

**THE ASSOCIATION BETWEEN BODY SIZE AND PHYSICAL FITNESS
AMIDST THE COVID-19 PANDEMIC: A SOUTH AFRICAN NAVAL
PERSONNEL RETROSPECTIVE LONGITUDINAL STUDY**

ADORÉE WENONAH GOLIATH-MANTIS

A mini thesis submitted in partial fulfilment of the requirements for the degree of Master of Public Health at the School of Public Health, University of the Western Cape

Supervisor: Prof. Zandile Mchiza

UNIVERSITY *of the*
WESTERN CAPE

Co-Supervisor: Lt Colonel (Dr) Charles van Wijk

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KEYWORDS

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Body Mass Index

Waist Circumference

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Personnel

Overweight

Obesity

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ABSTRACT

Background: The COVID-19 pandemic has exacerbated obesity among military personnel, particularly in sea rescues. South Africa (SA) has the highest prevalence, with a predicted increase of 47.7% in females and 23.3% in males by 2025. Health assessments and interventions are needed to improve weight status and fitness outcomes. This research study aimed to determine the prevalence of overweight and obesity and the association between the level of body size and physical fitness (PF) among South African Naval personnel.

Methodology: The study involved 2428 adults aged 18-60 working in the South African Navy (SAN), including males and females. The sample size was based on comprehensive health assessments (CHAs) and fitness tests (FT) conducted between 2018-2023. Participants included naval members who participated in CHAs and FT before and after the 2020/2021 pandemic. The study excluded participants under 18 and above 60, pregnant women, those with medical reasons, members on course or not arriving for scheduled fitness tests, and naval members conducting CHA at other units outside of the Institute for Maritime Medicine (IMM) and Naval Base Simon's Town (NBS). The study used Stata to analyse data, to reveal significant differences (using confidence intervals [CI] and p-values) between groups based on age, gender, workplace units, body mass index (BMI), and PF outcomes. The data are presented using counts, proportions, means, and standard deviations. The paired t-test analyses were conducted to determine if differences existed between time points. Logistic regressions analysis was conducted to determine factors that were associated with succeeding during the fitness test.

Results: Overweight prevalence was shown to be higher among SAN personnel in the offshore units, but those in the shore units had higher BMI. Older age groups seemed to have higher BMI means in all the different weight categories (i.e. Underweight, normal, overweight, and obese) than their younger counterparts. Males presented with lower mean BMIs than their female counterparts. Most overweight and obese SAN personnel failed the fitness test, while the majority of normal weight SAN personnel passed it. The study also found BMI, gender and work setting to be important factors that influenced success in fitness tests among the SAN personnel, especially when the confounding effects of age were removed.

Conclusion: Industry-related best practice interventions targeting shore-based units, females and older age groups are needed to reduce overweight and obesity and improve PF among SAN personnel.

DECLARATION

I, Adorée Wenonah Goliath-Mantis, do hereby declare that this dissertation is the result of my investigation and research and that this has not been submitted in part or in full for another degree or for any other degree to another university.



A.W. Goliath-Mantis

2025/01/10

Date

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ABBREVIATIONS

ACSM – American College of Sports Medicine
ACT – Acceptance and commitment therapy
ADMP – Active-Duty Military Personnel
AI- Artificial Intelligence
BMI – Body Mass Index
BMREC – Biomedical Research Ethics Committee
BWL – Behavioural weight loss
CI – Confidence Intervals
CHA – Comprehensive Health Assessment
DALYs – Disability-adjusted life years
DoH – Department of Health
FT – Fitness Tests
FFT – Failed fitness test
GDP – Gross domestic product
HIS – Health Information System
IMM – Institute for Maritime Medicine
LMICs - Low-and middle-income countries
NBS – Naval Base Simon’s Town
NCDs – Non-communicable diseases
OR – Odds Ratio
PA – Physical activity
PF – Physical fitness
PFT – Passed fitness test
RL – Reinforcement learning
SA – South Africa
SAA – South African Army
SAAF – South African Airforce
SAN – South African Navy
SAMHS – South African Medical Health Service
SANDF – South African National Defence Force

SADHS – South Africa Demographic and Health Survey
SANHANES-1 – South African National Health and Nutrition Examination Survey
SDGs – Sustainable Development Goals
SSA – Sub-Saharan Africa
ST – Simon’s Town
STATS SA – Statistics South Africa
SS – Ship Shape
T2DM – Type 2 diabetes mellitus
UWC – University of the Western Cape
UN – United Nations
U.S. – United States
USA – United States of America
WC – Waist circumference
WHR – Waist-to-hip ratio
WHO – World Health Organization
1MHREC – 1 Military Hospital Research Ethics Committee

CHAPTER 1

INTRODUCTION

1.1 Background to the study

Overweight and obesity and inadequate physical fitness (PF) are critical in assessing the health and wellbeing of service members and the readiness of military personnel to overcome dangerous situations during sea rescues in the navy (Sánchez-Chapul *et al.*, 2020).

Naval personnel are supposed to be extremely physically and psychologically fit, and highly qualified technically to navigate the high variability of external and internal factors in marine environments and combat situations (Sargent, Gebruers and O'Mahony, 2017).

According to Janvrin *et al.* (2024), the study examined 98,330 active-duty Sailors and 55,298 Marines. Among Sailors, the prevalence of underweight decreased by 11%, healthy weight declined by 11.1%, overweight rose by 2.1%, and obesity increased by 16.5% during the pandemic. For Marines, underweight dropped by 1%, healthy weight decreased by 16%, overweight rose by 3%, and obesity surged by 51%. Across both groups, the most significant increases in overweight and obesity were observed among females, individuals under 20 years old, and Junior Enlisted personnel.

Obesity is a significant risk factor for various non-communicable diseases (NCDs), including heart disease, hypertension, stroke, cancers, type 2 diabetes mellitus (T2DM), gallbladder disease, dyslipidaemia, osteoarthritis, gout, and pulmonary disorders (Bentham *et al.*, 2017). South Africa is among the Sub-Saharan Africa (SSA) nations with the greatest prevalence of obesity, with a predicted increase from 2010, 12.5% in males and 37.5% in females to 23.3% and 46.7% by 2025 (Lobstein and Brinsden, 2020). The development of various major NCDs renders obesity as a critical focus for preventative and/or therapeutic interventions (Samodien *et al.*, 2021). Therefore, initiatives focused on combating obesity could significantly reduce the prevalence of NCDs.

Factors contributing to overweight and obesity are excess intake food high in energy and inadequate physical activity (PA) (Nglazi and Ataguba, 2022).

The South African National Defence Force (SANDF) consists of four arms of service, namely the South African Army (SAA), South African Airforce (SAAF), SAN, and the South African Military

Health Service (SAMHS). Comprehensive health assessments (CHAs) are conducted on all naval members and assess their overall health. The CHAs assesses psychological and social wellbeing, rapid HIV and hepatitis test, immunisations, visual acuity and colour vision, blood pressure, audiometry test, urine analysis, oral health, and physical assessment. Comprehensive health assessments are conducted biennially on offshore (operational) members and on all shore-based naval members. Fitness tests are compulsory and are performed biannually on all naval personnel. The fitness test (FT) evaluates members' muscular endurance, strength, and aerobic capacity. Given that 20.39% of naval personnel were referred for intervention due to elevated BMI and waist circumference detected during their CHAs, targeted interventions are necessary to: (i) enhance weight status and physical fitness, (ii) improve fitness test pass rates, and (iii) support the retention of skilled and highly trained military personnel (Afari et al., 2019).

1.2 Problem statement

The 20.39% of SAN personnel were advised to engage in lifestyle modification due to their unhealthy body size statuses. However, while there are studies that investigated the relationship between body composition and PF (Gomwe et al., 2022; Monyeki et al., 2012) these studies focused on children and adolescents and not adults (Gomwe et al., 2022; Monyeki et al., 2012). To the best of our knowledge, there is no peer-reviewed published data detailing the prevalence of overweight and obesity among South African Navy (SAN) personnel, nor the relationship between these body size categories and their physical fitness levels. While similar research exists within other countries' naval forces, context-specific and customized health interventions for SAN personnel remain lacking.

