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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

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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_{2max} 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_{2max} , 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_{2max} , 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.

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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.

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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_{2max} score above $39-42\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ 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					
Study	Military force	Mean population number	Mean age	Duration	Results
A 10 year follow up of ischemic heart disease in military pilots (Grósz et al., 2007)	Hungarian Air Force	250	33 (\pm 6 years)	1994-1999-2004	Family history = 25.0% were at risk Obesity = 40.8% Smoking = 31.7% Inactivity = 23.9% Elevated BP = 13.1% Total cholesterol (with low HDL) = 53.9% ECG requirement = 1.3%
Cardiovascular disease risk factor among male veterans U.S 2009-2012 (Fryar et al., 2016)	US military	1107 veterans 3972 non-veterans	59.9 years 43.4 years	2014-2015	Increased age (veterans) associated with obesity (veterans = 42.6% versus non-veterans = 33.7%)
Prevalence of and risk factors for autopsy-determined atherosclerosis among US service members 2001-2011 (Webber, Seguin, Burnett, Clark, & Otto, 2012)	US military	3832	25.9 (18-59 years)	2001-2011	Autopsy revealed that 8.5% of personnel had coronary atherosclerosis
When Military Fitness Standards No Longer Apply: The High Prevalence of Metabolic Syndrome in Recent Air Force Retirees	US Air Force	381	48.2 years	2011-2013	Metabolic syndrome = 37.2% Central obesity = 39.8% Elevated fasted glucose = 32.4% High BP = 56.8% Total cholesterol (with low HDL) = 33.3% Elevated triglycerides = 42.7%

(Cranston, True, Wardian, Carriere, & Sauerwein, 2017)					
Hypercholesterolemia and smoking habits of Lithuanian military personnel (Vaicaitiene, Cerniauskiene, Luksiene, & Margeviciene, 2006)	Lithuanian Military	200	25-54 years	2001- 2002	Total cholesterol (men versus women) = 6.21mmol·L ⁻¹ (±1.2mmol·L ⁻¹), 6.04 mmol·L ⁻¹ (±1.09mmol·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 (Sundin, Fear, Wessely, & Rona, 2011)	UK Armed Forces	3759 Men = 2448, Women = 311	17-55 years	2006-2007	Obese BMI males = 13.5% Obese females = 12.9% Waist circumference (94-101.9cm males) = 14.8% Waist circumference males (+102cm) = 8.7% Waist circumference females (80-87.9cm) = 34.8% Waist circumference females (+88cm) = 12.6%
Health-related quality of life in the Royal Norwegian Navy: Does rank matter? (Magerøy, Riise, Johnsen, & Moen, 2007)	Royal Norwegian Navy	1316 male officers	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.
<i>BP = Blood Pressure, HDL = High Density Lipoproteins, BMI = Body Mass Index, CVD = Cardiovascular Disease</i>					

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, & Hanwella, 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 caloric 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 personnel 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 neuropeptide; 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 from fatty tissue, and increases the likelihood of CVD risk factors. Values that are above $25\text{kg}\cdot\text{m}^2$ 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 $22\text{kg}\cdot\text{m}^2$ - $25\text{kg}\cdot\text{m}^2$, while high-risk individuals had values between $26\text{kg}\cdot\text{m}^2$ - $31\text{kg}\cdot\text{m}^2$. 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 its 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 2: BMI for Europeans and Maori and Pacifica populations		
	European (kg·m²)	Maori/Pacific (kg·m²)
Underweight	<18.5	
Normal	18.6-24.9	18.5-25.9
Overweight	25.0-29.9	26-32
Obese Class 1	30.0-34.9	>32
Obese Class 2	35.0-39.9	
Obese Class 3	>40	

(ACSM, 2014; New Zealand Heart Foundation, 2017; Larsson, Broman, & Harms-Ringdahl, 2009).

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

(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 an individual's 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 610,00 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 ($+25\text{kg}\cdot\text{m}^2$), 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 ($200\text{mg}\cdot\text{dL}^{-1}$) and for those aged >25 years ($220\text{mg}\cdot\text{dL}^{-1}$) (Trent, 1991). In 659 active US Army personnel, 30% of males and 16% of females had fasted cholesterol levels above $200\text{mg}\cdot\text{dL}^{-1}$ 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 = $31.5\text{kg}\cdot\text{m}^2$, age = 39 years) were outside normal values when compared to the Ministry of Health recommendations, excluding LDL cholesterol ($3.05\text{mmol}\cdot\text{L}^{-1}$). 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 ($0.125\text{mmol}\cdot\text{L}^{-1}$) (Bruggisser, Burki, Haeusler, Rühli, & Staub, 2016). Additionally, for conscripts with total cholesterol values $>5.17\text{mmol}\cdot\text{L}^{-1}$, 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 raise 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 4: Peak times of the circadian rhythm	
Physiological Variable	Time of day
Increased metabolic process - recovery (lipid oxidation, glucose stored, protein synthesis)	12.00am
Deep sleep	2.00am
Lowest body temperature	4.30am
Sharp rise in BP	6.45am
Decrease in melatonin secretion	7.30am
Highest testosterone levels	9.00am
High alertness	10.00am
Increased metabolic process (increases fat uptake from muscles, high glycogen used, elevated insulin levels, increased lipogenesis)	12.00pm
Best coordination	2.30pm
Highest reaction time	3.30pm
Highest peak of muscle strength	5.00pm
Highest BP	6.30pm
Highest temperature	7.00pm
Melatonin secretion starts	9.00pm

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 assess 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 Army 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, 1997a). 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 foot wear 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 $>30\text{kg}\cdot\text{m}^2$ and $<18.5\text{kg}\cdot\text{m}^2$ 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 (Viestar et al., 2013). Obese populations were found to have significantly more musculoskeletal injuries in the upper and lower extremities, lower back, neck and shoulders (Viestar 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 $>30\text{kg}\cdot\text{m}^2$ 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, & Wheelless, 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 $\geq 60\text{mg}\cdot\text{dL}^{-1}$ ($1.55\text{mmol}\cdot\text{L}^{-1}$) 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 \pm 6 years, BMI = 22.1 \pm 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 and reliable, careful analysis of questions, such as those mentioned above, should be considered when analysing findings as total global score may not equal or ≥ 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 \pm 40.9 minutes, $r = 0.796$) sleep duration (7.6 hours, \pm 1.6 hours, $r = 0.633$) and sleep efficiency (84.9% \pm 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 \pm 15 years) and 45 control subjects (43.3 years \pm 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 (\pm 18 days). Results found the PSQI global score to be 12.5 (\pm 3.8) for insomnia patients and 3.3 (\pm 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 than 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 $\leq 88\%$ and $\leq 85\%$ for their UEYBT and $\leq 92\%$ and $\leq 89\%$ 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 5: Comparison of upper and lower YBT scores adjusted for gender and age among active serving US military personal		
	Upper YBT mean	Lower YBT mean
Overall	96.6% (± 8.6)	87.6% (± 9.6)
Male	98.3% (± 8.9)	89.5% (± 9.6)
Female	95.1% (± 7.8)	84.9% (± 9.1)
<30 years of age	88.2% (± 8.6)	98.1% (± 8.3)
≥ 30 years of age	89.9% (± 10.9)	95.2% (± 8.8)

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 Viciano, (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 - VO_{2max}

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, & Viciano, 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_{2max}

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 $48.3\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (males and females), male mean value (38.1 years) was $51.9\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ while females mean value (38.7 years) was $32.8\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (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 Beekley et al, (2004), the Finish defence force reported that male VO_{2max} values were between $44.8\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ and $47.4\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (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_{2max} score was $50\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (Newman, White, & Callister, 1999). It is important to note that VO_{2max} 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_{2max} is considered the gold standard of VO_{2max} 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_{2max} were well correlated with direct gas analysis measures and were reported to predict VO_{2max} analysis accurately in male participants. Females were found to have a $2.2\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ difference between direct and estimated values of VO_{2max} . This suggests there may be differences between genders seen with over/under prediction which is not uncommon for VO_{2max} 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 \pm 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 (\geq 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 VO_{2max} 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_{2max} test. On completion of the YMCA estimated VO_{2max} test, participants conducted the YBT, followed by the sit and reach test. Tests were 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 (≥ 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 ($\text{mmol}\cdot\text{L}^{-1}$); HDL ($\text{mmol}\cdot\text{L}^{-1}$); triglycerides ($\text{mmol}\cdot\text{L}^{-1}$); LDL ($\text{mmol}\cdot\text{L}^{-1}$) 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 0.5 μL 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_{2max}

The YMCA VO_{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⁻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 ($150\text{kgm}\cdot\text{min}^{-1}$, with 0.5kg). Estimated $\text{VO}_{2\text{max}}$ was calculated using the equations below:

$$\text{VO}_{21} (\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}) = [(1.8 \times \text{work rate}) / \text{Body weight in kg}] + 7$$

$$\text{VO}_{22} (\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}) = [(1.8 \times \text{work rate}) / \text{Body weight in kg}] + 7$$

To find the slope, the following calculation was used

$$\text{Slope } (m) = \text{VO}_2 (\text{VO}_{22} - \text{VO}_{21}) / (\text{HR}_2 - \text{HR}_1)$$

To find the estimated $\text{VO}_{2\text{max}}$

$$\text{VO}_{2\text{max}} (\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}) = m (\text{HR}_{\text{max}} - \text{HR}_2) + \text{VO}_{22}$$

Table 6: Workload and heart rate values for YMCA estimated $\text{VO}_{2\text{max}}$				
Stage 1	$150\text{ kgm}\cdot\text{min}^{-1}$ (0.5 kg)			
Heart rate	<80 bpm	80-89 bpm	90-100 bpm	>100 bpm
Stage 2	$750\text{ kgm}\cdot\text{min}^{-1}$ (2.5 kg)	$600\text{ kgm}\cdot\text{min}^{-1}$ (2.0 kg)	$450\text{ kgm}\cdot\text{min}^{-1}$ (1.5 kg)	$300\text{ kgm}\cdot\text{min}^{-1}$ (1.0 kg)
Stage 3	$900\text{ kgm}\cdot\text{min}^{-1}$ (3.0 kg)	$750\text{ kgm}\cdot\text{min}^{-1}$ (2.5 kg)	$600\text{ kgm}\cdot\text{min}^{-1}$ (2.0 kg)	$450\text{ kgm}\cdot\text{min}^{-1}$ (1.5 kg)
Stage 4	$1050\text{ kgm}\cdot\text{min}^{-1}$ (3.5 kg)	$900\text{ kgm}\cdot\text{min}^{-1}$ (3.0 kg)	$750\text{ kgm}\cdot\text{min}^{-1}$ (2.5 kg)	$600\text{ kgm}\cdot\text{min}^{-1}$ (2.0 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 spinous 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 = *anterior left* – *anterior right*

Posteromedial left and right variance = *posteromedial left* – *posteromedial right*

Posterolateral left and right variance = *posterolateral left* – *posterolateral right*

Composite score

Composite score = $(Anterior + posteromedial + posterolateral) / (3 * length\ of\ limb)$

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:

$$BMI = \text{weight (kg)} / \text{height}^2 \text{ (m)}$$

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:

$$WHR = \text{waist circumference (cm)} / \text{hip circumference (cm)}$$

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 (VO_{2max}) to age was conducted to highlight any gender differences. Significance was set at $p=0.05$ and all mean \pm 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 7: Summary of total RNZN participants (mean \pmSD values).	
Variable	Participants
Total participants	91
Age	
<35 years	52
\geq 35 years	39
Gender	
Male	62
Female	29
Ethnicity	
European	70
Maori	21
Age and gender	
Males aged <35 years	29
Males aged \geq 35 years	33
Females aged <35 years	23
Females aged \geq 35 years	6
Mean age	
Total	34 years (\pm 10.6 years)
Males	36.7 years (\pm 10.5 years)
Females	28.3 years (\pm 8.2 years)

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 ($1.31\text{mmol}\cdot\text{L}^{-1}$); estimated $\text{VO}_{2\text{max}}$ ($32.74\text{ml}\cdot\text{L}^{-1}\cdot\text{min}^{-1}$) (figure 3) and the PSQI (5.6) (see table 10 for PSQI results).

Table 8: Results of cardiovascular measures for RNZN participants.										
Measure	Total mean (n=91) (±SD)	Male (n=62) (±SD)	Female (n=29) (±SD)	P-value (0.05)	Effect size (men vs women)	<35 years (n=52) (±SD)	≥35 years (n=39) (±SD)	P-value (0.05)	Effect size (<35 years vs ≥35 years)	Normal value
Blood lipids										
Total chol (mmol·L ⁻¹)	4.41 (0.80)	4.58 (0.88)	4.04 (0.75)	0.005	0.84	4.04 (0.84)	4.89 (0.67)	0.000	-1.06	<5.18
HDL (mmol·L ⁻¹)	1.31 (0.38)	1.22 (0.34)	1.51 (0.39)	0.001	-1.09	1.29 (0.35)	1.34 (0.42)	0.564	-0.09	≥1.55
Triglyceride (mmol·L ⁻¹)	1.21 (0.78)	1.31 (0.69)	1.00 (0.42)	0.079	0.53	1.13 (0.58)	1.31 (0.98)	0.293	-0.33	<1.70
LDL (mmol·L ⁻¹)	2.57 (0.81)	2.79 (0.80)	2.11 (0.62)	0.000	1.23	2.25 (0.72)	3.00 (0.72)	0.000	-1.32	<2.59
Ratio	3.6 (0.18)	4.00 (1.20)	2.78 (0.58)	0.000	1.65	3.29 (0.99)	4.03 (1.29)	0.003	-0.93	<5
Fasted blood glucose (mmol·L ⁻¹)	5.10 (0.57)	5.22 (0.59)	4.86 (0.43)	0.004	0.88	5.00 (0.51)	5.25 (0.62)	0.042	-0.66	<5.55
Resting heart rate (bpm)	65.37 (11.59)	64.58 (11.06)	67.06 (12.69)	0.343	-0.30	65.82 (10.56)	64.76 (12.96)	0.669	-0.06	60-80
Systolic blood pressure (mmHg)	124.20 (13.39)	127.62 (13.18)	117.10 (10.97)	0.000	1.10	121.46 (12.08)	128.02 (14.28)	0.020	-0.70	120-130
Diastolic blood pressure (mmHg)	78.6 (12.23)	80.56 (13.16)	74.55 (9.21)	0.029	0.66	74.42 (10.91)	84.28 (11.94)	<0.000	-1.18	<85
Mean arterial pressure	93.85 (11.23)	96.25 (11.68)	88.73 (8.26)	0.002	0.93	90.10 (9.42)	98.8 (8.97)	<0.000	-1.17	70-100
VO _{2max} (ml·kg ⁻¹ ·min ⁻¹)	32.74 (10.15)	33.63 (11.16)	30.85 (7.38)	0.226	0.41	33.57 (9.76)	31.65 (10.67)	0.374	0.37	See appendix 14

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.

