALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.9 (Grade 2, Minimum Pass)</td>
<td>25</td>
<td>1  (Grade 2, Minimum Pass)</td>
</tr>
<tr>
<td>&gt;8.6 (Grade 7, Strong Pass)</td>
<td>&gt;54</td>
<td>&gt;14 (Grade 7, Strong Pass)</td>
</tr>
</tbody>
</table>

Presented with permission from the NZDF (2018)
Appendix 12
Royal NZ Army fitness tests

<table>
<thead>
<tr>
<th>MSFT (BEEP TEST)</th>
<th>CURL-UPS</th>
<th>PRESS-UPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.2  [Grade 2, Minimum Pass]</td>
<td>35 [Grade 2, Minimum Pass]</td>
<td>10 [Grade 2, Minimum Pass]</td>
</tr>
<tr>
<td><strong>FEMALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.3  [Grade 2, Minimum Pass]</td>
<td>25 [Grade 2, Minimum Pass]</td>
<td>3 [Grade 2, Minimum Pass]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RUN 2.4 KMS</th>
<th>CURL-UPS</th>
<th>PRESS-UPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Minutes</td>
<td>45</td>
<td>15</td>
</tr>
<tr>
<td><strong>FEMALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 Minutes</td>
<td>35</td>
<td>8</td>
</tr>
</tbody>
</table>

**ONGOING FITNESS REQUIREMENTS**

<table>
<thead>
<tr>
<th>RUN 2.4 KMS</th>
<th>CURL-UPS</th>
<th>PRESS-UPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Minutes 30 Seconds</td>
<td>60</td>
<td>28</td>
</tr>
<tr>
<td><strong>FEMALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Minutes 20 Seconds</td>
<td>50</td>
<td>14</td>
</tr>
</tbody>
</table>

**RFL G1 (REQUIRED FITNESS LEVEL - GRADE 1)**

RFL G1 is the desired fitness level for all serving Soldiers and Officers.

<table>
<thead>
<tr>
<th>RUN 2.4 KMS</th>
<th>CURL-UPS</th>
<th>PRESS-UPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Minutes</td>
<td>66</td>
<td>30</td>
</tr>
<tr>
<td><strong>FEMALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Minutes 50 Seconds</td>
<td>55</td>
<td>15</td>
</tr>
</tbody>
</table>

**THE '100 CLUB'**

The '100 Club' is the fitness level that all New Zealand Army officers and soldiers aspire to reach.

<table>
<thead>
<tr>
<th>RUN 2.4 KMS</th>
<th>CURL-UPS</th>
<th>PRESS-UPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Minutes</td>
<td>130</td>
<td>55</td>
</tr>
<tr>
<td><strong>FEMALE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Minutes 5 seconds</td>
<td>118</td>
<td>36</td>
</tr>
</tbody>
</table>

Presented with permission from the NZDF (2018)
Appendix 13

Royal NZ Air Force fitness tests

TIME STANDARDS FOR THE 5 KILOMETRE WEIGHTED MARCH

<table>
<thead>
<tr>
<th>AGE GROUPS</th>
<th>MALE</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time (F1)</td>
<td>Time (F2)</td>
</tr>
<tr>
<td>16-29</td>
<td>42:00</td>
<td>44:00</td>
</tr>
<tr>
<td>30-39</td>
<td>44:00</td>
<td>46:00</td>
</tr>
<tr>
<td>40-49</td>
<td>46:00</td>
<td>48:00</td>
</tr>
<tr>
<td>50+</td>
<td>48:00</td>
<td>50:00</td>
</tr>
</tbody>
</table>

(F1) is the highest level of pass. (F2) is the minimum standard required.

REPETITION STANDARDS FOR PRESS UP TEST

<table>
<thead>
<tr>
<th>AGE GROUPS</th>
<th>MALE</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Repetitions (F1)</td>
<td>Repetitions (F2)</td>
</tr>
<tr>
<td>16-29</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>30-39</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td>40-49</td>
<td>28</td>
<td>16</td>
</tr>
<tr>
<td>50+</td>
<td>22</td>
<td>12</td>
</tr>
</tbody>
</table>

(F1) is the highest level of pass. (F2) is the minimum standard required.