Modifiable risk factors associated with NCDs include overweight, obesity, physical inactivity, smoking, excessive alcohol intake and unhealthy diets. These factors can be modified through changes in behaviours or medications (engaging in a nutritious diet, engaging in regular physical exercise, refraining from tobacco use, and avoiding excessive alcohol consumption) (Bradshaw *et al.*, 2011). South African researchers have already shown the burden of diseases attributable to smoking, alcohol overconsumption, less consumption of fruits and vegetables, physical inactivity etc., as ranging from 21% to 23% of years of life lost and 16% to 33% of disability-adjusted life years (DALYs) in the country (Bradshaw et al., 2003; Shisana et al., 2013; Mfolozi, 2020). Moreover, substantiated SA studies have shown that ill-health due to overweight, obesity and

NCDs interfere with work performance (Maseko, 2019), puts a burden on health systems (Boachie *et al.*, 2022) and household income (Mfolozi, 2020). Hence, the SA strategies for obesity (National Department of Health, 2023) and NCDs (National Department of Health., 2022) recommend the prevention of these health conditions even at the workplace. This research study was timely, as it aimed to partly heed the SA strategical calls by providing background data on overweight and obesity among SAN personnel, to inform the development of targeted workplace interventions to address unhealthy body size, as a mechanism to improve the SAN personnel's health status, productivity, and combat readiness.

1.3 Significance of the study

The significance of this study is to gain knowledge on the burden of overweight and obesity and how body size is associated to PF within the SAN. The outcomes of this study can assist health professionals at the Institute for Maritime Medicine (IMM) in developing interventions that will address and improve the body size status and PF of the SAN personnel. These findings will also be disseminated to top structures within the SAN, where recommendations can be made on how to reduce the burden of overweight and obesity in the SAN and improve the PF of the SAN. This can significantly decrease the cost of healthcare and increase productivity and workplace combat readiness and contribute to the body of knowledge regarding the burden of disease and PF in the SAN, as many studies have found the effect of physical training on body size, but few studies have found the association between body size and PF.

1.4 Aim of the study

This study aimed to determine the prevalence of overweight and obesity and the association between body size and level of physical fitness among South African Naval personnel.

1.5 Research objectives

- To determine the prevalence of overweight and obesity among the SAN personnel and assess the changes in body size (BMI) amidst the COVID-19 pandemic
- To determine the level of physical fitness of the SAN personnel and assess its changes amidst the COVID-19 pandemic
- To determine the sociodemographic factors affecting body size and physical fitness level among the SAN personnel

- To assess the association between body size and physical fitness among SAN personnel

1.6 Chapters outline

The report is structured with each chapter dedicated to a distinct aspect of the research.

Chapter 1: Introduction

This section of the thesis presents the topic, background information, problem statement, significance, aims, objectives, and chapter breakdown.

Chapter 2: Literature review

In this chapter, previously published literature related to the subject is presented and critically analysed. This includes the introduction to body size, discussions on body size in military populations, prevalence and sociodemographic determinants of obesity, causes of overweight and obesity, physical fitness in military populations, the effects of obesity on the individual, family, health services and SA, the effect of PF on body size, and especially among naval employees and the drivers of obesity (nutrition transition, culture and globalisation).

Chapter 3: Research design and methodology

This chapter emphasises the research design, methods, sampling strategy, data collection instruments and data analysis.

Chapter 4: Results

This chapter includes the presentation and interpretation of findings from the conducted research. The findings are displayed using tables and are explained in the corresponding narratives.

Chapter 5: Discussion

In this chapter the findings are thoroughly examined to identify trends and establish connections between the findings and the research topic, aims, and objectives. These outcomes are then corroborated and/or contrasted with already existing similar literature from South Africa and globally. This chapter then concludes by emphasizing the strengths and the limitations of the current research to caution the reader about the factors that may have overemphasized or hindered the achievement of some sections of the objectives.

Chapter 6: Conclusion and recommendations

In this chapter, the key findings as a form of “*take home messages*” from the research undertaken are magnified. Based on these, it is outlined whether set research objectives have been met, and consequently recommendations are outlined to improve knowledge about the topic researched. Moreover, in this chapter the implication of these key messages to the SAN nutritional status, PF related policies and public health is emphasized.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter gives an overview of the existing literature globally on the prevalence and drivers of overweight and obesity, as well as the influence sociodemographic factors and body size have on PF among the SANDF.

2.2 Body size

The rise in obesity is a problem for global public health, with a projected increase in obesity of 23.3% for men and 47.7% for women by 2025 (van Vollenstee and van der Merwe, 2021). South Africa is one of the nations with the greatest prevalence of obesity (Vollenstee and Merwe, 2021). The World Health Organization (WHO) defines overweight and obesity as abnormal or excessive fat accumulation causing health concerns (World Health Organization, 2005). Body size differs from body composition, as body size refers to the total body mass and is measured by BMI, which assesses body weight relative to height and is an adiposity indicator calculated by dividing weight by height squared (Bentham *et al.*, 2017). Body composition on the other hand, consists of water, lean body mass (which encompasses organs, bones, and muscles), fat mass, and additional components such as minerals, is measured by skinfold tests, bioelectric impedance analysis and air displacement plethysmography to ascertain the proportion of body fat and lean body mass in a person's overall weight (Callahan, 2022). Body mass index is utilised to monitor variations in body size among a population over a period and is associated with greater health risks (Callahan, 2022). For adults, a BMI ≥ 30 kg/m² indicates obesity, whereas a BMI ≥ 25 kg/m² is classified as overweight (Bentham *et al.*, 2017). In newborns, children, and adolescents, the BMI categories that define obesity vary by age and gender (Bentham *et al.*, 2017).

Waist circumference measures body size and assesses body fat centralization where the layers of fat under the skin and around some vital organs, muscles and bones, is measured. While there is a strong correlation between WC and BMI, substantiated studies have shown that WC measurements can provide additional or even superior predictive value for disease risk compared to BMI alone (Gadde *et al.*, 2018). For example, in a case-control study that assessed the relation between BMI, waist and hip circumferences, and waist-to-hip ratio to myocardial infarction overall and for each

group, waist-to-hip ratio was found to be highly significant associated with myocardial infarction risk worldwide (Yusuf *et al.*, 2005).

Non-Communicable Diseases are conditions which are not infectious and are known to be the leading cause of death globally. They are responsible for 41 million deaths each year, which is equivalent to 71% of all deaths globally (WHO, 2023).

Most NCDs are associated with four specific behaviours: tobacco use, physical inactivity, a poor diet, and alcohol consumption. These behaviours result in four major metabolic/physiological changes i.e., hypertension, overweight/obesity, hyperglycaemia, and hyperlipidaemia (World Health Organization, 2010).

The Sustainable Development Goals (SDGs) are a set of international development goals from 2016 to 2030, which were adopted by the United Nations (UN) Sustainable Development Summit held in September 2015 (Smale, 2018). The SDG target 3.4 recommends the reduction of premature mortality from NCDs by one-third, through the prevention, treatment and promotion of mental health and well-being (WHO, 2019).

2.3 Body size in military populations

Occupational factors are now widely recognised as potentially contributing to the development of excessive body weight. Adverse lifestyle factors, such as high levels of occupational stress, and sedentary work are the primary occupational risk factors (Gravina *et al.*, 2023). Military personnel are a population that is more susceptible to obesity and mental health conditions, including post-traumatic stress disorder, severe depression, and disinhibited eating, due to their increased exposure to stress (Gravina *et al.*, 2023). The military population has been affected by the obesity epidemic, which may be attributed to the high levels of stress and detrimental environmental factors that are present, particularly during military exercises, missions, or deployment and relocation. In addition, there may be restrictions on the availability or selection of food, particularly among specific services like the Marines and navy (Gravina *et al.*, 2023). Other factors to consider include the necessity for military personnel to adhere to body weight and composition standards to remain in the military and be eligible for employment. Consequently, there may be an elevated level of attention and anxiety regarding fitness, body weight, and shape. It is a fact that soldiers are obligated to adhere to fitness standards that are not necessary for civilians to be prepared for

combat. In civilian society, overweight and obesity levels are on the rise, and the armed forces population is experiencing comparable trends (Gravina et al., 2023).