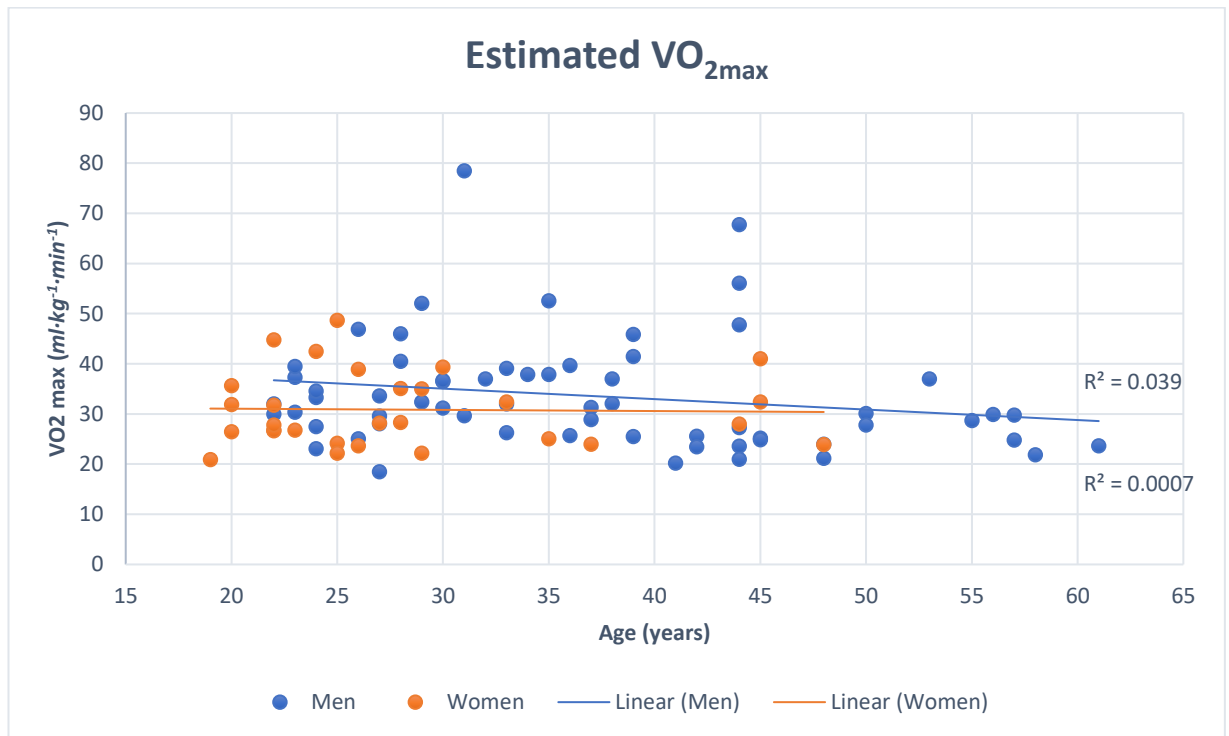


Figure 3: Estimated VO₂max (ml·kg⁻¹·min⁻¹) for males and females according to age, and best line fit with R² values. Correlated fitness values to age (shown in figure 3) show a slight decline for males with increasing age (R² = 0.039), while female fitness levels are more stable with age (R² = 0.0007).

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.

Measure	Total population (n=91) (±SD)	Male (n=62) (±SD)	Female (n=29) (±SD)	P-value (0.05)	Effect size (male vs female)	<35 years (n=52) (±SD)	≥35 years (n=39) (±SD)	P-value (0.05)	Effect size (<35 years vs ≥35 years)	Normal values	
Weight (kgs)	84.99 (16.57)	90.88 (15.77)	72.40 (10.00)	0.000	-	82.47 (16.12)	88.30 (16.79)	0.100	-	≤125	
Height (m)	1.74 (0.08)	1.78 (0.08)	1.67 (0.05)	0.000	-	1.73 (0.08)	1.76 (0.08)	0.228	-	≥ 1.52	
BMI (kg·m ²)	27.64 (4.36)	28.44 (4.56)	25.92 (3.35)	0.009	0.82	27.11 (4.11)	28.34 (4.62)	0.184	-0.42	European = 18.6-24.5 Maori/Pacifica = 18.5-25.9 *NZDF = 36	
Waist to hip ratio	0.87 (0.09)	0.91 (0.07)	0.79 (0.67)	0.000	2.25	0.84 (0.08)	0.90 (0.09)	0.002	-0.98	See table 3 - page 33	
Sit and reach (cm)	28.9 (9.09)	25.45 (7.69)	36.44 (7.16)	0.000	-2.09	31.16 (9.18)	26.27 (8.34)	0.041	0.60	See appendix 10	
Y-balance											
Upper body right (%)	87.02 (10.47)	86.86 (10.66)	87.36 (10.22)	0.836	-0.09	89.0 (10.76)	84.34 (9.54)	0.033	0.63	Male ≥88	Female ≥85
Upper body left (%)	86.81 (10.69)	86.43 (11.19)	87.61 (9.68)	0.624	-0.18	88.4 (10.93)	84.68 (10.11)	0.101	0.49	≥88	≥85
Lower body right (%)	89.59 (11.23)	91.02 (12.08)	91.01 (9.18)	0.413	-0.12	91.8 (8.07)	86.59 (13.97)	0.027	0.69	≥92	≥89
Lower body left (%)	89.23 (11.60)	88.60 (12.25)	89.69 (10.27)	0.798	0.29	91.3 (8.89)	86.40 (14.09)	0.043	0.60	≥92	≥89

*A BMI of ≥36kg·m² 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.						
Measure	Total population n=91	Men n=62	Women n=29	<35 years n=52	≥35 years n=39	Normal values
AHA/ACSM						
Total score	152	125	27	56	96	≤2
History (9 questions)	0	0	0	0	0	
Symptoms experience (6 questions)	17	14	3	6	11	
Other health issues (7 questions)	23	17	6	8	15	
Cardiovascular risk factors (11 questions)	112	94	18	42	70	
Total with high HDL (-1 risk factor)	140	119	21	53	87	
Mean score of participants	1.5	1.9	0.7	1	2.2	
PSQI						
Mean total score	5.6	5.7	5.4	5.6	5.6	≤5
Sleep quality	1.1	1.1	1.3	1.2	1.1	
Sleep latency	1.2	1.2	1.4	1.3	1.1	
Sleep duration	0.5	0.6	0.3	0.4	0.6	
Habitual sleep efficiency	1.3	0.4	0.1	0.2	0.3	
Sleep disturbances	1.1	1.1	1.1	1.0	1.1	
Use of medication	0.2	0.2	0.3	0.3	0.2	
Daytime dysfunction	0.8	0.9	0.8	0.8	0.9	

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 $\geq 1.55 \text{ mmol}\cdot\text{L}^{-1}$ 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 completion 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_{2max} 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_{2max} , 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 $18\text{-}33\text{kg}\cdot\text{m}^2$ 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 = $5.10\text{mmol}\cdot\text{L}^{-1}$; normal = $\leq 5.55\text{mmol}\cdot\text{L}^{-1}$). 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 = $5.20\text{mmol}\cdot\text{L}^{-1}$; males = $5.22\text{mmol}\cdot\text{L}^{-1}$; < 35 years = $5.00\text{mmol}\cdot\text{L}^{-1}$; female = $4.86\text{mmol}\cdot\text{L}^{-1}$). 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 $5.20\text{mmol}\cdot\text{L}^{-1}$ 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_{2max} of participants was 34 years and $32.74\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. According to the ACSM (2014) guidelines for exercise testing and prescription, this was considered to be a poor VO_{2max} score when compared to healthy populations. For healthy populations aged 34 years, a score between $39\text{--}42\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ 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_{2max} , parity with our current study, clarity of a low VO_{2max} is seen. A beep test score of 7.10 for males and 5.9 for females is equivalent to a VO_{2max} score of $36.8\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ and $32.9\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ respectively (see Ramsbottom, Brewer, and Williams, 1988 for conversion table – Appendix 20) (Ramsbottom, Brewer, & Williams, 1988). However, because a score of $32.74\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ was the mean overall score, we speculated that there was a difference in VO_{2max} between gender and age. This was attributed to the fact that female VO_{2max} is reported to be 70–75% of males VO_{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_{2max} values a year (Baur, Christophi, Cook, & Kales, 2012; Sharma & Kailashiya, 2016). However, with regards to the current study, when VO_{2max} was analysed by gender, a difference of $2.78\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ was found in favour of males. When further adjusted for age, there was a $1.92\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ 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_{2max} 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 visceral 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 ($1.31\text{mmol}\cdot\text{L}^{-1}$ versus $1.55\text{mmol}\cdot\text{L}^{-1}$). When HDL are below the recommended level of $\geq 1.55\text{mmol}\cdot\text{L}^{-1}$, 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 HDL cholesterol ($1.22\text{mmol}\cdot\text{L}^{-1}$); female HDL cholesterol ($1.51\text{mmol}\cdot\text{L}^{-1}$); male LDL cholesterol ($2.57\text{mmol}\cdot\text{L}^{-1}$) and female LDL cholesterol ($2.11\text{mmol}\cdot\text{L}^{-1}$) which are supported by their large effect sizes as seen in table 8. While female HDL cholesterol is slightly lower than the desired $1.55\text{mmol}\cdot\text{L}^{-1}$, reverse transportation can occur among females more efficiently than males. When age was considered, significant differences in LDL were found with the < 35 years group presenting with lower LDL cholesterol ($2.25\text{mmol}\cdot\text{L}^{-1}$ versus $3.00\text{mmol}\cdot\text{L}^{-1}$). 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 35years.

Reference Material

- Abt, J. P., Perlsweig, K., Nagai, T., Sell, T. C., Wirt, M. D., & Lephart, S. M. (2016). Effects of Age and Military Service on Strength and Physiological Characteristics of US Army Soldiers. *Military Medicine*, *181*(2), 173-179.
- ACSM. (2013). *American College of Sports Medicine's guidelines for exercise testing and prescription*: Lippincott Williams & Wilkins.
- ACSM. (2014). *ACSM's guidelines for exercise testing and prescription*. Prescription 9th Ed: Lippincott Williams & Wilkins.
- Alam, M. R., Haque, M., & Haque, M. (2017). An appraisal of mortality in Intensive Care Unit of a Level III military hospital of Bangladesh. *Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine*, *21*(9), 594.
- Ambrose, J. A., & Barua, R. S. (2004). The pathophysiology of cigarette smoking and cardiovascular disease: an update. *Journal of the American college of cardiology*, *43*(10), 1731-1737.
- Andersen, K. A., Grimshaw, P. N., Kelso, R. M., & Bentley, D. J. (2016). Musculoskeletal lower limb injury risk in army populations. *Sports medicine-open*, *2*(1), 22.
- ASH. (2017). New Zealand Defence Force to be the world's first smokefree military Retrieved from www.ASH.co.nz
- Assmann, G., & Gotto, A. M. (2004). HDL cholesterol and protective factors in atherosclerosis. *Circulation*, *109*(23 suppl 1), III-8-III-14.
- Australian Defence Force. (2014). Australian Government. Retrieved from www.comcare.gov.au
- Backhaus, J., Junghanns, K., Broocks, A., Riemann, D., & Hohagen, F. (2002). Test-retest reliability and validity of the Pittsburgh Sleep Quality Index in primary insomnia. *Journal of psychosomatic research*, *53*(3), 737-740.
- Bandyopadhyay, A. (2015). Validity of Cooper's 12-minute run test for estimation of maximum oxygen uptake in male university students. *Biology of sport*, *32*(1), 59.
- Barreira, T., Staiano, A., Harrington, D., Heymsfeild, S., Smith, S., Bouchard, C., & Katzmarzyk, P. (2014). Anthropometric Correlates of Total Body Fat, Abdominal

- Adiposity, and Cardiovascular Disease Risk Factors in a Biracial Sample of Men and Women. *Mayo Clinic*, 87(5), 452-460.
- Baur, D. M., Christophi, C. A., Cook, E. F., & Kales, S. N. (2012). Age-related decline in cardiorespiratory fitness among career firefighters: modification by physical activity and adiposity. *Journal of obesity*, 2012.
- Baxi, N. S., Jackson, J. L., Ritter, J., & Sessums, L. L. (2011). How well do the Framingham risk factors correlate with diagnoses of ischemic heart disease and cerebrovascular disease in a military beneficiary cohort? *Military medicine*, 176(4), 408-413.
- Beauchamp, M. K., Lee, A., Ward, R. F., Harrison, S. M., Bain, P. A., Goldstein, R. S. Jette, A. M. (2017). Do Exercise Interventions Improve Participation in Life Roles in Older Adults? A Systematic Review and Meta-Analysis. *Physical therapy*, 97(10), 964-974.
- Becker, J., Nora, D., Gomes, I., Stringari, F., Seitensus, R., Panosso, J., & Ehlers, J. (2002). An evaluation of gender, obesity, age and diabetes mellitus as risk factors for carpal tunnel syndrome. *Clinical Neurophysiology*, 113(9), 1429-1434.
- Beekley, M. D., Brechue, W. F., Dehoyos, D. V., Garzarella, L., Werber-Zion, G., & Pollock, M. L. (2004). Cross-validation of the YMCA submaximal cycle ergometer test to predict VO₂max. *Research quarterly for exercise and sport*, 75(3), 337-342.
- Bekkelund, S. I., & Jorde, R. (2017). Lean body mass and creatine kinase is associated with reduced inflammation in obesity. *European journal of clinical investigation*.
- Bernritter, J. A., Johnson, J. L., & Woodard, S. L. (2011). Validation of a novel method for measuring waist circumference. *Plastic Surgical Nursing*, 31(1), 9-15.
- Booth-Kewley, S., Larson, G., & Ryan, M. (2001). *Predictors of Navy attrition: I. Analysis of 1-year attrition*.
- Booth, C. K., Probert, B., Forbes-Ewan, C., & Coad, R. A. (2006). Australian army recruits in training display symptoms of overtraining. *Military medicine*, 171(11), 1059-1064.