Presented with permission from the NZDF (2018)
### Appendix 14

YMCA estimated VO$_{2\text{max}}$ test for males

<table>
<thead>
<tr>
<th>% Ranking</th>
<th>18-25</th>
<th>26-35</th>
<th>36-45</th>
<th>46-55</th>
<th>56-65</th>
<th>66</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
<td>95</td>
<td>90</td>
<td>83</td>
<td>65</td>
<td>53</td>
</tr>
<tr>
<td>Excellent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>75</td>
<td>66</td>
<td>61</td>
<td>55</td>
<td>50</td>
<td>42</td>
</tr>
<tr>
<td>90</td>
<td>65</td>
<td>60</td>
<td>55</td>
<td>49</td>
<td>43</td>
<td>38</td>
</tr>
<tr>
<td>85</td>
<td>60</td>
<td>55</td>
<td>49</td>
<td>45</td>
<td>40</td>
<td>34</td>
</tr>
<tr>
<td>Good</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>56</td>
<td>52</td>
<td>47</td>
<td>43</td>
<td>38</td>
<td>33</td>
</tr>
<tr>
<td>75</td>
<td>53</td>
<td>50</td>
<td>45</td>
<td>40</td>
<td>37</td>
<td>32</td>
</tr>
<tr>
<td>70</td>
<td>50</td>
<td>48</td>
<td>43</td>
<td>39</td>
<td>35</td>
<td>31</td>
</tr>
<tr>
<td>Above average</td>
<td>49</td>
<td>45</td>
<td>41</td>
<td>38</td>
<td>34</td>
<td>30</td>
</tr>
<tr>
<td>65</td>
<td>48</td>
<td>44</td>
<td>40</td>
<td>36</td>
<td>33</td>
<td>29</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>45</td>
<td>42</td>
<td>38</td>
<td>35</td>
<td>32</td>
<td>28</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>44</td>
<td>40</td>
<td>37</td>
<td>33</td>
<td>31</td>
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ACSM (2014)

Permission Norms for Max VO$_{2\text{max}}$ (ml·kg$^{-1}$·min$^{-1}$) - Males sought – awaiting response from ACSM.
YMCA estimated VO$_{2\text{max}}$ test for females

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ACSM (2014)

Permission Norms for Max VO$_{2\text{max}}$ (ml·kg$^{-1}$·min$^{-1}$) - Females sought– awaiting response from ACSM.
Confidentiality Agreement

Health and Wellness of Royal Navy Personal
CONFIDENTIALITY AGREEMENT

I .......................................................... (Full Name - printed)
agree to keep confidential all information concerning the project
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.......................................................... (Health and Wellness of Royal Navy Personnel).

I will not retain or copy any information involving the project.

  Signature: .......................................................... Date: ..........................................................

Presented with permission from Massey University
Transcribers Confidentiality Agreement

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TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Health and Wellness of Royal Navy Personal

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I ………………………………………………………………………………... (Full Name - printed) agree to transcribe the recordings provided to me.

I agree to keep confidential all the information provided to me.

I will not make any copies of the transcripts or keep any record of them, other than those required for the project.

Signature: ................................................................. Date: ..........................................................

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Appendix 17
Standard operating procedures for conducting finger prick analysis (glucose and cholesterol)

**Purpose:**
A tool that lets you analyse the instantaneous value of lactic acid in the blood. In athletic training, lactate levels can show when exercise changes from aerobic to anaerobic, what an individual's heart rate training zone and recovery time are, and how an athlete's body responds to each workout.

**Advantages:** Instantaneous value of lactic acid in the blood is given. Portable hand held device that is easy to use and is affordable. Only requires a small sample to measure blood lactate levels.

**Disadvantages:** It is invasive as you need to be pricked to get a blood sample. It is no longer sold by the manufacturer and has been taken over by the Lactate Pro 2, so gaining strips and parts will be difficult.

**Method:**
1. Wash and dry your hands thoroughly and use gloves when testing others.
2. Insert a new test strip into your meter. Place the end of the strip with the 2 or 3 contact bars as far into the meter as it can go. Your meter will turn on automatically and if the strip is OK a beep will be heard.
3. Clean the area with an alcohol wipe where you will be collecting the blood sample. Alcohol wipes are effective as alcohol evaporates rapidly so there's no need to dry the area. That will just re-contaminate it.
4. Place a test strip into the slot provided on the lactate Pro so that it is ready for when you need to analyse your blood sample.

5. Use the lancet and prick the area for the sample. Some people find that getting a blood sample from the side of their fingertip, rather than the top, makes it easier to apply the blood to the test strip.

6. Wipe away the first lot of blood and press gently on the area again to get another blood sample.

7. Apply the blood droplet to the test strip. Touch and hold the drop of blood to the narrow channel at the top edge of the test strip.

8. Make sure that the channel in the strip is completely full. This ensures that your meter has a large enough blood sample to give you an accurate reading. If your sample doesn’t fill the channel, add more blood to that strip within 5 seconds. If you get an error reading, discard the strip and start again.

9. Record the reading after 15 seconds and discard the strip and clean up the site. A plaster can be applied if necessary.

Presented with permission from Massey University
Appendix 18
Positioning for sit and reach

Figure 6: Start and final position for the sit and reach rest

Presented with permission by Chance Crawford-Mickleson
Appendix 19

The Frankfort head plane

**Figure 7:** The Frankfort head plane. The line from the Orbitale (most prominent point of the cheekbone) to the Tragion (centre of the ear) (M. Jones, 2008).

Presented with permission by Chance Crawford-Mickleson
### Appendix 20
Conversion table for VO$_{2\text{max}}$

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