2.3.1 Global situation

According to the International Diabetes Federation and World Obesity Federation (2022), by the year 2030, one billion people worldwide, including one in five women and one in seven men, with 70% in low-and middle-income countries (LMICs), will be obese (World Heart Federation, 2016; Nglazi and Ataguba, 2022). In 2022, global obesity affected one in eight individuals, with adolescent obesity quadrupling and adult obesity more than doubled since 1990 (Phelps *et al.*, 2024). According to Phelps *et al.*, (2024) 2.5 billion adults aged 18 and older were classified as overweight and 890 million individuals were obese in 2022. This is a rise from 1990, when 25% of adults aged 18 years and over were overweight, to a current figure of 43% (43% of men and 44% of women) who are overweight (Phelps *et al.*, 2024). Overweight prevalence varied by region, ranging from 31% in the WHO South-East Asia Region and the African Region to 67% in the Region of the Americas (Phelps *et al.*, 2024). The prevalence of obesity was 16%, while 43% of adults aged 18 years and older were overweight in 2022 (Phelps *et al.*, 2024). The Americas region has the highest rates of overweight (61%) and obesity (27%), with 50% of women overweight and 50% obese in Europe, the Americas, and the Eastern Mediterranean (World Health Organization, 2014). The rate of obesity among United States (U.S.) active-duty military personnel (ADMP) service members increased by 68% between 2002 and 2015, resulting in nearly two-thirds of military personnel across all branches classified as overweight and obese (Smith et al., 2012; Miggantz et al., 2023). Subsequently, the overall prevalence of obesity within the U.S. active service members increased from 16.3% in 2015 to 17.9% in 2019 (Legg et al., 2022; Armed Forces Health Surveillance Division | Health.mil, 2020). Similarly, to Smith et al., (2012) in a study to assess changes in the prevalence of overweight and obesity from 2002 to 2005 among a representative sample of U.S. military personnel, and to identify the association of select socio-demographic factors with overweight and obesity, found that the combined prevalence of overweight and obesity in the military was higher in 2005 compared to 2002 12.9% vs. 8.7%, respectively. Navy personnel have been reported to have the third highest rate of overweight and obesity (64.6%) among all service branches, with 48.9% being overweight and 15.7% obese (Meadows *et al.*, 2018).

Contrary to U.S., the United Kingdom's data indicates slightly lower rates of obesity, with 38% being overweight and 14% being obese (Gravina *et al.*, 2023). Published literature shows that in the U.S. Army, 15% of soldiers are obese, while 12% of the British Army, 13% of the Iranian Army, 6% of the Polish Air Force, and 44% of the Saudi Arabian Army are obese (Legg *et al.*, 2022; Sanderson, Clemes and Biddle, 2014; Sundin *et al.*, 2011; Quertier *et al.*, 2022; Salimi *et al.*, 2019; Gażdzińska, Jagielski and Baran, 2019; Al-Qahtani, Imtiaz and Shareef, 2005).

Published data from the United States of America (USA) showed that the COVID-19 pandemic affected the prevalence rates of obesity among U.S. ADMP (Legg *et al.*, 2022). The monthly prevalence of obesity ranged from 15.0% in August 2020 to 19.3% in April 2021. The authors attributed this to restrictions imposed due to the pandemic, which affected, among other things, engagement in physical activity.

2.3.2 South African National Defence Force

Although data on the rates of obesity for the South African population exist, there is little or no data for the military community. Given the fact that obesity could affect recruitment for military service, military readiness to deploy and/or be operational, as well as retention of military personnel, there is an urgent need to make this data available.

A recent study undertaken, Haasbroek *et al.* to determine the prevalence of overweight and obesity at Air Force Base Bloemfontein in Bloemfontein, found a prevalence of overweight and obesity of 38.6% and 36.1% respectively (Haasbroek *et al.*, 2022).

A study undertaken in an Army Support Base in Gauteng to assess the association between meaning in life and healthy eating, weight status and PA of the members of the SANDF at Lenz Military Base reported a 26.3% and 42.1% prevalence of overweight and obesity respectively in women and 31% and 35.7% in men (Ngoepe, 2019). The literature shows that in efforts to prevent and control obesity and related conditions among employees within its health centres, the SAMHS utilizes a multidisciplinary approach to provide comprehensive health care (Department of Defence, 2013). In addition, the SANDF makes provision for regular participation in sport and recreation as well as fitness testing in its Physical Training, Sport and Recreation Policy (South African Department of Defence, 2003).

Despite the provisions made for exercise, not all members complied. However, on evaluation, Ngoepe, 2019 found that fewer women (44%) than men (71.2%) participated in the recommended weekly physical activity.

2.4 Sociodemographic determinants of obesity

Obesity has changed from being viewed as a problem that only exists in high-income countries to one that is causing increasing concern in many of LMICs (World Heart Federation, 2016). This may be a result of nutrition transition with increased availability of energy dense food (obesogenic environment).

The obesogenic environment is characterised by increased access to unhealthy food and unavailability of healthy, sustainable food at locally affordable prices, and the absence of an adequate legal and regulatory environment (Abbafati *et al.*, 2020). These factors increase the risks of obesity in individuals, populations, and various settings (Abbafati *et al.*, 2020). In addition, the absence of an effective health system response to identify individuals with excess weight gain and fat deposition in their early stages results in progression to obesity in large number of individuals (Abbafati *et al.*, 2020).

Sub-Saharan Africa suffers from increased rates of malnutrition (both undernutrition and obesity) (WHO, 2016). Immediate variables contributing to the increase of overweight and obesity in SSA include increased caloric intake, physical inactivity, and heredity, while intermediate factors, such as occupation, cultural perceptions of weight, globalisation, and urbanisation, are also responsible (WHO, 2016). Ghana, Seychelles, and Swaziland have the highest prevalence of adult obesity, with 26.9%, followed by the Americas, Europe, and Eastern Mediterranean, with adult women three times more likely to be obese (WHO, 2016).

South Africa, an upper-middle-income country, is characterized by high poverty and unemployment rate (Bradshaw *et al.*, 2019). Obesity prevalence is linked to higher rates of NCDs, including T2DM, cardiovascular diseases, and hypertension, which pose significant threats to population health and development (Manafe, Chelule and Madiba, 2022). The WHO declared obesity an epidemic in 1997 due to the significant global consequences of its increasing prevalence (WHO, 2000). The prevalence of overweight and obesity has progressively grown over time in SA, from 56% in 2002 to 65% in 2012, with black African women living in urban townships and

certain rural areas being the most impacted (Otang-Mbeng, Otunola and Afolayan, 2017). According to Statistics South Africa (STATS SA) report of 2017, the South African Health Survey of 2016 revealed that, based on BMI score, 68% of women in SA are overweight or obese, 3% are underweight, and 30% are in the normal range. On the other hand, 31% men are overweight or obese, 10% are thin, and 59% are within the normal range (Statistics South Africa, 2017).

In SA, the issue of obesity may be perceived as less urgent due to the prevalence of infectious diseases (such as HIV/AIDS and tuberculosis), poverty, and undernutrition. However, the lives of numerous South Africans are adversely affected by obesity and its co-morbidities, and the resulting burden of disease contributes to the escalating cost of health care in both the private and state sectors (ACTION: African Centre for Obesity Prevention, 2021).

In SA, individuals who are 18 years of age and older, the age-standardized prevalence of obesity is 26.8% (World Health Organization, 2014). In 2016, the South Africa Demographic and Health Survey (SADHS) found that 20% of men and 27% of women who were 15 years or older were overweight (SADHS, 2016). Males 15 years and older who were obese had an obesity prevalence of 11%, while females had a prevalence of 41% (SADHS, 2016). In SA, more than 70% of adults over the age of 35 who are women and 45% of adults over the age of 35 who are men are overweight or obese (Bradshaw *et al.*, 2011). In SA, women are more likely than men to be overweight or obese (Bradshaw *et al.*, 2011). The South African National Health and Nutrition Examination Survey (SANHANES-1), undertaken in 2012, found that only 41.5% of the population had a healthy weight, while 7.5%, 22.3%, and 28.7% were underweight, overweight, and obese, respectively for both males and females (McHiza *et al.*, 2019). The study further found that the risk of obesity increased with age up to 65 years in both genders and that women have a lower proportion of underweight and healthy weight than men, (McHiza *et al.*, 2019).

The literature shows that there is urban-rural and gender differences in the rates of obesity. According to the World Obesity Federation (2019) 19.3% of adults living in rural areas were overweight and 6.8% were obese. In comparison to urban areas, 20.6% of adults were overweight and 13.3% were obese (World Obesity Federation, 2019). The SADHS in 2016, also found that black females (20.2%) are more obese than white females (14.5%) and the opposite was found in white males (14.1%) which were more obese than black males (2.1%) (SADHS, 2016). The Western Cape province had the highest obesity prevalence for females (14.4%), in comparison to

the North West having the highest obesity prevalence for males (5.0%) (SADHS, 2016). The highest income wealth quantile had the highest prevalence of obesity for both females (28.5%) and males (9.5%) (SADHS, 2016).

2.5 Causes of overweight and obesity

Numerous factors, such as genetic, demographic, and lifestyle factors, all have an impact on obesity, which is a complex disorder. Obesity-related lifestyle factors including physical inactivity, poor eating habits, smoking, and alcohol overconsumption may often be changed (modifiable risk factors), while genetic and demographic factors like age, ethnicity, sex, and family history of obesity cannot (non-modifiable risk factors) (Al-Hazzaa *et al.*, 2012).

2.5.1 Unhealthy food choices

Increased consumption of high-fat and high-sugar foods, increased consumption of highly refined and processed foods, decreased consumption of fruits, vegetables, seeds, and legumes, and enhanced sedentary lifestyles (ACTION: African Centre for Obesity Prevention, 2021).