- Boutari, C., & Mantzoros, C. S. (2017). Decreasing Lean Body Mass with Age: Challenges and Opportunities for Novel Therapies. *Endocrinology and Metabolism*, 32(4), 422-425.
- Boyko, E. J., Jacobson, I. G., Smith, B., Ryan, M. A., Hooper, T. I., Amoroso, P. J. (2010). Risk of diabetes in US military service members in relation to combat deployment and mental health. *Diabetes Care*, 33(8), 1771-1777.
- Braithwaite, M., Nicholson, G., Thornton, R., Jones, D., Simpson, R., McLoughlin, D., & Jenkins, D. (2009). Armed Forces occupational health—a review. *Occupational Medicine*, 59(8), 528-538.
- Bray, R., Camlin, C., Fairbank, J., Dunteman, G., & Wheelless, S. (2001). The Effects of Stress on Job Functioning of Military Men and Women. *Armed Forces & Society*, 27(3), 397-417.
- Bray, R., Hourani, L., Rae-Olmsted, K., Witt, M., Brown, J., Pemberton, M., . . . Vandermaas-Peeler, R. (2006). *2005 Department of Defense survey of health related behaviors among active duty military personnel*.
- Bray, R., Hourani, L., Rae, K., Dever, J., Brown, J., Vincus, A. Vandermaas-Peeler, R. (2003). *2002 Department of Defense Survey of Health Related Behaviours and Military Personnel*. RTI International.
- Bray, R. M., Hourani, L. L., Rae Olmsted, K. L., Witt, M., Brown, J. M., Pemberton, M. R. Vandermaas-Peeler, R. (2006). *2005 Department of Defense survey of health related behaviors among active duty military personnel*. Retrieved from
- Brehm, B. J., Seeley, R. J., Daniels, S. R., & D'alessio, D. A. (2003). A randomized trial comparing a very low carbohydrate diet and a calorie-restricted low fat diet on body weight and cardiovascular risk factors in healthy women. *The Journal of Clinical Endocrinology & Metabolism*, 88(4), 1617-1623.
- Bridger, R., Munnoch, K., Dew, A., & Brasher, K. (2009). Smoking, BMI and psychological strain and fitness in the Naval Service. *Occupational medicine*, 59(3), 195-196.
- Brown, C. A., Berry, R., & Schmidt, A. (2013). Sleep and military members: emerging issues and nonpharmacological intervention. *Sleep disorders*, 2013.
- Browning, L. M., Hsieh, S. D., & Ashwell, M. (2010). A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and

- diabetes: 0.5 could be a suitable global boundary value. *Nutrition research reviews*, 23(2), 247-269.
- Bruen, D., Delaney, C., Florea, L., & Diamond, D. (2017). Glucose sensing for diabetes monitoring: recent developments. *Sensors*, 17(8), 1866.
- Bruggisser, M., Burki, D., Haeusler, M., Rühli, F. J., & Staub, K. (2016). Multivariable analysis of total cholesterol levels in male Swiss Armed Forces conscripts 2006-2012. *BMC cardiovascular disorders*, 16(1), 43.
- Burg, M., Brandt, C., Buta, E., Schwartz, J., Bathulapalli, H., Harini, D. Haskell, S. (2017). Risk for incident hypertension associated with posttraumatic stress disorder in military veterans and the effects of post traumatic stress disorder. *Psychosomatic Medicine*, 29(2), 181-188.
- Burton, D. A., Stokes, K., & Hall, G. M. (2004). Physiological effects of exercise. *Continuing Education in Anaesthesia Critical Care & Pain*, 4(6), 185-188.
- Buysse, D. J., Reynolds III, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry research*, 28(2), 193-213.
- Caminha, T. C., Ferreira, H. S., Costa, N. S., Nakano, R. P., Carvalho, R. E. S., Xavier Jr, A. F., & Assunção, M. L. (2017). Waist-to-height ratio is the best anthropometric predictor of hypertension: A population-based study with women from a state of northeast of Brazil. *Medicine*, 96(2).
- Cederberg, H., Mikkola, I., Jokelainen, J., Laakso, M., Härkönen, P., Ikäheimo, T. Keinänen-Kiukaanniemi, S. (2011). Exercise during military training improves cardiovascular risk factors in young men. *Atherosclerosis*, 216(2), 489-495.
- Ceppa, F., Merens, A., Burnat, P., Mayaundont, H., & Bauduceant, B. (2008). Military Community: A Privileged Site for Clinical Research: Epidemiological Study of Metabolic Syndrome Risk Factors in the Military Environment. *Military medicine*, 173(10).
- Chao, S. Y., Zarzabal, L. A., Walker, S. M., Herzog, C. M., Eilerman, P. A., Luce, B. K., & Carnahan, D. H. (2013). Estimating diabetes prevalence in the Military Health System population from 2006 to 2010. *Military medicine*, 178(9), 986-993.

- Charles, L. E., Gu, J. K., Andrew, M. E., Violanti, J. M., Fekedulegn, D., & Burchfiel, C. M. (2011). Sleep duration and biomarkers of metabolic function among police officers. *Journal of occupational and environmental medicine*, *53*(8), 831-837.
- Chen, L., Magliano, D. J., & Zimmet, P. Z. (2012). The worldwide epidemiology of type 2 diabetes mellitus—present and future perspectives. *Nature Reviews Endocrinology*, *8*(4), 228.
- Chen, Y., Copeland, W., Vedanthan, R., Grant, E., Lee, J., Gu, D. Tsugane, S. (2013). Association between body mass index and cardiovascular disease mortality in east Asians and south Asians: pooled analysis of prospective data from the Asia Cohort Consortium. *Bmj*, *347*.
- Cohen, J. (1988). Statistical power analysis.
- Cole, J. C., Motivala, S. J., Buysse, D. J., Oxman, M. N., Levin, M. J., & Irwin, M. R. (2006). Validation of a 3-factor scoring model for the Pittsburgh sleep quality index in older adults. *Sleep*, *29*(1), 112-116.
- Cosio-Lima, L., Knapik, J. J., Shumway, R., Reynolds, K., Lee, Y., Greska, E., & Hampton, M. (2016). Associations Between Functional Movement Screening, the Y Balance Test, and Injuries in Coast Guard Training. *Military medicine*, *181*(7), 643-648.
- Cox, K. A., Clark, K. L., Li, Y., Powers, T. E., & Krauss, M. R. (2000). Prior knee injury and risk of future hospitalization and discharge from military service. *American Journal of Preventive Medicine*, *18*(3), 112-117.
- Cranston, M., True, M., Wardian, J., Carriere, R., & Sauerwein, T. (2017). When Military Fitness Standards No Longer Apply: The High Prevalence of Metabolic Syndrome in Recent Air Force Retirees. *Military medicine*, *182*(8), 1780-1786.
- Cronan, T. A., Conway, T. L., & Kaszas, S. L. (1991). Starting to smoke in the Navy: when, where and why. *Social Science & Medicine*, *33*(12), 1349-1353.
- Crump, C., Sundquist, J., Winkleby, M. A., & Sundquist, K. (2016). Interactive effects of physical fitness and body mass index on the risk of hypertension. *JAMA internal medicine*, *176*(2), 210-216.
- Dalton, M., Cameron, A., Zimmet, P., Shaw, J., Jolley, D., Dunstan, D. Committee, A. S. (2003). Waist circumference, waist-hip ratio and body mass index and their

- correlation with cardiovascular disease risk factors in Australian adults. *Journal of internal medicine*, 254(6), 555-563.
- Davidson, P. L., Chalmers, D. J., Wilson, B. D., & McBride, D. (2008). Lower limb injuries in New Zealand Defence Force personnel: descriptive epidemiology. *Australian and New Zealand journal of public health*, 32(2), 167-173.
- de Silva, V. A., Jayasekera, N. E., & Hanwella, R. (2012). Smoking among troops deployed in combat areas and its association with combat exposure among navy personnel in Sri Lanka. *Substance abuse treatment, prevention, and policy*, 7(1), 27.
- DeFronzo, R. A. (2004). Pathogenesis of type 2 diabetes mellitus. *Medical Clinics*, 88(4), 787-835.
- Dhingra, R. V., RS, . (2012). Age as a Cardiovascular Risk Factor. *Med Clin*, 96(1), 87-91.
- Dong, L., Keum, N., Hu, F., & Orav, J. (2017). Development and validation of anthropometric prediction equations for lean body mass, fat mass and percent fat in adults using the National Health and Nutrition Examination Survey (NHANES) 1999-2006. *British Journal of Nutrition* 188(10), 858.
- Driver, H. S., & Taylor, S. R. (2000). Exercise and sleep. *Sleep medicine reviews*, 4(4), 387-402.
- Dudina, A., Cooney, M., Bacquer, D., Backer, G., Ducimetière, P., Jousilahti, P. Oganov, R. (2011). Relationships between body mass index, cardiovascular mortality, and risk factors: a report from the SCORE investigators. *European Journal of Cardiovascular Prevention & Rehabilitation*, 18(5), 731-742.
- Eckart, R. E., Scoville, S. L., Campbell, C. L., Shry, E. A., Stajduhar, K. C., Potter, R. N. Virmani, R. (2004). Sudden death in young adults: a 25-year review of autopsies in military recruits. *Annals of internal medicine*, 141(11), 829-834.
- Elbejjani, M., Auer, R., Duloi, S., Jacobs Jr, D., Haight, T., Goff Jr, D. Launer, L. (2018). Cigarette smoking and cerebral blood flow in a cohort of middle-aged adults. *Journal of Cerebral Blood Flow & Metabolism*.
- Erbach, M., Freckmann, G., Hinzmann, R., Kulzer, B., Ziegler, R., Heinemann, L., & Schnell, O. (2016). Interferences and limitations in blood glucose self-testing: an overview of the current knowledge. *Journal of diabetes science and technology*, 10(5), 1161-1168.

- Ezzati, A., Jiang, J., Katz, M. J., Sliwinski, M. J., Zimmerman, M. E., & Lipton, R. B. (2013). Validation of the Perceived Stress Scale in a community sample of older adults. *Geriatric Psychiatry, 29*, 645-352.
- Fichtenberg, N. L., Putnam, S. H., Mann, N. R., Zafonte, R. D., & Millard, A. E. (2001). Insomnia screening in postacute traumatic brain injury: utility and validity of the Pittsburgh Sleep Quality Index. *American journal of physical medicine & rehabilitation, 80*(5), 339-345.
- Finestone, A., Milgrom, C., Evans, R., Yanovich, R. A. N., Constantini, N., & Moran, D. S. (2008). Overuse Injuries in Female Infantry Recruits during Low-Intensity Basic Training. *Medicine & Science in Sports & Exercise, 40*.
- Flegal, K. M., Graubard, B. I., Williamson, D. F., & Gail, M. H. (2005). Excess deaths associated with underweight, overweight, and obesity. *Journal of American Medical Association, 293*(15), 1861-1866.
- Forey, B., Fry, J., Lee, P., Thornton, A., & Coombs, K. (2013). The effect of quitting smoking on HDL-cholesterol-a review based on within-subject changes. *Biomarker research, 1*(1), 26.
- Fryar, C. D., Herrick, K., Afful, J., & Ogden, C. L. (2016). Cardiovascular disease risk factors among male veterans, US, 2009–2012. *American journal of preventive medicine, 50*(1), 101-105.
- Fullagar, H. H., Skorski, S., Duffield, R., Hammes, D., Coutts, A. J., & Meyer, T. (2015). Sleep and athletic performance: the effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. *Sports Medicine, 45*(2), 161-186.
- Funderburk, L. K., & Arsenault, J. E. (2013). Prevalence of abnormal serum lipids among overweight and obese soldiers. *Military medicine, 178*(10), 1137-1140.
- Geary, K. G., .D., I., & Croff, A. M. (2002). Does military service damage females An analysis of medical discharge data in the British armed forces.pdf. *Occupational Medicine., 52*(2), 85 - 90.
- Gebicke, M. E. (1998). Military Attrition: Better Data, Coupled With Policy Changes, Could Help the Services Reduce Early Separations: NSIAD-98-213.