In a cross-sectional study conducted in Bloemfontein, SA on 58 ADMP diagnosed with obesity five factors were identified as obstacles to the development of healthy eating habits: an excessive appetite, difficulty managing appetites, difficulty maintaining motivation, the perception that healthy food is costly, and a lack of willpower (Alcock and Wolvaardt, 2023).

2.5.2 Physical inactivity

Physical inactivity is classified as less than 600 MET minutes of activity per week (WHO, 2016). Physical inactivity is a major risk factor for worldwide mortality, causing 3.2 million deaths and 69.3 million DALYs. The WHO recommends 150 minutes of moderate-intensity activity per week to reduce heart attacks and strokes (WHO, 2014). The prevalence of physical inactivity is highest in the Americas region (32%) and East Mediterranean region (31%) (World Health Organization, 2014). Females are less PA than men, and PA decreases with increased income per country (World Health Organization, 2014). Insufficient levels of PA are responsible for approximately \$117 billion in healthcare expenses each year (Obesity Medicine Association, 2020). The countries in SSA with the highest prevalence of physical inactivity in both genders are Mali (59%), Mauritania (51%) and Cameroon (44%) (WHO, 2016). Females had the highest prevalence of physical

inactivity in Mali (66%) and Mauritania (53%) (WHO, 2016). The age-standardized prevalence for physical inactivity in adults 18 years and older in SA are (46.9%), which is higher than the Americas (32%) and East Mediterranean (31%) regions but lower in comparison to the SSA country Mali (59%) and Mauritania (51%) (World Health Organization, 2014; WHO, 2016). The prevalence of physical inactivity in SA for males is 48% and is even higher among females (63%) (Bradshaw *et al.*, 2011). This magnifies the need to improve physical activity since it is an important factor to induce energy expenditure a strong contributor to energy balance, weight maintenance, and obesity prevention (World Health Organization, 2014).

South Africa has a lower prevalence of physical inactivity than the SSA country Mali (66%), but higher than Mauritania (53%) (WHO, 2016). According to Haasbroek *et al.*, (2022) 35.5% members of the SAAF who are obese engage in moderate physical activity, but the prevalence of physical inactivity in this group is not known. Similarly, physical inactivity prevalence among the SAN is not known, hence the need for the current research. Physical inactivity is a frequently targeted intervention to improve the weight status of individuals since it is one of the key causes to the obesity epidemic globally, even though it is easily modifiable at the individual level (Gray *et al.*, 2018). In 2015, a study conducted in the Eastern Cape, SA, found that the prevalence of overweight and obesity was significantly greater among sedentary individuals (Otang-Mbeng, Otunola and Afolayan, 2017). Sedentary behaviour is described as any activity that does not increase energy expenditure much above a resting level, such as sleeping, sitting, and laying down, and is frequently measured as leisure "screen time" such as watching television, films, or the computer (Otang-Mbeng, Otunola and Afolayan, 2017). In this study, a negative correlation was identified between physical activity, and overweight and obesity (Otang-Mbeng, Otunola and Afolayan, 2017) also allude to the fact that lack of exercise is a strong risk factor for obesity and overweight, particularly among teenagers and young adults. Physical activity is not only a matter of personal choice, but also a function of the built environment (Ferdinand *et al.*, 2012). The built environment refers to the collective availability of sidewalks, parks, trails, recreational facilities, traffic safety, and other neighbourhood characteristics that promote recreational PA as well as active transport to work, school, or errands (Ferdinand *et al.*, 2012). There is also evidence that low-income neighbourhoods and minority communities have less access to recreational facilities and that the quality of the facilities available to them is lower. Consequently, changing constructed

surroundings to be more physically active-friendly is often supported as a means of creating healthier and less obese populations (Ferdinand *et al.*, 2012).

The five barriers to PA that were identified were a lack of willpower to initiate physical activity, social activities that do not involve physical activity, a lack of physical training centres and shower facilities at work, no motivation to adhere to a healthy food plan, and overcommitment (Alcock and Wolvaardt, 2023). According to Alcock and Wolvaardt (2023) study found that 43% of the participants reported that their respective units had a gymnasium or exercise facility, even though 19% of respondents reported that they had access to these facilities, only 16% were permitted to exercise during their workday. This indicated that the availability of exercise facilities does not necessarily imply that they are accessible. In the same way, the ability to exercise does not necessarily equate to the availability of time to do so during a workday. In this study, physical exercise is significantly associated with accessibility and opportunity (Alcock and Wolvaardt, 2023).

2.6 Physical fitness in military populations

The health and fitness of military personnel is critical in assessing their ability to successfully execute operational tasks and to recover adequately from both acute and long-term physiological and psychological duress associated with the military environment (Vaara, 2017).

Assessment of PF is therefore done on a regular basis with the purpose of encouraging year-round physical conditioning, and increased productivity, reduced absenteeism, and optimised readiness (Turner, Wagner and Langhals, 2022). In a study that evaluated the fitness of service members in the U.S. Air Force in 2021, found that several Airmen in the dataset are obese. A large percent (82%) of female Airmen was obese, and 51% of female Airmen failed the FT, 60% of Airmen were obese, but only 30% of Airmen failed the FT overall (Turner, Wagner and Langhals, 2022). The literature shows that members of the U.S. Army Reserve, the Army National Guard, and soldiers over the age of 45 also experience reduced pass rates (RAND, 2022).

In SA, most studies assessed the outcome of PF among young military recruits. Some assessed the PF outcomes post physical training interventions. There is limited literature showing the PF outcomes of total military populations within the SANDF. Hence, the objective is to determine what the physical fitness outcomes are among SAN personnel.

2.7 Effects of obesity on the individual, family, health services and South Africa

Excessive fat accumulation in the body is linked to cardiovascular disease, T2DM, osteoarthritis, and several cancers, which pose serious health risks to overweight or obese individuals (WHO, 2013). These disorders cause early mortality and severe disability, and result in more than three million deaths annually worldwide (WHO, 2013; Djalalinia *et al.*, 2015). The number of years that patients experience obesity-related illness and disability will increase as the prevalence of obesity rises (Djalalinia *et al.*, 2015). Obesity is strongly associated with the development of chronic medical disorders, a decrease in quality of life related to health, and a rise in medical and drug costs (Djalalinia *et al.*, 2015). This can lead to an increase in absenteeism from work, lower productivity which can result in lower wages and impact the mental health of individuals (Okunogbe *et al.*, 2021). Low socioeconomic status directly impacts families, which can cause food shortages and leads to cheaper foods being bought and increases the risk of adopting unhealthy diets causing overweight and obesity (Goetjes *et al.*, 2021). There are huge economic consequences of the obesity epidemic, and if no action is taken, the global costs of overweight and obesity are expected to exceed US\$ 18 trillion by 2060 and reach US\$ 3 trillion annually by 2030 (Okunogbe *et al.*, 2022). In 2020, the cost of overweight and obesity in South Africa was ZAR33,194 million, which accounted for 15.38% of government health expenditures and 0.67% of the gross domestic product (GDP). This cost was predominantly related to cardiovascular and endocrine illnesses, particularly hypertension and diabetes. The reason for this is that these conditions are exceedingly prevalent, and BMI is highly predictive of their occurrence (Boachie *et al.*, 2022). Hospitalization is a significant cost driver, with hypertensive disorders and diabetes being among the top 10 causes of mortality in SA incurring enormous costs to government due to these diseases (Boachie *et al.*, 2022). The 67% rise in DALYs attributable to NCDs in SSA between 1990 and 2017 places an enormous strain on a health system already battling to combat infectious illnesses (Boachie *et al.*, 2022). In 2017, 9.4 million DALYs were attributable to NCDs in SA, and factors such as overweight and obesity have been identified as key causes (Boachie *et al.*, 2022).

2.8 The effect body size on physical fitness

Physical activity encompasses all bodily movements generated by skeletal muscles that require energy, while PF is a quantifiable condition, such as strength or endurance (Obesity Medicine

Association, 2020). Exercise is a deliberate form of PA that aims to enhance PF and promote good health. Physical fitness is categorised into five distinct areas: cardiovascular endurance, muscular strength, muscular endurance, flexibility, and body composition (Obesity Medicine Association, 2020). The American College of Sports Medicine (ACSM) is widely recognised as the benchmark for exercise recommendations in the industry. The guidelines suggest that individuals who are in good health and between the ages of 18 and 65 should engage in aerobic exercise of moderate intensity for a minimum of 30 minutes per session, five days per week (ASCM, 2018). Alternatively, they can participate in aerobic exercise of vigorous intensity for at least 20 minutes per session, three days per week. Moreover, it is crucial for all adults to engage in activities that maintain or enhance their muscular strength and endurance, allocating at least two days per week for this purpose (ASCM, 2018). Excess weight creates more resistance during athletic movement. This requires the individual to exert more muscle force to perform the same amount of work. Excess adipose tissue can impair endurance, balance, coordination, and mobility. Excessive body mass and fat can have a detrimental impact on joint range of motion. Additionally, excess body mass can create a physical obstacle that hinders complete joint movement (Kinetic Select, 2017). Enhancing lean body mass promotes the development of strength and power. Muscle size is directly correlated with strength and power. Therefore, an increase in lean body mass empowers the individual to produce a greater amount of force within a designated timeframe. Having an adequate amount of lean body mass is also a contributing factor to one's speed, quickness, and agility performance. Decreasing body fat enhances the development of muscular and cardiorespiratory endurance, speed, and agility (Kinetic Select, 2017).

Existing literature extensively examined the correlation between PA and body composition, with a particular emphasis on children, adolescents, and individuals with obesity (Kochman *et al.*, 2022). Therefore, there are few studies that investigated the association between physical fitness and body size among adults. According to Schilling *et al.*, (2023) PA is linked to reduced obesity rates and weight loss in adults ranging from 18 to 85 years of age. Consequently, PA has a substantial influence on health and acts as a protection against the onset of numerous NCDs. A longitudinal study that examined the relationship between different types of daily life PA and PF and health throughout adulthood found a positive relationship between habitual activity and PF and physical health status (Schmidt *et al.*, 2017). There is a strong correlation between having a

higher body weight and higher BMI and having a lower level of activity and poorer physical fitness (Gadde *et al.*, 2018).

2.9 The drivers of overweight and obesity include:

2.9.1 The Nutrition Transition

The nutrition transition, first characterised by Popkin (2015) is the result of large dietary shifts toward higher refined carbs, added sugars, edible oils, and animal-source foods, and decreased consumption of fruits, vegetables, and legumes (Nel and Steyn, 2022). Economic expansion, urbanization, and increased consumption of ultra-processed foods, also known as fractionated whole foods, have led to a rise in consumption of these foods, often containing cosmetic additives (Nel and Steyn, 2022). Ultra-processed meals, including soft beverages, snacks, and packaged foods, have been linked to health issues like obesity, diabetes, cardiovascular diseases, irritable bowel syndrome, cancer, depression, and overall mortality (Nel and Steyn, 2022).

2.9.2 Culture

Obesity is influenced by environmental and individual factors, with high-calorie consumption linked to metropolitan regions adopting western lifestyles, contributing to the growing prevalence of overweight and obesity (Manafe, Chelule and Madiba, 2022). Cultural views and aspirations in Africa contribute to the rise in overweight and obesity, often promoting the belief that thinness symbolizes poverty and poor health (Manafe, Chelule and Madiba, 2022). Obesity, often linked to happiness, can become an obesogenic factor, leading to comfort eating and weight gain. Countries like South Africa, Morocco, and the U.S. view overweight as desirable and healthy (Manafe, Chelule and Madiba, 2022). In African settings, myths suggest that post-childbirth, mothers are encouraged to eat more for their own and child's health, leading to excessive weight gain and obesity (Manafe, Chelule and Madiba, 2022). Regional studies show moderately overweight women in South Africa are attractive and associated with respect, dignity, and wealth, while black women sometimes associate slimness with illness, including HIV/AIDS (Kruger *et al.*, 2005).

2.9.3 Globalization

Globalization is primarily influenced by Western culture, which promotes the Western ideal of beauty through advertising, mass media, and entertainment (Zhou, 2021). Globalization can

increase energy usage and expenditure by increasing the consumption of calorie-dense ultra-processed foods and promoting lifestyles with reduced energy expenditure, such as car usage and indoor activities (Zhou, 2021). Globalization and the rapid adoption of Western dietary habits lead to increased consumption of energy-dense foods like meat and soft drinks and a decrease in fruits and vegetables, as seen in underserved regions (Adeniyi, Longo-Mbenza and Ter Goon, 2015). The South African obesity pandemic is largely due to globalization, driven by dietary shifts from traditional low-fat, high-fibre diets to saturated fat, refined foods (Govender and Sunnasy, 2025). Urbanization leads to lifestyle changes, physical inactivity, and increased access to tobacco and high-fat foods, which are risk factors for non-communicable diseases (Govender and Sunnasy, 2025). Migrants frequently live in informal urban settlements, which greatly influence how they prepare, consume, and maintain the hygiene of their food. (Govender and Sunnasy, 2025).

2.10 Conclusion

Obesity is a global health problem and is a significant risk factor for NCDs. A strong correlation exists between body size and WC; however, WC is a greater predictor for disease risk than BMI. There is no SA guideline on workplace prevention of NCDs, suggesting a need for a local evidence-based guideline in this area. Therefore, special consideration should be given to multicomponent programs that integrate healthy food and physical activity into employees' daily routines. Obesity is a growing concern in low-income countries, with healthcare systems and professionals struggling to effectively manage and treat the issue. South Africa is predicted to experience a significant increase in obesity rates, from 2010 with females experiencing a predicted 46.7% increase and males experiencing a 23.3% increase by 2025.

Previous studies have primarily focused on children, adolescents, and obesity, but there is a lack of research on the relationship between physical fitness and body size among adults in the SAN population. Therefore, this study is anticipated to significantly enhance research in this field as a form of partly influencing policies directed at endorsing the prevention and management of obesity in the SAN population. The subsequent section provides an overview of the study's methodology, detailing the approach used to conduct the study.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter provides a detailed account of the research methodology which was employed. The study's processes, data collection instruments, and methodologies of participant selection are all delineated. Subsequently, the ethical considerations of the study are outlined, followed by a description of the data analysis methods and the methods used to ensure validity and reliability.

3.2 Research setting

The Institute for Maritime Medicine is a military outpatient healthcare facility (sickbay), based in Simon's Town and is responsible for shipboard support, diving medicine, submarine medicine, training, research and development and primary health services (Department of Defence, 2024). The sickbay is a specialist unit of the SAMHS which delivers healthcare services to naval members and their dependents. The SAN has a total population of 6500 personnel and 1000 reserve force members, with 4500 naval personnel located at Naval Base Simon's Town (NBS). This study included a sample of NBS personnel which consists of males and females who are commissioned and non-commissioned officers, ranging from 18 – 60 years old. The SANDF comprises both commissioned and non-commissioned officers. Commissioned officers undergo formal training, while non-commissioned officers advance through the ranks based on their experience and proven abilities. The majority of the NBS personnel works ashore (shore-based units) with an estimated 675 members staffed onboard ships and submarines. The sickbay is located along the False Bay coast in a semi-urban area in Simon's Town, which is about 40 kilometres outside Cape Town, in the Western Cape province in SA. The study was conducted at IMM on NBS members presenting for their Comprehensive Health Assessment and FT.

3.3 Study Design

A retrospective longitudinal study design was conducted. A retrospective study design are snapshots of a specific population at a single point in time (Varkevisser, Pathmanathan and Brownlee, 2003). In retrospective studies, the outcome of interest has already occurred (or not

occurred – e.g., in controls) in each individual by the time s/he is enrolled, and the data was collected either from records or by asking participants to recall exposures (Thomas, 2020). A retrospective longitudinal study is the most appropriate research design because the researcher is using already existing data and seeks to continually examine the same individuals to discover any changes in outcomes that may occur over time (Varkevisser, Pathmanathan and Brownlee, 2003; Thomas, 2020). Two similar studies conducted in SA, investigated the relationship between body composition and PF in children and adolescents (Armstrong, Lambert and Lambert, 2017; Toriola, Monyeki and Toriola, 2015).

3.4 Study population and sampling procedures

The study population included all adult (18 – 60 years old) males and females working in the SAN, who presented with a CHA at the IMM and a FT at NBS from 2018-2023. Therefore, only participants that had data for both CHAs and FT were included for this study over the specified time frame. This period was chosen because existing data was available for SAN personnel which presented a CHA at IMM and FT at NBS between 2018-2023. Only retrospective baseline measurements for CHAs and FT that have already been collected and conducted in 2018, 2019, 2022 and 2023 at IMM and NBS were utilized. Therefore, we were interested to see the changes in body size and PF of the SAN personnel before and after the 2020/2021 COVID-19 country lockdown period, when SA adopted the unique international measures that allowed citizens to stay away from areas of work and where there are group gatherings to prevent the spread of COVID-19 infections. During 2020/2021, no or few CHAs and FT were done; hence no data during these two years will be presented. Moreover, we are also curious to know whether this period affected the SAN personnel's body size and PF, since like the other SA citizens, the SAN personnel were not active during this time and might have adopted unhealthy behaviours to cope with the COVID-19 related stress that might have resulted in them having unhealthy body size statuses and became physically unfit. However, 7267 SAN personnel, of which an estimated 88.3% has presented in more than one CHA at the IMM and a FT at NBS between 2018-2023.