- Gentles, D., Metcalf, P., Dyall, L., Sundborn, G., Schaaf, D., Black, P. Jackson, R. (2007). Metabolic syndrome prevalence in a multicultural population in Auckland, New Zealand. *The New Zealand Medical Journal*, 120(1248).
- Gleeson, M., & Walsh, N. P. (2012). The BASES expert statement on exercise, immunity, and infection. *Journal of sports sciences*, 30(3), 321-324.
- Goldbeck, T. G., & Davies, G. J. (2000). Test-retest reliability of the closed kinetic chain upper extremity stability test: a clinical field test. *Journal of Sport Rehabilitation*, 9(1), 35-45.
- Goncalves, M. P., M. Daleprane, J. Koury, J. (2014). Is it possible to identify underlying cardiovascular risk in young trained military? *The Journal of Sports Medicine and Physical Fitness*, 56(1-2), 125-132.
- Gorham, E. D., Barrett-Connor, E., Highfill-McRoy, R. M., Mohr, S. B., Garland, C. F., Garland, F. C., & Ricordi, C. (2009). Incidence of insulin-requiring diabetes in the US military. *Diabetologia*, 52(10), 2087-2091.
- Gorman, P. P., Butler, R. J., Plisky, P. J., & Kiesel, K. B. (2012). Upper Quarter Y Balance Test: reliability and performance comparison between genders in active adults. *The Journal of Strength & Conditioning Research*, 26(11), 3043-3048.
- Goymann, W., & Wingfield, J. C. (2014). Male-to-female testosterone ratios, dimorphism, and life history—what does it really tell us? *Behavioral Ecology*, 25(4), 685-699.
- Granado, N. S., Smith, T. C., Swanson, G. M., Harris, R. B., Shahar, E., Smith, B. Ryan, M. A. (2009). Newly reported hypertension after military combat deployment in a large population-based study. *Hypertension*, 54(5), 966-973.
- Grandner, M. A., Kripke, D. F., Yoon, I.-Y., & Youngstedt, S. D. (2006). Criterion validity of the Pittsburgh Sleep Quality Index: investigation in a non-clinical sample. *Sleep and biological rhythms*, 4(2), 129-136.
- Gray, G. W. (1995). *Lower extremity functional profile*: Wynn Marketing, Incorporated.
- Grósz, A., Tóth, E., & Péter, I. (2007). A 10-year follow-up of ischemic heart disease risk factors in military pilots. *Military medicine*, 172(2), 214-219.
- Guo, X., Zheng, L., Wang, J., Zhang, X., Zhang, X., Li, J., & Sun, Y. (2013). Epidemiological evidence for the link between sleep duration and high blood pressure: a systematic review and meta-analysis. *Sleep medicine*, 14(4), 324-332.

- Haddock, C. K., Poston, W. S., Heinrich, K. M., Jahnke, S. A., & Jitnarin, N. (2016). The benefits of high-intensity functional training fitness programs for military personnel. *Military Medicine*, *181*(11-12).
- Hagnäs, M. P., Cederberg, H., Mikkola, I., Ikäheimo, T. M., Jokelainen, J., Laakso, M. Keinänen-Kiukaanniemi, S. (2012). Reduction in metabolic syndrome among obese young men is associated with exercise-induced body composition changes during military service. *Diabetes research and clinical practice*, *98*(2), 312-319.
- HajSalem, M., Chtourou, H., Aloui, A., Hammouda, O., & Souissi, N. (2013). Effects of partial sleep deprivation at the end of the night on anaerobic performances in judokas. *Biological Rhythm Research*, *44*(5), 815-821.
- Harridge, S. D., & Lazarus, N. R. (2017). Physical activity, aging, and physiological function. *Physiology*, *32*(2), 152-161.
- Haskell, S. G., Brandt, C., Burg, M., Bastian, L., Driscoll, M., Goulet, J. Dziura, J. (2017). Incident Cardiovascular Risk Factors Among Men and Women Veterans After Return From Deployment. *Medical care*, *55*(11), 948-955.
- Hauschild, V., DeGroot, D., Hall, S., Deaver, K., Hauret, K., Grier, T., & Jones, B. (2014). *Correlations between physical fitness tests and performance of military tasks: a systematic review and meta-analyses*.
- Heir, T. (1998). Musculoskeletal Injuries in Officer Training – One-Year Follow-Up. *Military Medicine*, *163*(4), 229-233.
- Hertel, J., Braham, R. A., Hale, S. A., & Olmsted-Kramer, L. C. (2006). Simplifying the star excursion balance test: analyses of subjects with and without chronic ankle instability. *Journal of Orthopaedic & Sports Physical Therapy*, *36*(3), 131-137.
- Herzog, C. M., Chao, S. Y., Eilerman, P. A., Luce, B. K., & Carnahan, D. H. (2015). Metabolic syndrome in the Military Health System based on electronic health data, 2009–2012. *Military medicine*, *180*(1), 83-90.
- Heymsfeild, S., Peterson, C., Thomas, D., Heo, M., & Schuna, J. (2016). Why are there race/ethnic differences in adult body mass index–adiposity relationships? A quantitative critical review. *Obesity reviews : an official journal of the International Association for the Study of Obesity*, *17*(3), 262-275.

- Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L. Kheirandish-Gozal, L. (2015). National Sleep Foundation's sleep time duration recommendations: methodology and results summary. *Sleep Health, 1*(1), 40-43.
- Hoglin, P. J., & Barton, N. (2015). First-term Attrition of Military Personnel in the Australian Defence Force. *ARMED FORCES & SOCIETY, 41*(1), 43-68.
- Holliday, S. B., DeSantis, A., Germain, A., Buysse, D. J., Matthews, K. A., & Troxel, W. M. (2017). Deployment Length, Inflammatory Markers, and Ambulatory Blood Pressure in Military Couples. *Military Medicine, 182*(7).
- The Human Rights Act 1993 : guidelines for Government policy advisers.* (2000). Wellington, N.Z. : Ministry of Justice, [2000].
- Hurd, E., Rockswold, P., & Westphal, R. (2013). Comparison of chronic disease prevalence between US Navy ships without medical doctors and a similar shore-based population. *Military medicine, 178*(5), 543-548.
- Huxley, R., Mendis, S., Zheleznyakov, E., Reddy, S., & Chan, J. (2010). Body mass index, waist circumference and waist: hip ratio as predictors of cardiovascular risk—a review of the literature. *European journal of clinical nutrition, 64*(1), 16.
- Initiative,. (1998). Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. *National Institutes of Health, 98-4083*.
- Iremonger, G., Atalag, K., Johnston, B., & Campbell, A. (2015). Epidemiology of medical discharge in the New Zealand Defence Force. *Journal of Military and Veterans Health, 23*(4), 82-91.
- Jones, M. (2008). Ministry of Health - Protocol for Collecting Height, Weight and Waist Measurements in New Zealand Health Monitor (NZHM) Surveys. *Ministry of Health*.
- Joy, E. A., & Pescatello, L. S. (2016). Pre-exercise screening: role of the primary care physician. *Israel journal of health policy research, 5*(1), 29.
- Joyce, D., & Lewindon, D. (2014). *High-performance training for sports: Human Kinetics*.
- Kendall, F. P., McCreary, E., Provance, P., Rodgers, M., & Romani, W. (2005). *Muscles: Testing and function, with posture and pain (Kendall, Muscles)*: Philadelphia: Lippincott Williams & Wilkins.

- Kennedy-Armbruster, C., Evans, E. M., Sexauer, L., Peterson, J., & Wyatt, W. (2013). Association among functional-movement ability, fatigue, sedentary time, and fitness in 40 years and older active duty military personnel. *Military Medicine*, *178*(12), 1358-1364.
- Kenney, W. L., Wilmore, J., & Costill, D. (2015). *Physiology of sport and exercise 6th edition: Human kinetics*.
- Kim, M.B., Kim, H.J., Kim, S.H., Lee, S.H., Lee, S.H., & Park, W.J. (2017). Metabolic Syndrome and Cardio-Cerebrovascular Risk Disparities Between Pilots and Aircraft Mechanics. *Aerospace medicine and human performance*, *88*(9), 866-870.
- King, O., Nancarrow, S., Grace, S., & Borthwick, A. (2017). Diabetes educator role boundaries in Australia: a documentary analysis. *Journal of foot and ankle research*, *10*(1), 28.
- Knapik, J. (1989). The Army Physical Fitness Test (APFT): a review of the literature. *Military medicine*, *154*(6), 326-329.
- Knapik, J. J., Jones, B. H., Hauret, K., Darakjy, S., & Piskator, E. (2004). *A review of the literature on attrition from the military services: Risk factors for attrition and strategies to reduce attrition*.
- Krauss, M. R., Garvin, N. U., Cowan, D. N., & Boivin, M. R. (2017). Excess Stress Fractures, Musculoskeletal Injuries, and Health Care Utilization Among Unfit and Overweight Female Army Trainees. *American Journal of Sports Medicine*, *45*(2), 311-316.
- Kreher, J. B., & Schwartz, J. B. (2012). Overtraining syndrome: a practical guide. *Sports health*, *4*(2), 128-138.
- Krupenevich, R., Rider, P., Domire, Z., & DeVita, P. (2015). Males and Females Respond Similarly to Walking With a Standardized, Heavy Load. *Military Medicine*, *180*(9), 994-1000.
- Kuehn, B. M. (2017). Resetting the circadian clock might boost metabolic health. *JAMA*, *317*(13), 1303-1305.
- Lappe, J. M., Stegman, M. R., & Recker, R. R. (2001). The impact of lifestyle factors on stress fractures in female Army recruits. *Osteoporosis International: A Journal Established As Result Of Cooperation Between The European Foundation For*

- Osteoporosis And The National Osteoporosis Foundation Of The USA*, 12(1), 35-42.
- Larsson, H., Broman, L., & Harms-Ringdahl, K. (2009). Individual Risk Factors Associated with Premature Discharge from Military Service. *Military Medicine*, 174(1), 009-020.
- Larsson, H., Tegern, M., & Harms-Ringdahl, K. (2012). Influence of the implementation of a comprehensive intervention programme on premature discharge outcomes from military training. *Work*, 42(2), 241-251.
- Lastella, M., Vincent, G. E., Duffield, R., Roach, G. D., Halson, S. L., Heales, L. J., & Sargent, C. (2018). Can Sleep Be Used as an Indicator of Overreaching and Overtraining in Athletes? *Frontiers in physiology*, 9, 436-436.
- Latvala, A., Kuja-Halkola, R., & Ruck, C. (2016). Association of Resting Heart Rate and Blood Pressure in Late Adolescence With Subsequent Mental Disorders: A Longitudinal Population Study of More Than 1 Million Men in Sweden. *JAMA Psychiatry*, 73(12), 1268-1275.
- Laugesen, M., Glover, M., Fraser, T., McCormick, R., & Scott, J. (2010). Four policies to end the sale of cigarettes and smoking tobacco in New Zealand by 2020 *The New Zealand Medical Journal*, 123(1314), 55-67.
- Leahy, J. L. (2005). Pathogenesis of type 2 diabetes mellitus. *Archives of medical research*, 36(3), 197-209.
- Lemmink, K. A., Kemper, H. C., Greef, M. H., Rispen, P., & Stevens, M. (2003). The validity of the sit-and-reach test and the modified sit-and-reach test in middle-aged to older men and women. *Research quarterly for exercise and sport*, 74(3), 331-336.
- Lettieri, C. J., Eliasson, A. H., Andrada, T., Khramtsov, A., Raphaelson, M., & Kristo, D. A. (2005). Obstructive sleep apnea syndrome: are we missing an at-risk population? *Journal of Clinical Sleep Medicine*, 1(04), 381-385.
- Lewis, C. L., Laudicina, N. M., Khuu, A., & Loverro, K. L. (2017). The human pelvis: Variation in structure and function during gait. *The Anatomical Record*, 300(4), 633-642.
- Lieberman, H., Farina, E., Caldwell, J., Williams, K., Thompson, L., Niro, P. McClung, J. (2016). Cognitive function, stress hormones, heart rate and nutritional status

- during simulated captivity in military survival training. *Physiology & behavior*, 165, 86-97.
- Lincoln, M. L., Moore, R. S., & Ames, G. M. (2018). Sleep disturbances after deployment: National Guard soldiers' experiences and strategies. *Sleep Health: Journal of the National Sleep Foundation*.
- Littman, A. J., Jacobson, I. G., Boyko, E. J., Powell, T. M., & Smith, T. C. (2013). Weight change following US military service. *International Journal of Obesity*, 37(2), 244-253.
- Liu, Y.-Z., Wang, Y.-X., & Jiang, C.-L. (2017). Inflammation: the common pathway of stress-related diseases. *Frontiers in human neuroscience*, 11, 316.
- Liutsko, L., Muiños, R., & Tous-Ral, J. M. (2014). Age-related differences in proprioceptive and visuo-proprioceptive function in relation to fine motor behaviour. *European journal of ageing*, 11(3), 221-232.
- Mackinnon, L. (1997). Immunity in athletes. *International Journal of Sports Medicine*, 18(S 1).
- Magal, M., & Riebe, D. (2016). New preparticipation health screening recommendations: what exercise professionals need to know. *ACSM's Health & Fitness Journal*, 20(3), 22-27.
- Magerøy, N., Riise, T., Johnsen, B. H., & Moen, B. E. (2007). Health-related quality of life in the Royal Norwegian Navy: does officer rank matter? *Military medicine*, 172(8), 835-842.
- Maiorana, A., Williams, A., Askew, C., Levinger, I., Coombes, J., Vicenzino, B. Selig, S. (2018). Exercise Professionals with Advanced Clinical Training Should be Afforded Greater Responsibility in Pre-Participation Exercise Screening: A New Collaborative Model between Exercise Professionals and Physicians. *Sports Medicine*, 1-10.
- Manddela, V. (2016). How Tobacco and Cannabis Smoking Effects Human Physiology. *Research and Reviews: Journal of Nursing and Health Science*.
- Manzar, M. D., BaHammam, A. S., Hameed, U. A., Spence, D. W., Pandi-Perumal, S. R., Moscovitch, A., & Streiner, D. L. (2018). Dimensionality of the Pittsburgh Sleep Quality Index: a systematic review. *Health and quality of life outcomes*, 16(1), 89.