Inclusion Criteria

- The study population included 2428 adults (18 – 60 years old), males and females working in the SAN. The total number of participants (2428) is based on the total number of CHAs and FT done in 2018, 2019, 2022 and 2023, and is the total (maximum) sample size. The

total sample (2428) CHAs and FT conducted at IMM and NBS between 2018 – 2023 (excluding 2020/2021) have been extracted and confirmed by the health informatics system (HIS)

- All naval members who participated in a CHA at the IMM and a FT at NBS before and after the 2020/2021 COVID-19 pandemic
- Fitness test results of members that completed all components of the battery test and had a pass or fail outcome

Exclusion Criteria

- Because 18yrs is the age for employment qualification and 60yrs is the retirement age at SAN, the exclusion criteria were participants who were younger than 18 years and above 60 years of age
- Pregnant women as anthropometric measurements and FT was distorted
- Fitness tests that were not performed because of medical reasons, members on course or did not arrive for their scheduled FT
- Naval members who have conducted a CHA at other units outside of IMM and a FT outside of NBS

3.5 Data collection procedure

Existing data was extracted from the SAMHS HIS, patient files, and routine information generated at the CHAs, and FT data was extracted from the SAN T-drive, which is a central server used to access shared files and resources. Data for CHAs and FT was already collected at previous CHAs and FT conducted in 2018, 2019, 2022 and 2023. The data for measurements and FT was analysed for each year and compared to a pre-COVID (2018-2019) and post-COVID period (2022-2023).

Advantages

- Data has already been collected, allowing for a relatively rapid and cost-effective study.
- The sample size can be considerably larger than that of primary research often due to resource constraints, therefore the broader selection of data.

3.5.1 Sociodemographic factors

- Age, gender and workplace data have been collected at CHAs and FT that were conducted

before and after the 2020/2021 COVID-19 pandemic. Age has been categorized into four categories: (18-25; 26-35; 36-45; 46-60) and gender categorized into male and female. Workplace units were divided into two groups, shore based, and offshore units as shown in Table 3.1:

Table 3.1 South African Navy workplace units

Shore based units	Offshore units
FLEET COMMAND HEAD QUATERS	SAS SPIOENKOP
FLEET LOGISTICS DIVISION	SAS ISANDLWANA
FLEET HUMAN RESOURCES DIVISION	SAS AMATOLA
FLEET QUALITY ASSURANCE DIVISION	SAS MENDI
NAVAL BASE DURBAN	SAS DRAKENSBERG
NAVAL ENGINEERING SERVICES	SAS PROTEA
NAVAL BASE SIMON'S TOWN	SAS MANTHATISI
NAVAL STAFF COLLEGE	SAS QUEEN MODJADJI
SA NAVAL COLLEGE	SAS CHARLOTTE MAXEKE
SA NAVAL ARMOURMENT DEPOT	SAS UMHLOTI
FLEET MAINTENANCE UNIT	SAS UMZIMKULU
NAVAL PUBLICATIONS UNIT	SAS SEKHUKHUNE
SAS WINGFIELD	SAS KING SHAKA
NAVAL SUPPLY DEPOT WINGFIELD	
NAVAL STATION PORT ELIZABETH	
SAS SIMONSBERG	
DIVISION FLEET FORCE PREPARATION	
MARITIME REACTION SQUADRON	

3.5.2 Anthropometry data collection

Anthropometric data for weight, height, WC, and hip circumference was already collected at previous CHAs conducted in 2018, 2019, 2022 and 2023. Only weight and height data was used

to calculate the BMI for this study, and the following protocol was applied:

Weight

The weight was measured in kg using a calibrated scale. The mechanical column scale Seca 786 with stadiometer Seca 224, is a large round dial, with a maximum capacity of 150kg and 500kg graduation, made in Germany.

Height

The height was measured using the stadiometer with a sliding headpiece. The stadiometer was placed on an even, uncarpeted surface. The participants were asked to remove their shoes and stood with their heels together, arms to the side, legs straight, shoulders relaxed, and head in the Frankfort horizontal plane. Shoulder blades, buttocks, and heels was touching the measuring rod, and the sliding headpiece was held in place to take the reading (World Health Organisation (WHO), 2008).

Body mass index

Data for BMI has already been collected at previous CHAs conducted in 2018, 2019, 2022 and 2023 and the following protocol was applied: BMI was calculated using weight and height. The following formula was used to calculate $BMI = \text{weight (kg)} / [\text{height (m)}]^2$. Body mass index data was already calculated and extracted from the existing data and was categorized according to the following classifications and cutoff points: underweight ($< 18.5 \text{ kg/m}^2$), normal weight ($18.5 \text{ kg/m}^2 - 24.9 \text{ kg/m}^2$), overweight ($\geq 25 \text{ kg/m}^2 - 29.9 \text{ kg/m}^2$) and obese ($\geq 30 \text{ kg/m}^2$) (Centers for Disease Control and Prevention, 2022).

3.5.3 Measurement of physical fitness

The SANDF standardised FT consists of a cardiorespiratory component (2.4 km run and 4 km walk), muscular endurance component (2 min sit-ups and 2 min push-ups), and a speed component (10 x 25m shuttle runs) (South African Department of Defence, 2003). Minimum and maximum points achieved in each component have been allocated according to age and gender. Data for FT has already been collected at FT conducted in 2018, 2019, 2022 and 2023 and the following protocol was applied: The 2.4 km running test was executed as the first component of the battery test. The last component of the battery test was the 4 km walking test. Participants were given a maximum rest period of 15 minutes but not less than 10 minutes after the 2.4 km running test. A minimum rest period of two minutes between other components was allowed.

3.6 Data analysis

Once data was de-identified, it was extracted using the Excel spreadsheet which documented each year that data was collected and sorted based on the desired variables, which included age, gender, workplace units, BMI, and outcomes of FT (pass or failure). Only retrospective baseline measurements for CHAs and FT that have already been collected and conducted in 2018, 2019, 2022 and 2023 at IMM and NBS were utilized. The data was processed by categorizing; coding; and summarizing it (Varkevisser, Pathmanathan and Brownlee, 2003). Variables of this study involved, for example, using the raw data/actual outcome for BMI and categorized according to the following BMI classifications: Underweight ($<18.5 \text{ kg/m}^2$); Normal ($18.5 -24.9 \text{ kg/m}^2$); Overweight ($25-29.9 \text{ kg/m}^2$); Obese $\geq 30 \text{ kg/m}^2$ (Vaamonde and Álvarez-Món, 2020). Fitness test standards and pass requirements were as follows: Points were allocated to the performance level (time achieved and number of repetitions achieved) per component. A member passed a component if 600 points were achieved. A member passed the battery test if the following points were achieved, which was the sum-total of points achieved for all the components: i. Age Group up to 34 Years (Male and Female): 3 000 points. ii. Age Group 35 to 44 Years (Male and Female): 3 000 points. iii. Age Group 45 to 54 Years (Male): 2 400 points. iv. Age Group 45 to 54 Years (Female): 1 800 points. v. Age Group 55 Years and Older (Male and Female): 1 800 points. Points that were allocated as less than the pass requirements, were determined as a failed FT (FFT). The overall fitness test outcomes were considered for the study, as a FFT and passed FT (PFT). Data was analysed using the Stata Statistical package whereby descriptive data analysis was conducted to show group differences based on proportion/prevalence, means and standard deviations (for normally distributed data), chi-squared test and logistic regression analysis was conducted to show associations between factors. P values that are <0.05 and CI that do not overlap showed significant differences between groups. Furthermore, the trends of outcomes collected at each time point (2018, 2019, 2022, 2023) were observed and a paired t-test analyses were conducted for age, gender, workplace units, BMI, and outcomes of PF. This test determined if differences existed between groups according to age, gender, workplace units, BMI, and outcomes of PF (dependent variables). This test also determined whether the differences between these two groups were statistically significant.

3.7 Validity and reliability

No selection bias was expected as all the available data in the databases indicated above was included and analysed retrospectively. Information bias might be present, as anthropometric measurements were already collected before the extraction of data. Measurement bias was minimized by using validated instruments, data collected by trained health service providers, and the protocols for data collection were followed and consistent for both the CHA at IMM and the FT at NBS.

3.8 Ethical considerations

Ethics approval to conduct the study was obtained from the Biomedical Research Ethics Committee (BMREC) of University of the Western Cape (UWC) (Appendix I). Permission to conduct the research study at IMM and access data, was sought from 1 Military Hospital Research Ethics Committee (1MHREC) (Appendix II), the Officer Commanding of IMM (Appendix III) and Defence Intelligence (Appendix IV). Moreover, the current research followed the ethics principles outlined in the Department of Health Ethics in Health Research Principles (2015) policy document. Data was managed according to the POPIA ACT. No consent was sought from participants, given that this is a retrospective study. In fact, there was no direct contact with patients. However, all data was treated with total confidentiality. Records were accessed only at the IMM onsite and at times convenient for the facility. All data was de-identified and anonymized by the researcher at the facility using study codes on data documents. A separate document that links the study codes to patients' identifiers was stored separately from the data collection documents. Access to patient-identifying data, apart from the facility data managers and custodians (the healthcare providers who manage the onsite patient files), was restricted to the researcher, supervisor, and co-supervisor. Data was electronic in nature and will be stored for 10 years in a password-protected electronic file on the primary researcher's computer at work located at IMM. Data can be accessed by 1MHREC upon request via lotus notes. Once the study has been concluded, the results will be communicated to the IMM, Defence Intelligence and 1MHREC. No patient or facility details were used during outcome reporting (i.e., thesis document writing, technical report writing and respective article publications), and thus, the identities of the patients will be protected. The results of the study will be disseminated to the Officer Commanding of

IMM, Defence Intelligence and 1 Military Hospital Research Ethics Committee and permission will be sought from 1MHREC and Defence Intelligence before publishing.

3.9 Conclusion

This chapter provided a comprehensive description of the research methodology employed to conduct the study. In the subsequent chapter of the study, the findings are described and interpreted.

CHAPTER 4

RESULTS

4.1 Introduction

This chapter presents the current study's outcomes, which are interpreted considering the current study's objectives. The first section outlines the sociodemographic characteristics of the SAN personnel, in this case, the age, gender, and work setting [presented as shore and offshore units]. The second section presents SAN personnel's overall BMI and PF outcomes and their sociodemographic characteristics. The third section presents the association between BMI and PF. The fourth section presents the changes in BMI and FT over 4 years. The fifth and final section presents outcomes on the factors that seem to influence FT over 4 years.

4.2 Sociodemographic information

4.2.1 Sociodemographic characteristics of the South African naval personnel

The sociodemographic information of the study sample includes age, gender, and workplace units, (SAN units) which are shore and offshore units. Table 4.1 shows that between 2018 and 2023 there were 2428 SAN personnel who had comprehensive health assessments including body size (BMI) and physical FT measurements. Of these SAN personnel, the majority (58.48%) were based at the offshore units; while the rest were based at the shore units (41.52%), and these proportions were significantly different ($p=0.000$). Among these SAN personnel, 232, 932, 776, and 494 had their comprehensive health assessment undertaken in 2018, 2019, 2022 and 2023, respectively. A similar pattern was seen among these groups where among the SAN personnel who had comprehensive health assessment in 2019, 2022, and 2023, there were more personnel who were based at offshore units than at shore units, except for those having comprehensive health assessment in 2018, where the majority were based at the shore units.

Most of the SAN personnel (58%) in all the respective years were within the age group 26-35 years. The majority of the younger age groups 18-25 (53.57%, 73.50%, 78.22%, 69.15%) and 26-35 (52.35%, 60.92%, 65.63%, 63.91%) were based at offshore units, while the majority of the older age groups 36-45 (66.67%, 57.40%, 52.38%) and 46-60 (73.68%, 76.67%, 56.06%, 69.57%) were based at shore units in all the respective years. The exception was that SAN personnel

measured in 2022, with a significantly larger proportion of 36–45-year-old personnel based at the offshore units (58.39%). Overall, the difference in age groups working at the shore versus the offshore units was significant (all p values were = 0.043, 0.000, 0.000, 0.000). The majority of those who participated in the study were males (73.99%) based at the offshore units in all the respective years except for the SAN personnel measured in 2018. There was no significant pattern for females in terms of being based at the shore / offshore units over the 4 years.

Table 4.1: Study sample distribution by age, gender and South African Navy units

Socio-demography		2018			2019			2022			2023			Combined Total 2018-2023		
		Shore n (%) [CI]	Offshore n (%) [CI]	Total	Shore n (%) [CI]	Offshore n (%) [CI]	Total	Shore n (%) [CI]	Offshore n (%) [CI]	Total	Shore n (%) [CI]	Offshore n (%) [CI]	Total	Shore n (%) [CI]	Offshore n (%) [CI]	Total
Overall Total	SAN	122 (52.59) [.464- .646]	110 (47.41) [.535- .708]	232 (100)	403 (43.24) [.264-.352]	529 (56.76) [.735- .807]	932 (100)	280 (36.08) [.217-.308]	496 (63.92) [.782-.852]	776 (100)	205 (41.50) [.308-.408]	289 (58.50) [.691-.776]	494 (100)	1008 (41.52) [.285- .336]	1420 (58.48) [.714-.760]	2428 (100)
Age (yrs)	18-25	13 (46.43) [.464- .646]	15 (53.57) [.535- .708]	28 (12.07)	31 (26.50) [.264-.352]	86 (73.50) [.735- .807]	117 (12.55)	22 (21.78) [.217-.308]	79 (78.22) [.782-.852]	101 (13.02)	29 (30.85) [.308-.408]	65 (69.15) [.691-.776]	94 (19.03)	95 (28.02) [.285- .336]	244 (71.98) [.714-.760]	339 (13.96)
	26-35	71 (47.65) [.476- .557]	78 (52.35) [.523- .602]	149 (64.22)	229 (39.08) [.390-.430]	357 (60.92) [.609- .647]	586 (62.87)	154 (34.38) [.343-.389]	294 (65.63) [.656-.698]	448 (57.73)	83 (36.09) [.360-.425]	147 (63.91) [.639-.698]	230 (46.56)	537 (38.06) [.394- .420]	874 (61.94) [.605- .631]	1411 (58.11)
	36-45	24 (66.67) [.666- .800]	12 (33.33) [.333- .500]	36 (15.52)	97 (57.40) [.573-.646]	72 (42.60) [.426- .501]	169 (18.13)	67 (41.61) [.416-.493]	94 (58.39) [.583-.657]	161 (20.75)	77 (52.38) [.523-.603]	70 (47.62) [.476-.557]	147 (29.76)	263 (51.47) [.518- .562]	248 (48.53) [.481- .524]	511 (21.05)
	46-60	14 (73.68) [.736- .886]	5 (26.32) [.263-.499]	19 (8.19)	46 (76.67) [.766- .856]	14 (23.33) [.233-.356]	60 (6.43)	37 (56.06) [.560-.674]	29 (43.94) [.439-.560]	66 (8.51)	16 (69.57) [.695-.847]	7 (30.43) [.304-.515]	23 (4.66)	113 (67.66) [.693-.759]	54 (32.34) [.306- .381]	167 (6.87)
Chi square test		chi2(3) = 8.1360 P = 0.043			chi2(3) = 58.6156 P = 0.000			chi2(3) = 23.0805 P = 0.000			chi2(3) = 21.7979 P = 0.000			chi2(3) = 100.2378 P = 0.000		
Overall Total		122 (62.56)	73 (37.44)	195 (100)	399 (43.61)	516 (56.39)	915 (100)	279 (36.95)	476 (63.05)	755 (100)	204 (41.63)	286 (58.36)	490 (100)	1002 (42.66)	1347 (57.34)	2349 (100)
Gender	Male	76 (56.30) [.562-.644]	59 (43.70) [.437-.522]	135 (69.23)	301 (75.44) [.425- .461]	407 (78.88) [.574- .610]	708 (77.38)	201 (72.04) [.343-.383]	384 (80.67) [.656-.693]	585 (77.48)	116 (56.86) [.368-.423]	199 (69.58) [.631-.683]	315 (64.29)	693 (69.16) [.398- .421]	1045 (77.58) [.601- .624]	1738 (73.99)
	Female	46 (76.67) [.766-857]	14 (23.33) [.233-.357]	60 (30.77)	98 (24.56) [.473-.541]	109 (21.12) [.526-.593]	207 (22.62)	78 (27.96) [.458-.534]	92 (19.33) [.541-.614]	170 (22.52)	88 (43.14) [.502-.576]	87 (30.42) [.497-.570]	175 (35.71)	309 (30.84) [.505-.545]	302 (22.42) [.494- .533]	611 (26.01)
Chi-Square Test		chi2(1) = 7.3593 P = 0.007			chi2(1) = 1.5188 P = 0.218			chi2(1) = 7.5076 P = 0.006			chi2(1) = 8.3880 P = 0.004			chi2(1) = 21.1572 P = 0.000		

CI: confidence intervals, %: percentages, n: count

4.2.2 Body size and physical fitness of the South African Naval personnel and sociodemographic characteristics

Table 4.2 shows that from 2018 to 2023, there were 2349 SAN personnel who had BMI values collected. There was significantly more SAN personnel based at the offshore units than those based at the shore unit (i.e. 57.34% vs 42.66%, $p=0.002$). Of these a total of 232, 932, 776, and 494 were measured in 2018, 2019, 2022, and 2023, respectively from both shore and offshore units. There were more SAN personnel based at offshore units that were measured during 2019, 2022, and 2023. However, there were significantly more SAN personnel based at offshore units in 2023 than at shore units (i.e. 58.50% vs 41.50%, $p=0.050$).