- Maron, B., Thompson, P. D., Puffer, J., McGrew, C., Strong, W., Douglas, P. Atkins, D. (1996). Cardiovascular preparticipation screening of competitive athletes: a statement for health professionals from the Sudden Death Committee (clinical cardiology) and Congenital Cardiac Defects Committee (cardiovascular disease in the young), American Heart Association. *Circulation*, *94*(4), 850-856.
- Marshall, G. J., & Turner, A. N. (2016). The importance of sleep for athletic performance. *Strength & Conditioning Journal*, *38*(1), 61-67.
- Massar, S. A., Liu, J. C., Mohammad, N. B., & Chee, M. W. (2017). Poor habitual sleep efficiency is associated with increased cardiovascular and cortisol stress reactivity in men. *Psychoneuroendocrinology*, *81*, 151-156.
- Mathers, C. D., & Loncar, D. (2006). Projections of global mortality and burden of disease from 2002 to 2030. *PLoS medicine*, *3*(11).
- Mayorga-Vega, D., Aguilar-Soto, P., & Viciano, J. (2015). Criterion-related validity of the 20-m shuttle run test for estimating cardiorespiratory fitness: a meta-analysis. *Journal of sports science & medicine*, *14*(3), 536.
- Mayorga-Vega, D., Merino-Marban, R., & Viciano, J. (2014). Criterion-related validity of sit-and-reach tests for estimating hamstring and lumbar extensibility: A meta-analysis. *Journal of sports science & medicine*, *13*(1), 1.
- Mays, R. J., Boér, N. F., Mealey, L. M., Kim, K. H., & Goss, F. L. (2010). A comparison of practical assessment methods to determine treadmill, cycle and elliptical ergometer VO₂peak. *Journal of strength and conditioning research/National Strength & Conditioning Association*, *24*(5), 1325.
- McAuley, K. A., Williams, S. M., Mann, J. I., Goulding, A., & Murphy, E. (2002). Increased risk of type 2 diabetes despite same degree of adiposity in different racial groups. *Diabetes Care*, *25*(12), 2360-2361.
- McConnell-Nzungu, J., Naylor, P. J., Macdonald, H., Rhodes, R. E., Hofer, S. M., & McKay, H. (2017). Classification of obesity varies between body mass index and direct measures of body fat in boys and girls of Asian and European ancestry. *Measurement in Physical Education and Exercise Science*, 1-13.
- McGee, S. (2016). *Evidence-based physical diagnosis e-book*: Elsevier Health Sciences.

- McGraw, L. K., Turner, B. S., Stotts, N. A., & Dracup, K. A. (2008). A review of cardiovascular risk factors in US military personnel. *Journal of Cardiovascular Nursing, 23*(4), 338-344.
- Mendoza-Nunez, V. (2016). What is the onset of age of human aging and old age? *International Journal of Gerontology, 10*(56).
- Mensah, G. A., Croft, J. B., & Giles, W. H. (2002). The heart, kidney, and brain as target organs in hypertension. *Cardiology clinics, 20*(2), 225-247.
- Messner, B., & Bernhard, D. (2014). Smoking and cardiovascular disease: mechanisms of endothelial dysfunction and early atherogenesis. *Arteriosclerosis, thrombosis, and vascular biology, 34*(3), 509-515.
- Minassian, A., Geyer, M., Baker, D., Nievergelt, C., O'Connor, D., Risbrough, V., & MRS, T. (2014). Heart rate variability characteristics in a large group of active-duty marines and relationship to posttraumatic stress. *Psychosomatic medicine, 76*(4), 292.
- Ministry of Health. (2014). Tobacco Use 2012/13: New Zealand Health Survey. from Ministry of Health
- Ministry of Health. (2016). Annual Update of Key results 2015/2016: New Zealand Health Survey. from Ministry of Health
- Ministry of Health. (2018). Ministry of Health: Smoke free 2025. from New Zealand Government www.health.govt.nz
- Mollayeva, T., Thurairajah, P., Mollayeva, S., Shapiro, C., Burton, K., & Colantonio, A. (2015). The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: A systematic review and meta-analysis. *Sleep medicine, 16*.
- Molloy, J. M. (2016). Factors influencing running-related musculoskeletal injury risk among US military recruits. *Military Medicine, 181*(6), 512-523.
- Morkedal, B., Romundstad, P., & Vatten, L. (2011). Informativeness of indices of blood pressure, obesity and serum lipids in relation to ischaemic heart disease mortality; the HUNT-II study. *European Journal of Epidemiology, 26*(6), 457-461.
- Mosca, L., Barrett-Connor, E., & Kass Wenger, N. (2011). Sex/gender differences in cardiovascular disease prevention: what a difference a decade makes. *Circulation, 124*(19), 2145-2154.

- Mullie, P., Clarys, P., Hulens, M., & Vansant, G. (2010). Distribution of cardiovascular risk factors in Belgian army men. *Archives of environmental & occupational health, 65*(3), 135-139.
- Myer, G. D., Kushner, A. M., Brent, J. L., Schoenfeld, B. J., Hugentobler, J., Lloyd, R. S. McGill, S. M. (2014). The back squat: A proposed assessment of functional deficits and technical factors that limit performance. *Strength and conditioning journal, 36*(6), 4.
- Myers, D., & Twenge, J. (2013). *Social Psychology* (11th ed.). New York: McGraw-Hill.
- Mysliwiec, V., Matsangas, P., & Baxter, T. (2016). *The utility of the Pittsburgh Sleep Quality Index in U.S. Military Personnel*.
- Nagai, M., Hoshida, S., & Kario, K. (2010). Sleep duration as a risk factor for cardiovascular disease- a review of the recent literature. *Current cardiology reviews, 6*(1), 54-61.
- Naghii, M. (2006). The importance of body weight and weight management for military personnel. *Military medicine, 171*(6), 550-555.
- Naito, N. A., & Higgins, S. T. (2012). Controlling health care costs in the military: The case for using financial incentives to improve beneficiary personal health indicators. *Preventive Medicine, 55*(Supplement), S113-S115.
- Naitoh, P., Englund, C., & Ryman, D. (1983). *Extending human effectiveness during sustained operations through sleep management*. Retrieved from
- Nance, R., Delaney, J., McEvoy, J., Blaha, M., Burke, G., Navas-Acien, A., . . . McClelland, R. (2017). Smoking intensity (pack/day) is a better measure than pack-years or smoking status for modeling cardiovascular disease outcomes. *Journal of clinical epidemiology, 81*, 111-119.
- Nangia, R., Singh, H., & Kaur, K. (2016). Prevalence of cardiovascular disease (CVD) risk factors. *medical journal armed forces india, 72*(4), 315-319.
- Naylor, M., & Vasan, R. S. (2016). Recent update to the US cholesterol treatment guidelines: A comparison with international guidelines. *Circulation, 133*(18), 1795-1806.
- Neath, A., & Quail, G. (2001). Comparison of Morbidity in the Australian Defence Force with Australian General Practice. *Military medicine, 166*(1), 75-81.

- Neely, F. G. (1998). Intrinsic Risk Factors for Exercise-Related Lower Limb Injuries. *Sports Medicine*, 26(4), 253-263.
- Newman, D. G., White, S. W., & Callister, R. (1999). Patterns of physical conditioning in Royal Australian Air Force F/A-18 pilots and the implications for +Gz tolerance. *Aviat Space Environ Med*, 70(8), 739-744.
- New Zealand Heart Foundation. (2017). BMI Calculator. Retrieved from www.heartfoundation.org.nz
- NHLBI. (2000). *The practical guide: identification, evaluation, and treatment of overweight and obesity in adults*.
- Nickerson, B. S., Esco, M. R., Bishop, P. A., Fedewa, M. V., Snarr, R. L., Kliszczewicz, B. M., & Park, K.-S. (2018). Validity of BMI-Based Body Fat Equations in Men and Women: A 4-Compartment Model Comparison. *The Journal of Strength & Conditioning Research*, 32(1), 121-129.
- Niebuhr, D., Powers, T., Krauss, M., Cuda, A., & Johnson, B. (2006). A review of initial entry training discharges at Fort Leonard Wood, MO, for accuracy of discharge classification type: fiscal year 2003. *Military Medicine*, 171(11), 1142.
- Nindl, B., Williams, T., Butler, N., & Jones, B. (2013). Strategies for optimizing military physical readiness and preventing musculoskeletal injuries in the 21st century. *U.S. Army Medical Department Journal*, 5-19.
- Nindl, B. C., Jones, B. H., Van Arsdale, S. J., Kelly, K., & Kraemer, W. J. (2016). Operational Physical Performance and Fitness in Military Women: Physiological, Musculoskeletal Injury, and Optimized Physical Training Considerations for Successfully Integrating Women Into Combat-Centric Military Occupations. *Military Medicine*, 181(1S), 50-62.
- Nishiyama, T., Mizuno, T., Kojima, M., Suzuki, S., Kitajima, T., Ando, K. B., . . . Nakayama, M. (2014). Criterion validity of the Pittsburgh Sleep Quality Index and Epworth Sleepiness Scale for the diagnosis of sleep disorders. *Sleep medicine*, 15(4), 422-429.
- Nishizawa, A., Suemoto, C. K., Farias-Itao, D. S., Campos, F. M., Silva, K. C., Bittencourt, M. S. Farfel, J. M. (2017). Morphometric measurements of systemic atherosclerosis and visceral fat: Evidence from an autopsy study. *PloS one*, 12(10).

- Nunns, M., House, C., Rice, H., Mostazir, M., Davey, T., Stiles, V. Dixon, S. (2016). Four biomechanical and anthropometric measures predict tibial stress fracture: a prospective study of 1065 Royal Marines. *British Journal of Sports Medicine*.
- NZDF. (2017). Personnel Summary. Retrieved from <http://www.nzdf.mil.nz/personnel-records/personnel-branch/>
- NZDF. (2018). Fitness Requirements. Retrieved from <https://www.defencecareers.mil.nz/navy>
- NZDF. (2019). Defence Careers. Retrieved from <https://www.defencecareers.mil.nz>
- Obnibene, A. J., & Barrett Jr, O. (1982). *Medical Department, United States Army Internal Medicine In Vietnam, Volume 2. General Medicine and Infectious Diseases*. Retrieved from
- Okpala, N., Walker, R., & Hosni, A. (2011). Prevalence of snoring and sleep-disordered breathing among military personnel. *Military medicine*, 176(5), 561-564.
- Panichkul, S., Hatthachote, P., Napradit, P., Khunphasee, A., & Nathalang, O. (2007). Systematic review of physical fitness testing to evaluate the physical combat readiness of Royal Thai Armed Forces. *Military medicine*, 172(12), 1234-1238.
- Paris, R. M., Bedno, S. A., Krauss, M. R., Keep, L. W., & Rubertone, M. V. (2001). Weighing in on type 2 diabetes in the military: characteristics of US military personnel at entry who develop type 2 diabetes. *Diabetes Care*, 24(11), 1894-1898.
- Payab, M., Hasani-Ranjbar, S., Merati, Y., Esteghamati, A., Qorbani, M., Hematabadi, M., Shirzad, N. (2017). The prevalence of metabolic syndrome and different obesity phenotype in Iranian male military personnel. *American journal of men's health*, 11(2), 404-413.
- Peterson, A. L., Goodie, J. L., Satterfield, W. A., & Brim, W. L. (2008). Sleep disturbance during military deployment. *Military medicine*, 173(3), 230-235.
- Plisky, P. J., Gorman, P. P., Butler, R. J., Kiesel, K. B., Underwood, F. B., & Elkins, B. (2009). The reliability of an instrumented device for measuring components of the star excursion balance test. *North American journal of sports physical therapy: NAJSPT*, 4(2), 92.

- Plisky, P. J., Rauh, M. J., Kaminski, T. W., & Underwood, F. B. (2006). Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. *Journal of Orthopaedic & Sports Physical Therapy*, 36(12), 911-919.
- Pollack, L. M., Boyer, C. B., Betsinger, K., & Shafer, M. A. (2009). Predictors of one-year attrition in female Marine Corps recruits. *Military Medicine*, 174(4), 382-391.
- Pollock, M. L., Garzarella, L., deHoyos, D., Brechue, W., Beekley, M., Werber, G., & Lowenthal, D. T. (1994). *The cross-validation of the United States Air Force submaximal cycle ergometer test to estimate aerobic capacity*.
- Potter, R. N., Tremaine, L. A., & Gaydos, J. C. (2017). Mortality Surveillance for Infectious Diseases in the US Department of Defense (1998–2013). *Military medicine*, 182(3-4).
- Prentice, A., & Jebb, S. (2001). Beyond Body Mass Index. *Obesity Reviews*, 2, 141-147.
- Pylypchuk, R., Wells, S., Kerr, A., Poppe, K., Riddell, T., Harwood, M. Wu, B. P. (2018). Cardiovascular disease risk prediction equations in 400 000 primary care patients in New Zealand: a derivation and validation study. *The Lancet*, 391(10133), 1897-1907.
- Ramsbottom, R., Brewer, J., & Williams, C. (1988). A progressive shuttle run test to estimate maximal oxygen uptake. *British journal of sports medicine*, 22(4), 141-144.
- Ray, S., Kulkarni, B., & Sreenivas, A. (2011). Prevalence of prehypertension in young military adults & its association with overweight & dyslipidaemia. *The Indian journal of medical research*, 134(2), 162.
- Razi, S., Manish, G., Keshav, G., Sukriti, K., & Gupta, A. (2016). Site or Size of Waist Circumference, Which one is More important in Metabolic Syndrome? *International Journal of Medicine and Public Health*, 6(2).
- Regitz-Zagrosek, V. (2012). Sex and gender differences in health. Science & Society Series on Sex and Science. *EMBO reports*, 13(7), 596-603.
- Reilly, T. (1997). Energetics of high-intensity exercise (soccer) with particular reference to fatigue. *Journal of sports sciences*, 15(3), 257-263.
- Reilly, T. (2009). The body clock and athletic performance. *Biological Rhythm Research*, 40(1), 37-44.

- Reis, J., Trone, D., Macera, C., & Rauh, M. (2007). Factors Associated with Discharge during Marine Corps Basic Training. *Military Medicine*, *172*(9), 936-941.
- Riebe, D., Franklin, B. A., Thompson, P. D., Garber, C. E., Whitfield, G. P., Magal, M., & Pescatello, L. S. (2015). Updating ACSM's recommendations for exercise preparticipation health screening. *Medicine & Science in Sports & Exercise*, *47*(11), 2473-2479.
- Rinanty, R., Widodo, P., Setyasaki, A., & Pujowaskito, P. (2017). 48 Prevalence of Hypertension in Military Personnel During Routine Medical Check Up. *Journal of Hypertension*, *35*.
- RNZN. (2018). Defence Careers. Retrieved from www.defencecareers.mil.nz
- RNZN. (2019). About your Navy. Retrieved from <https://www.navy.mil.nz>
- Rom, O., Reznick, A., Keidar, Z., Karkabi, K., & Aizenbud, D. (2015). Smoking cessation-related weight gain—beneficial effects on muscle mass, strength and bone health. *Addiction*, *110*(2), 326-335.
- Rosa, J. P. P., Rodrigues, D. F., Silva, A., Moura Simim, M. A. d., Costa, V. T., Noce, F., & de Mello, M. T. (2016). 2016 Rio Olympic Games: Can the schedule of events compromise athletes' performance? *Chronobiology international*, *33*(4), 435-440.
- Rudzki, S. J. (1997a). Injuries in Australian Army recruits. Part I: Decreased incidence and severity of injury seen with reduced running distance. *Military medicine*, *162*(7), 472-476.
- Rudzki, S. J. (1997b). Injuries in Australian Army recruits. Part II: Location and cause of injuries seen in recruits. *Military Medicine*, *162*(7), 477-480.
- Sackett, P. R., & Mavor, A. S. (2006). *Assessing Fitness for Military Enlistment : Physical, Medical, and Mental Health Standards*. Washington, D.C.: National Academies Press.
- Saely, C. H., Risch, L., Frey, F., Lupi, G. A., Leuppi, J. D., Drexel, H., & Huber, A. R. (2009). Body mass index, blood pressure, and serum cholesterol in young Swiss men: an analysis on 56784 army conscripts. *Swiss medical weekly*, *139*(35), 518.
- Sahrman, S. (2010). *Movement system impairment syndromes of the extremities, cervical and thoracic spines-e-book*: Elsevier Health Sciences.

- Salahuddin, M., Maru, T. T., Kumalo, A., Pandi-Perumal, S. R., Bahammam, A. S., & Manzar, M. D. (2017). Validation of the Pittsburgh sleep quality index in community dwelling Ethiopian adults. *Health and quality of life outcomes, 15*(1), 58.
- Samet, J. (2016). Smoking and cancer. *Oxford Textbook of Oncology, 127*.
- Santtila, M., Hakkinen, K., Pihlainen, K., & Kyrolainen, H. (2013). Comparison Between Direct and Predicted Maximal Oxygen Uptake Measurement During Cycling. *Military medicine, 178*(2), 234-238.
- Savva, S., & Kourides, Y. (2000). Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. *International Journal of Obesity, 24*, 1453-1458.
- Sawicka, K., Szczyrek, M., Jastrzebska, I., Prasal, M., Zwolak, A., & Daniluk, J. (2011). Hypertension—The silent killer. *Journal of Pre-Clinical and Clinical Research, 5*(2).
- Saxena, A., & Mittal, S. (2009). Limitation of portable glucose meters. *Indian pediatrics, 46*, 911.
- Schneider, H. J., Friedrich, N., Klotsche, J., Pieper, L., Nauck, M., John, U., . . . Pittrow, D. (2010). The predictive value of different measures of obesity for incident cardiovascular events and mortality. *The Journal of Clinical Endocrinology & Metabolism, 95*(4), 1777-1785.
- Schulze, C., Lindner, T., Goethel, P., Müller, M., Kundt, G., Stoll, R. Bader, R. (2015). Evaluation of the physical activity of German soldiers depending on rank, term of enlistment, and task area. *Military medicine, 180*(5), 518-523.
- Schwartz, O., Libenson, T., Astman, N., & Haim, L. (2014). Attrition due to orthopedic reasons during combat training: rates, types of injuries, and comparison between infantry and noninfantry units. *Military Medicine, 179*(8), 897.
- Shaffer, S. W., Teyhen, D. S., Lorenson, C. L., Warren, R. L., Koreerat, C. M., Straseske, C. A., & Childs, J. D. (2013). Y-balance test: a reliability study involving multiple raters. *Military medicine, 178*(11), 1264-1270.
- Sharma, H. B., & Kailashiya, J. (2016). Gender difference in aerobic capacity and the contribution by body composition and Haemoglobin concentration: a study in

- young Indian National Hockey Players. *Journal of clinical and diagnostic research: JCDR*, 10(11).
- Siddall, A., Bilzon, J., Thompson, D., Greeves, J., Izzard, R., & Stokes, K. (2017). Smoking status and physical fitness during initial military training. *Occupational Medicine*, 67(3), 205-210.
- Sikorski, C., Emerson, M. A., Cowan, D. N., & Niebuhr, D. W. (2012). Risk factors for medical disability in US enlisted Marines: fiscal years 2001 to 2009. *Military Medicine*, 177(2), 128-134.
- Simões, N., Domingos, A., De Oliveira, F., Caldas, I., Guedes, M., Fajardo, V., & De Freitas, S. (2018). Resistin and visfatin concentrations are related to central obesity and inflammation in Brazilian children. *Nutrire*, 43(1), 1.
- Smith, D. J., Bono, R. C., & Slinger, B. J. (2017). Transforming the Military Health System Transforming TRICARE and the Military Health System Transforming TRICARE and the Military Health System. *JAMA*, 318(24), 2427-2428.
- Smoley, B. A., Smith, N. L., & Runkle, G. P. (2008). Hypertension in a population of active duty service members. *The Journal of the American Board of Family Medicine*, 21(6), 504-511.
- Stoner, L., Shultz, S. P., Lambrick, D. M., Krebs, J., Weatherall, M., Palmer, B. R. Williams, M. A. (2013). The combating obesity in Māori and Pasifika adolescent school-children study: COMPASS methodology and study protocol. *International journal of preventive medicine*, 4(5), 565.
- Sullenberger, L., & Gentlesk, P. J. (2008). Cardiovascular disease in a forward military hospital during Operation Iraqi Freedom: a report from deployed cardiologists. *Military medicine*, 173(2), 193-197.
- Sunde, E., Bråtveit, M., Pallesen, S., & Moen, B. E. (2016). Noise and sleep on board vessels in the Royal Norwegian Navy. *Noise & health*, 18(81), 85.
- Sundin, J., Fear, N. T., Wessely, S., & Rona, R. J. (2011). Obesity in the UK Armed Forces: risk factors. *Military medicine*, 176(5), 507-512.
- Swainson, M., Batterham, A., Tsakirides, C., Rutherford, Z., & Hind, K. (2017). Prediction of whole-body fat percentage and visceral adipose tissue mass from five anthropometric variables. *PLOS*, 12(5).

- Swedler, I., Knapik, J., Williams, W., Grier, L., & Jones, H. (2011). Risk Factors for Medical Discharge From United States Army Basic Combat Training. *Military Medicine*, 176(10), 1104-1110.
- Taanila, H., Suni, J., Pihlajamäki, H., Mattila, V. M., Ohrankämnen, O., Vuorinen, P., & Parkkari, J. (2009). Musculoskeletal disorders in physically active conscripts: a one-year follow-up study in the Finnish Defence Forces. *BMC musculoskeletal disorders*, 10(1), 89.
- Talbot, L. A., Weinstein, A. A., & Fleg, J. L. (2009). Army Physical Fitness Test scores predict coronary heart disease risk in Army National Guard soldiers. *Military medicine*, 174(3), 245-252.
- Taylor, R. W., Brooking, L., Williams, S. M., Manning, P. J., Sutherland, W. H., Coppell, K. J. Mann, J. I. (2010). Body mass index and waist circumference cutoffs to define obesity in indigenous New Zealanders—. *The American journal of clinical nutrition*, 92(2), 390-397.
- Teyhen, D. S., Riebel, M. A., McArthur, D. R., Savini, M., Jones, M. J., Goffar, S. L. Plisky, P. J. (2014). Normative data and the influence of age and gender on power, balance, flexibility, and functional movement in healthy service members. *Military medicine*, 179(4), 413-420.
- Teyhen, D. S., Shaffer, S. W., Butler, R. J., Goffar, S. L., Kiesel, K. B., Rhon, D. I. Plisky, P. J. (2016). Application of athletic movement tests that predict injury risk in a military population: development of normative data. *Military medicine*, 181(10), 1324-1334.
- Thompson, P. D., Arena, R., Riebe, D., & Pescatello, L. S. (2013). ACSM's new preparticipation health screening recommendations from ACSM's guidelines for exercise testing and prescription, ninth edition. *Curr Sports Med Rep*, 12(4), 215-217.
- Tipene-Leach, D., Pahau, H., Joseph, N., Coppell, K., McAuley, K., Booker, C. Mann, J. (2004). Insulin resistance in a rural Maori community. *The New Zealand Medical Journal (Online)*, 117(1207).
- Trank, T. V., Ryman, D. H., Minagawa, R. Y., Trone, D. W., & Shaffer, R. A. (2001). *Running mileage, movement mileage, and fitness in male US Navy recruits.*

- Travensolo, C., Monteiro, W., Lima, T., Pinto, R., Farinatti, P., & Polito, M. (2018). Can the Six-Minute Step Test Predict the VO₂ Peak in Healthy Young Men? *Journal of Clinical & Diagnostic Research*, 12(6).
- Trent, L. K. (1991). Prevalence of elevated serum cholesterol in personnel of the US Navy. *Public Health Reports*, 106(2), 167.
- Trone, W., Cipriani, D., Raman, R., Wingard, D., Shaffer, R., & Macera, C. (2013). The Association of Self-Reported Measures With Poor Training Outcomes Among Male and Female U.S. Navy Recruits. *Military Medicine*, 178(1), 43-49.
- Troxel, W. M., Shih, R. A., Pedersen, E. R., Geyer, L., Fisher, M. P., Griffin, B. A. Steinberg, P. S. (2015). Sleep in the military: Promoting healthy sleep among US servicemembers. *Rand health quarterly*, 5(2).
- Tucci, H. T., Martins, J., de Carvalho Sposito, G., Camarini, P. M. F., & de Oliveira, A. S. (2014). Closed Kinetic Chain Upper Extremity Stability test (CKCUES test): a reliability study in persons with and without shoulder impingement syndrome. *BMC musculoskeletal disorders*, 15(1), 1.
- Ulanday, K. T., Jeffery, D. D., Nebeling, L., & Srinivasan, S. (2017). Perceived deterrence of cigarette use and smoking status among active duty military personnel. *Military medicine*, 182(5-6).
- Ulmer, S., Bosworth, H., Germain, A., Lindquist, J., Olsen, M., Brancu, M., & Beckham, J. (2015). Associations between sleep difficulties and risk factors for cardiovascular disease in veterans and active duty military personnel of the Iraq and Afghanistan conflicts. *Journal of Behavioural Medicine*, 38(3), 544-555.
- Vaicaitiene, R., Cerniauskiene, L., Luksiene, D., & Margeviciene, L. (2006). Hypercholesterolemia and Smoking Habits of Lithuanian Military Personnel. *Military medicine*, 171(6), 512-515.
- Vaidya, R., & Bhalwar, B. (2009). Anthropometric parameters of armed forces personnel. *medical journal armed forces india*, 65(4), 313-318.
- Vaidya, R., Bhalwar, R., & Bobdey, S. (2009). Anthropometric Parameters of Armed Forces Personnel. *Medical Journal Armed Forces India*, 65(4), 313-318.
- Verma, A., Bhalwar, R., & Sharma, A. (1998). CAN WAIST/HIP RATIO BE USED AS A SIMPLE MEASURE OF CARDIOVASCULAR RISK IN THE ARMED FORCES: RESULTS

FROM A FIELD EPIDEMIOLOGICAL STUDY. *medical journal armed forces india*, 54(2), 137-139.

- Vickers Jr, R. R., & Barnard, A. C. (2010). *Effects of Physical Training in Military Populations: A Meta-Analytic Summary*. Retrieved from
- Viester, L., Verhagen, E. A., Hengel, K. M. O., Koppes, L. L., van der Beek, A. J., & Bongers, P. M. (2013). The relation between body mass index and musculoskeletal symptoms in the working population. *BMC musculoskeletal disorders*, 14(1), 238.
- Villacorta-Lyew, R., Laselle, B., Mazzoncini, J. P., Merchant, E., & Buckley, P. J. (2008). Cardiac pathological conditions in young soldiers: case series. *Military medicine*, 173(11), 1122-1131.
- Wang, D., Li, W., Cui, X., Meng, Y., Zhou, M., Xiao, L. Chen, W. (2016). Sleep duration and risk of coronary heart disease: A systematic review and meta-analysis of prospective cohort studies. *International journal of cardiology*, 219, 231-239.
- Webber, B. J., Seguin, P. G., Burnett, D. G., Clark, L. L., & Otto, J. L. (2012). Prevalence of and risk factors for autopsy-determined atherosclerosis among US service members, 2001-2011. *Jama*, 308(24), 2577-2583.
- Wedge, R., & Bondurant, S. (2009). *Combating tobacco use in military and veteran populations*: National Academies Press.
- Westrick, R. B., Miller, J. M., Carow, S. D., & Gerber, J. P. (2012). Exploration of the y-balance test for assessment of upper quarter closed kinetic chain performance. *International journal of sports physical therapy*, 7(2), 139.
- Whitfeild, G., Pettee- Gabriel, K., Rahbar, M., & Kohl, H. (2014). Application of the AHA/ACSM Adult Preparticipation Screening Checklist to a Nationally Representative Sample of US Adults Aged 40 and Older from NHANES 2001–2004. *Circulation*.
- Whitney, E. J., Krasuski, R. A., Personius, B. E., Michalek, J. E., Maranian, A. M., Kolasa, M. W. Gotto, A. M. (2005). A randomized trial of a strategy for increasing high-density lipoprotein cholesterol levels: effects on progression of coronary heart disease and clinical events. *Annals of internal medicine*, 142(2), 95-104.
- WHO. (1948). Constitution of WHO: principles. Retrieved from <https://www.who.int>

- WHO. (1989). The Ottawa Charter for Health Promotion. Retrieved from <https://www.who.int>
- WHO. (2011). Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8-11 December 2008.
- WHO. (2017). Cardiovascular diseases (CVDs). Retrieved from <http://www.who.int/mediacentre/factsheets/fs317/en/>
- WHO. (2018). Noncommunicable diseases. Retrieved from [www.WHO.int](http://www.who.int)
- WHO. (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet (London, England)*, 363(9403), 157.
- Williams, V., Stahlman, S., & Hu, Z. (2017). Diabetes mellitus, active component, US Armed Forces, 2008-2015. *MSMR*, 24(1), 8-11.
- Woodruff, S. I., Conway, T. L., & Edwards, C. C. (2000). Effect of an eight week smoking ban on women at US Navy recruit training command. *Tobacco Control*, 9(1), 40-46.
- Woodward, M., Huxley, H., Lam, T., Barzi, F., Lawes, C., & Ueshima, H. (2017). A comparison of the associations between risk factors and cardiovascular disease in Asia and Australasia. *European Journal of Cardiovascular Prevention & Rehabilitation*.
- Wu, S., Wang, R., Ding, Y., Wu, M., Ma, X., Zhao, Y., & He, J. (2014). Abdominal obesity and its association with health-related quality of life in adults: a population-based study in five Chinese cities. *BioMed Central*, 100(12).
- Zacharewicz, E., Hesselink, M. K., & Schrauwen, P. (2018). Exercise counteracts lipotoxicity by improving lipid turnover and lipid droplet quality. *Journal of internal medicine*.
- Zhou, L., Li, C., Gao, L., & Wang, A. (2015). High-density lipoprotein synthesis and metabolism (Review). *Mol Med Rep*, 12(3), 4015-4021.
- Zhu, K., Hunter, M., James, A., Lim, E. M., & Walsh, J. P. (2015). Associations between body mass index, lean and fat body mass and bone mineral density in middle-aged Australians: The Busselton Healthy Ageing Study. *Bone*, 74, 146-152.
- Zinn, C., McPhee, J., Harris, N., Williden, M., Prendergast, K., & Schofield, G. (2017). A 12-week low-carbohydrate, high-fat diet improves metabolic health outcomes

over a control diet in a randomised controlled trial with overweight defence force personnel. *Applied Physiology, Nutrition, and Metabolism*, 42(11), 1158-1164.

Zinner, C., & Sperlich, B. (2016). *Marathon Running: Physiology, Psychology, Nutrition and Training Aspects*: Springer.

Zupan, M. F., Bullinger, D. L., Buffington, B., Koch, C., Parker, S., Fragleasso, S. Rasmussen-Woerner, S. (2018). Physiological Effects of Wearing Athletic Mouth Pieces While Performing Various Exercises. *Military Medicine*, 183, 510-515.

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

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

(ACSM., 2014)

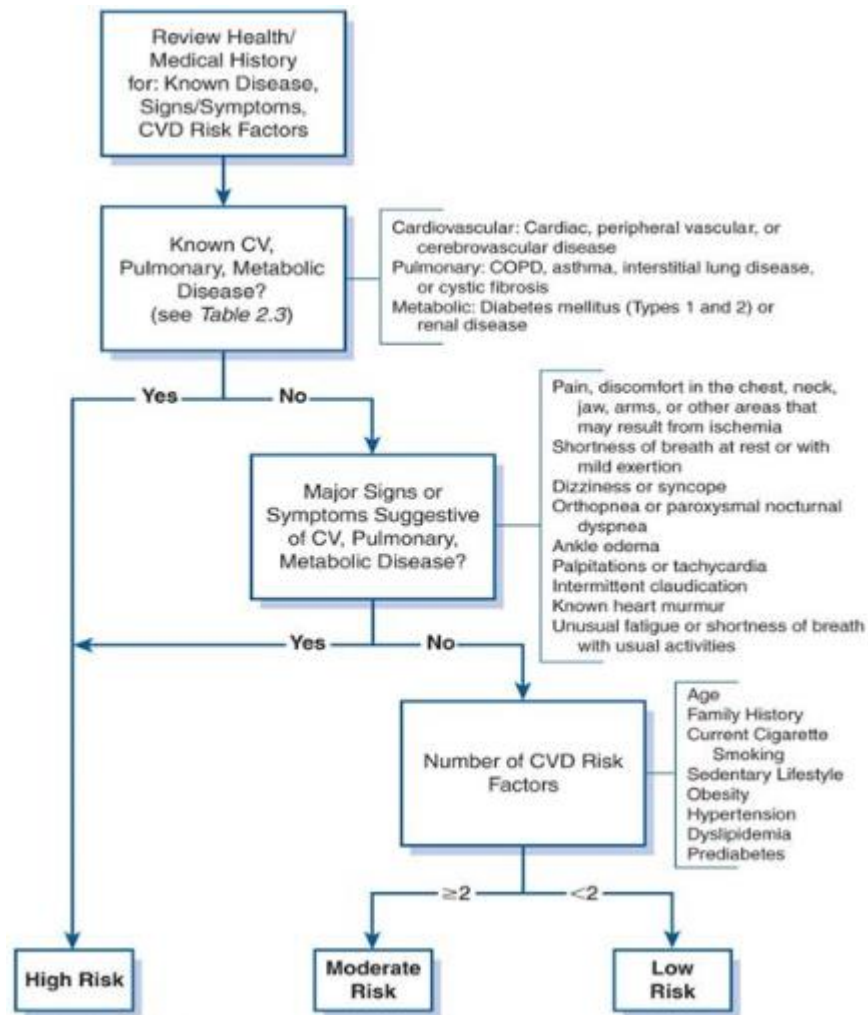
Note: *Asymptomatic individuals who score ≥ 2 are at moderate risk while asymptomatic individuals who score < 2 are at low risk (Maiorana et al., 2018). Asymptomatic individuals do not require medical supervision but do require medical clearance (Riebe et al., 2015).*

ACSM (2014)

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

Appendix 3

The logic model for classification of risk for CVD

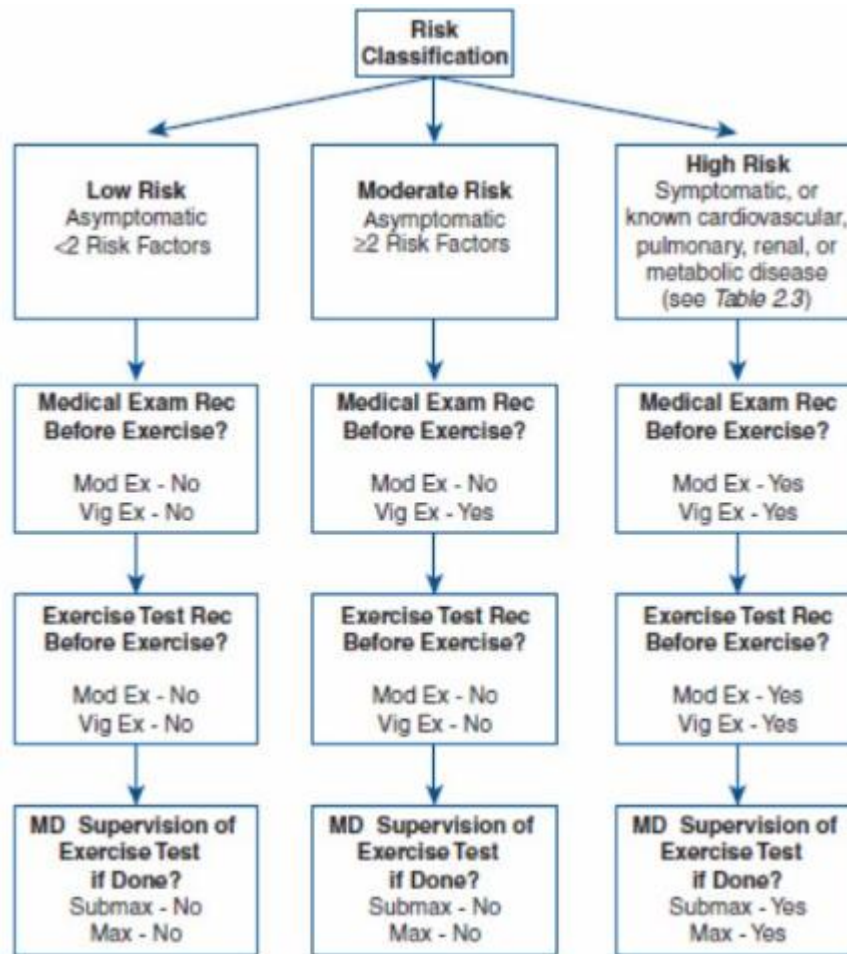


ACSM (2014)

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

Appendix 4

The risk classification table for CVD

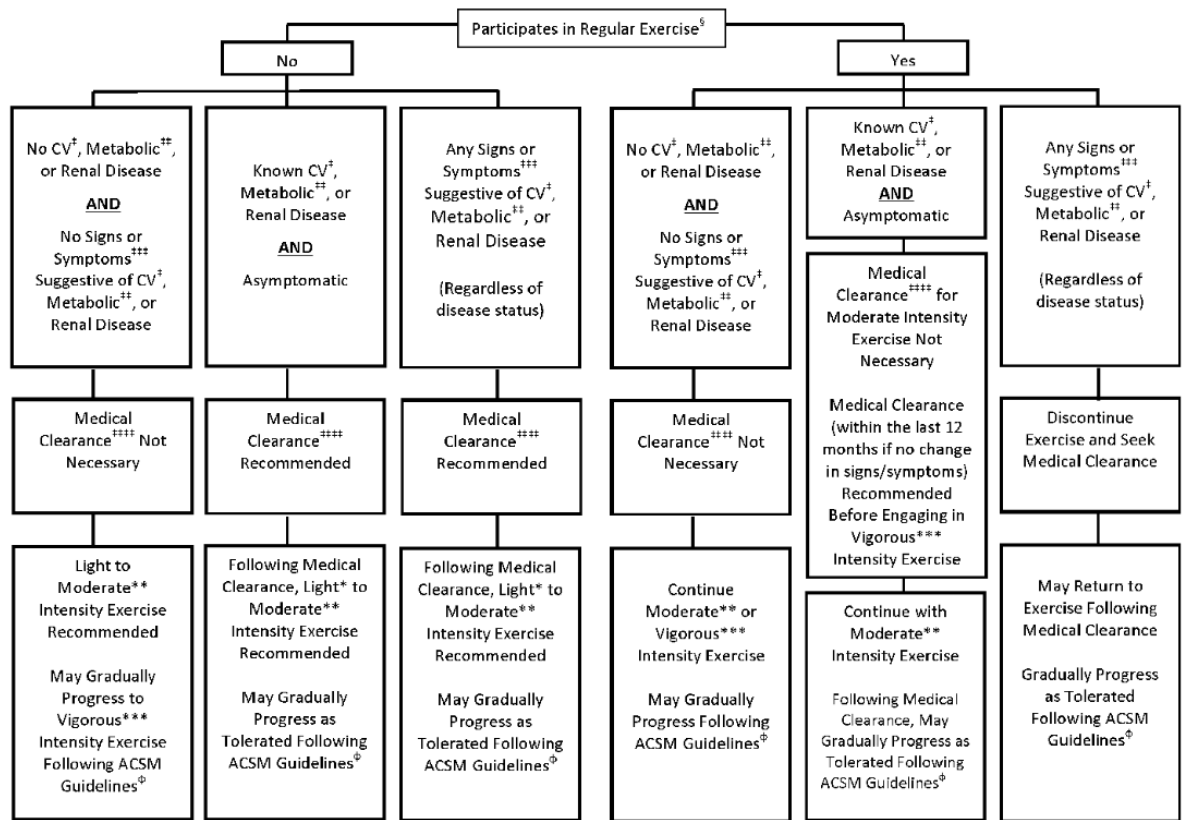


ACSM (2014)

Permission for the risk classification table for CVD sought– awaiting response from ACSM.

Appendix 5

Updated risk classification table for cardiovascular disease



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...

	Not during the last month	Less than once a week	Once or twice a week	Three or more times a week
(a) cannot get to sleep within 30 minutes				
(b) wake up in the middle of the night or early morning				
(c) have to get up to use the bathroom				
(d) cannot breathe comfortably				
(e) cough or snore loudly				
(f) feel too cold				
(g) feel too hot				
(h) have bad dreams				
(i) have pain				
(j) other reasons				

Appendix 7

Scoring the PSQI

Component 1: Subjective sleep Quality

1. Examine question 6, and assign score as follows:

Response	Score
Very good	0
Fairly good	1
Fairly bad	2
Very bad	3

Component 1 score: _____

Component 2: Sleep latency

1. Examine question 2, and assign score as follows:

Response	Score
<15 minutes	0
16-30 minutes	1
31-60 minutes	2
>60 minutes	3

Question 2 score _____

2. Examine question 5a, and assign score 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

Question 5a score _____

3. Add 2 and 5a scores together _____

4. Assign component score as follows:

Sum of 2 and 5a	Score
0	0
1-2	1
3-4	2
5-6	3

Component 2 score: _____

Component 3: Sleep duration

1. Examine question 4, and assign score as follows:

Response	Score
>7 hours	0
6-7 hours	1
5-6 hours	2
<5hours	3

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:

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

Component 6 score: _____

Component 7: Daytime dysfunction

1. Examine question 8 and assign scores 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

Question 8 score: _____

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

Response	Score
No problem at all	0
Only a very slight problem	1
Somewhat of a problem	2
A very big problem	3

3. Add the scores for question 8 and 9:

Sum of 8 and 9: _____

4. Assign component 7 score as follows

Sum of 8 and 9	Score
0	0
1-2	1
2-4	2
5-6	3

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

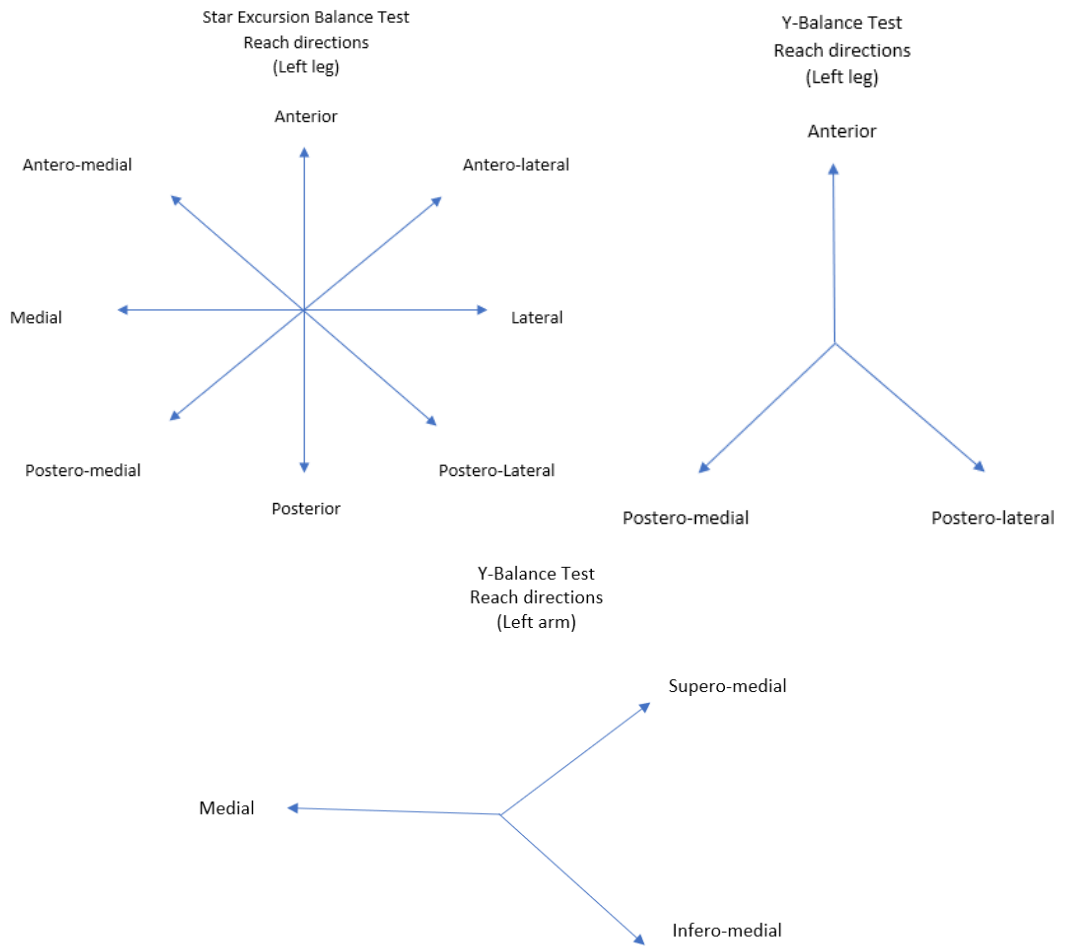


Figure 4: Reach directions for the Star Excursion Balance Test and the Y-Balance test (left leg) and the upper extremity Y-Balance test (left arm).

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

Values for sit and reach (cm)										
Categories (age)	20-29		30-39		40-49		50-59		60-69	
Sex	M	W	M	W	M	W	M	W	M	W
Excellent	40	41	38	41	35	38	35	39	33	35
Very good	39	40	37	40	34	37	34	38	32	34
	34	37	33	36	29	34	28	33	25	31
Good	33	36	32	35	28	33	27	32	24	30
	30	33	28	32	24	30	24	30	20	27
Fair	29	32	27	31	23	29	23	29	19	26
	25	28	23	27	18	25	16	25	15	23
Needs improvement	24	27	22	26	17	24	15	24	14	22

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

MINIMUM FITNESS LEVEL	MSFT	LIFT & CARRY 20KG WEIGHT	BODY DRAG A DUMMY
Male under 30 years old	7.10	4x 15m shuttles in under 45 seconds	15 m in under 30 seconds
Male 30-39 years old	6.10	4x 15m shuttles in under 45 seconds	15 m in under 30 seconds
Male 40+ years old	5.9	4x 15m shuttles in under 45 seconds	15 m in under 30 seconds
Female under 30 years old	5.9	4x 15m shuttles in under 45 seconds	15 m in under 30 seconds
Female 30-39 years old	4.9	4x 15m shuttles in under 45 seconds	15 m in under 30 seconds
Female 40+ years old	4.1	4x 15m shuttles in under 45 seconds	15 m in under 30 seconds

*Multi-Stage Fitness Test (beep test).

	MSFT (BEEP TEST)	CURL-UPS (NOT GRADED)	PRESS-UPS
MALE	7.10 [Grade 2, Minimum Pass]	35	5 [Grade 2, Minimum Pass]
	>10.5 [Grade 7, Strong Pass]	>65	>29 [Grade 7, Strong Pass]
FEMALE	5.9 [Grade 2, Minimum Pass]	25	1 [Grade 2, Minimum Pass]
	>8.6 [Grade 7, Strong Pass]	>54	>14 [Grade 7, Strong Pass]

Presented with permission from the NZDF (2018)

Appendix 12

Royal NZ Army fitness tests

	MSFT (BEEP TEST)	CURL-UPS	PRESS-UPS
MALE	9.2 (Grade 2, Minimum Pass) >12.5 (Grade 7, Strong Pass)	35 (Grade 2, Minimum Pass) >65 (Grade 7, Strong Pass)	10 (Grade 2, Minimum Pass) >34 (Grade 5)
FEMALE	7.3 (Grade 2, Minimum Pass) >11 (Grade 7, Strong Pass)	25 (Grade 2, Minimum Pass) >54 (Grade 7, Strong Pass)	3 (Grade 2, Minimum Pass) >20 (Grade 7, Strong Pass)

	RUN 2.4 KMS	CURL-UPS	PRESS-UPS
MALE	12 Minutes	45	15
FEMALE	14 Minutes	35	8

ONGOING FITNESS REQUIREMENTS

	RUN 2.4 KMS	CURL-UPS	PRESS-UPS
MALE	10 Minutes 30 Seconds	60	28
FEMALE	12 Minutes 20 Seconds	50	14

RFL G1 (REQUIRED FITNESS LEVEL - GRADE 1)

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

	RUN 2.4 KMS	CURL-UPS	PRESS-UPS
MALE	10 Minutes	66	30
FEMALE	11 Minutes 50 Seconds	55	15

THE '100 CLUB'

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

	RUN 2.4 KMS	CURL-UPS	PRESS-UPS
MALE	8 Minutes	130	55
FEMALE	10 Minutes 5 seconds	118	36

Presented with permission from the NZDF (2018)

Appendix 13

Royal NZ Air Force fitness tests

TIME STANDARDS FOR THE 5 KILOMETRE WEIGHTED MARCH

AGE GROUPS	MALE		FEMALE	
	Time (F1)	Time (F2)	Time (F1)	Time (F2)
16-29	42:00	44:00	44:30	46:30
30-39	44:00	46:00	46:30	48:30
40-49	46:00	48:00	48:30	50:30
50 +	48:00	50:00	50:30	52:30

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

REPETITION STANDARDS FOR PRESS UP TEST

AGE GROUPS	MALE		FEMALE	
	Repetitions (F1)	Repetitions (F2)	Repetitions (F1)	Repetitions (F2)
16-29	40	30	22	16
30-39	33	23	18	13
40-49	28	18	16	11
50 +	22	12	12	08

(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_{2max} test for males

		Norms for Max VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$) - Males					
% Ranking		18-25	26-35	36-45	46-55	56-65	66
100	Excellent	100	95	90	83	65	53
95		75	66	61	55	50	42
90		65	60	55	49	43	38
85	Good	60	55	49	45	40	34
80		56	52	47	43	38	33
75		53	50	45	40	37	32
70	Above average	50	48	43	39	35	31
65		49	45	41	38	34	30
60		48	44	40	36	33	29
55	Average	45	42	38	35	32	28
50		44	40	37	33	31	27
45		43	39	37	32	30	26
40	Below Average	42	38	35	31	28	25
35		39	37	33	30	27	24
30		38	34	31	29	26	23

ACSM (2014)

Permission Norms for Max VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$) - Males sought– awaiting response from ACSM.

YMCA estimated VO_{2max} test for females

		Norms for Max VO _{2max} (ml·kg ⁻¹ ·min ⁻¹) - Female					
% Ranking		18-25	26-35	36-45	46-55	56-65	66
100		95	95	75	72	58	55
95	Excellent	69	65	56	51	44	48
90		59	58	50	45	40	34
85		56	53	46	41	36	31
80	Good	52	51	44	39	35	30
75		50	48	42	36	33	29
70		47	45	41	35	32	28
65	Above average	45	44	43	34	31	27
60		44	43	37	32	30	26
55		42	41	36	31	28	25
50	Average	40	40	34	30	27	24
45		39	37	33	29	26	23
40		38	36	32	28	25	22
35	Below Average	37	35	30	27	24	21
30		35	34	29	26	23	20

ACSM (2014)

Permission Norms for Max VO_{2max} (ml·kg⁻¹·min⁻¹) - Females sought– awaiting response from ACSM.

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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-Mickleon

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-Mickleston

Appendix 20

Conversion table for VO_{2max}

Level	Shuttle	LUT Predicted VO ₂ max	Level	Shuttle	LUT Predicted VO ₂ max
4	2	26.8	14	2	61.1
4	4	27.6	14	4	61.7
4	6	28.3	14	6	62.2
4	9	29.5	14	8	62.7
			14	10	63.2
			14	13	64.0
5	2	30.2	15	2	64.6
5	4	31.0	15	4	65.1
5	6	31.8	15	6	65.6
5	9	32.9	15	8	66.2
			15	10	66.7
			15	13	67.5
6	2	33.6	16	2	68.0
6	4	34.3	16	4	68.5
6	6	35.0	16	6	69.0
6	8	35.7	16	8	69.5
6	10	36.4	16	10	69.9
			16	12	70.5
			16	14	70.9
7	2	37.1	17	2	71.4
7	4	37.8	17	4	71.9
7	6	38.5	17	6	72.4
7	8	39.2	17	8	72.9
7	10	39.9	17	10	73.4
			17	12	73.9
			17	14	74.4
8	2	40.5	18	2	74.8
8	4	41.1	18	4	75.3
8	6	41.8	18	6	75.8
8	8	42.4	18	8	76.2
8	11	43.3	18	10	76.7
			18	12	77.2
			18	15	77.9
9	2	43.9	19	2	78.3
9	4	44.5	19	4	78.8
9	6	45.2	19	6	79.2
9	8	45.8	19	8	79.7
9	11	46.8	19	10	80.2
			19	12	80.6
			19	15	81.3
10	2	47.4	20	2	81.8
10	4	48.0	20	4	82.2
10	6	48.7	20	6	82.6
10	8	49.3	20	8	83.0
10	11	50.2	20	10	83.5
			20	12	83.9
			20	16	84.8
11	2	50.8			
11	4	51.4			
11	6	51.9			
11	8	52.5			
11	10	53.1			
11	12	53.7			
12	2	54.3			
12	4	54.8			
12	6	55.4			
12	8	56.0			
12	10	56.5			
12	12	57.1			
13	2	57.6			
13	4	58.2			
13	6	58.7			
13	8	59.3			
13	10	59.8			

Permission for VO_{2max} conversion table sought– awaiting response from the British Journal of Sports Medicine