Overall, the majority (43.04%) of the SAN personnel were overweight, followed by those who were of normal weight (34.14%) and obese (22.14%). There were significantly more SAN personnel who were overweight and obese at the offshore units compared to those at the shore units (25.67% and 11.20% vs 17.37% and 10.94%, $p=0.002$, respectively). This pattern was similar in 2023 where the differences were significant (25.10% and 13.97% vs 13.16 and 13.77%, $p=0.050$).

Moreover, overall, the mean BMI of the naval personnel was $26.96 \pm 7.01 \text{ kg/m}^2$ (BMI \pm SD). Despite most overweight and obese SAN personnel being based at offshore units the overall mean BMI was significantly higher at the shore units when compared to the offshore units (Mean \pm SD = $27.24 \pm 5.00 \text{ kg/m}^2$ vs $26.75 \pm 8.13 \text{ kg/m}^2$). This pattern was observed within all the respective years.

Table 4.2: Distribution of Body Mass Index of SA Naval personnel by work units

		2018 n (%)			2019 n (%) (CI)			2022 n (%) (CI)			2023 n (%) (CI)			Combined Total (2018-2023) n (%) (CI)		
		Shore n (%) (CI)	Off-Shore n (%) (CI)	Total	Shore n (%) (CI)	Off-Shore n (%) (CI)	Total	Shore n (%) (CI)	Off-Shore n (%) (CI)	Total	Shore n (%) (CI)	Off-Shore n (%) (CI)	Total	Shore n (%) (CI)	Off-Shore n (%) (CI)	Total
BMI n (%) (CI)	Underweight	1 (0.43) [.008-.056]	1 (0.43) [.009-.062]	2 (0.86) 18.35 ±0.77	1 (0.11) [.002-.017]	5 (0.54) [009-.022]	6 (0.64) 17.42 ±.404	0 [0]	6 (0.77) [.012-.026]	6 (0.77) 17.5 ±1.02	3 (0.61) [.014-.044]	4 (0.81) [.013-.036]	7 (1.42) 15.97 ±3.54	4 (0.17) [.003-.010]	12 (0.51) [.008-.015]	16 (0.68) 16.22 ±4.23
	Normal weight	48 (20.69) [.393-.483]	50 (21.55) [.454-.548]	98 (42.24) [22.75 ±1.33]	150 (16.09) [.372-.420]	213 (22.85) [.402-.445]	363 (38.95) 22.48 ±1.69	92 (11.86) [.328-.385]	187 (24.10) [.377-.420]	279 (35.95) 22.36 ±1.67	69 (13.97) [.336-.404]	92 (18.62) [.318-.374]	161 (32.59) 22.61 ±1.76	333 (14.18) [.332-.362]	469 (19.97) [.348-.374]	802 (34.14) 22.43 ±1.79
	Overweight	44 (18.97) [.360-.449]	40 (17.24) [.363-.457]	84 (36.21) [27.64 ±1.46]	166 (17.81) [.411-.364]	223 (23.93) [.421-.464]	389 (41.74) 27.19 ±1.37	112 (14.43) [.4-.458]	196 (25.26) [.395-.438]	308 (39.69) 27.24 ±1.38	65 (13.16) [.317-.384]	124 (25.10) [.429-.486]	189 (38.26) 27.39 ±1.44	408 (17.37) [.407-.437]	603 (25.67) [.447-.474]	1011 (43.04) 27.20 ±1.40
	Obese	29 (12.50) [.237-.321]	19 (8.19) [.172-.255]	48 (20.69) [33.46 ±3.58]	86 (9.23) [213-.256]	88 (9.44) [.166-.200]	174 (18.67) 32.87 ±2.95	76 (9.79) [.271-.326]	107 (13.79) [.215-.254]	183 (23.58) 33.34 ±3.52	68 (13.77) [.331-.399]	69 (13.97) [.238-.291]	137 (27.73) 33.46 ±3.66	257 (10.94) [.256-.284]	263 (11.20) [.195-.217]	520 (22.14) 33.79 ±11.66
Overall Total		122 (52.59) 26.71 ±4.54	110 (47.41) 26.01 ±4.28	232 (100) 26.70 ±4.60	403 (43.24) 26.71 ±4.54	529 (56.76) 26.01 ±4.28	932 (100) 26.32 ±4.40	280 (36.08) 27.40 ±5.10	496 (63.92) 26.49 ±4.65	776 (100) 26.82 ±4.84	205 (41.50) 27.69 ±6.07	289 (58.50) 26.95 ±4.80	494 (100) 27.26 ±5.37	1002 (42.66) 27.24 ±5.00	1347 (57.34) 26.75±8.13	2349 (100) 26.96 ±7.01
Chi-square test		chi2(3) = 1.6985 P = 0.637			chi2(3) = 5.0334 P = 0.169			chi2(3) = 6.9206 P = 0.074			chi2(3) = 7.7959 P = 0.050			chi2(3) = 14.3826 P = 0.002		

BMI: body mass index, CI: confidence intervals, %: percentages, n: count

Table 4.3 shows the BMI categories of the SAN personnel by biological characteristics (age and gender). Overall, the mean BMI for underweight, normal, overweight and obese SAN personnel was $16.32 \pm 4.12 \text{ kg/m}^2$, 22.61 ± 1.76 , $27.39 \pm 1.44 \text{ kg/m}^2$ and $33.46 \pm 3.66 \text{ kg/m}^2$, respectively. The mean BMI categories were lower than 18.5 kg/m^2 and normal weight in all age groups and ranged between $18.35 \pm 0.77 \text{ kg/m}^2$ to $24.28 \pm 0.33 \text{ kg/m}^2$. Moreover, the mean BMI categories were higher than 25 kg/m^2 and 30 kg/m^2 in all age group and ranged between $26.69 \pm 1.48 \text{ kg/m}^2$ and $34.04 \pm 3.97 \text{ kg/m}^2$.

The trend remained consistent in 2018, 2019, 2022, and 2023, respectively. Females exhibited higher mean BMIs for underweight, normal, overweight and obesity ($17.8 \pm 0.64 \text{ kg/m}^2$, $22.34 \pm 1.81 \text{ kg/m}^2$, $27.16 \pm 1.52 \text{ kg/m}^2$, $34.04 \pm 3.97 \text{ kg/m}^2$) overall, in comparison to males. The trend remained consistent in 2018, 2019, 2022, and 2023, respectively.

Table 4.3: BMI categories of the SAN personnel by biological characteristics (age and gender)

		2018 Mean ±SD [CI]				2019 Mean ±SD [CI]				2022 Mean ±SD [CI]				2023 Mean ±SD [CI]				2018-2023 Mean ±SD (%) [CI]			
BMI		Underweight	Normal	Overweight	Obese	Underweight	Normal	Overweight	Obese	Underweight	Normal	Overweight	Obese	Underweight	Normal	Overweight	Obese	Underweight	Normal	Overweight	Obese
Overall Mean ±SD		18.35 ±0.77	22.75 ±1.33	27.64 ±1.46	33.46 ±3.58	17.43 ±4.04	22.48 ±1.69	27.19 ±1.37	32.87 ±2.95	17.5 ±1.02	22.48 ±1.69	27.19 ±1.37	32.87 ±2.95	15.98 ±3.54	22.36 ±1.67	27.24 ±1.38	33.34 ±3.52	16.32 ±4.12	22.61 ±1.76	27.39 ±1.44	33.46 ±3.66
Age	18-25	No measurements	22.25 ±1.82 [0.000044-0.7876]	27.20±1.43 [0.00031-0.6967]	31.2±0.71 [0.0000026-0.9997]	No measurements	22.11 ±1.78 [0.000033-0.9924]	26.44±1.42 [0.0001-0.741]	No measurements	No measurements	21.42 ±1.90 [0.00029-0.4847]	28 ±1.41 [0.0000023-0.9067]	32.01 ±17.95 [0.063-0.22]	17.8±0 [0.000000057-0.9042]	22.41 ±1.86 [0.00048-0.9095]	26.69±1.48 [0.00095-0.7698]	33.14 ±3.17 [0.000000000009-0.00981]	17.8±0 [0.0000000095-0.948]	22.05 ±1.86 [0.00000000000009-0.9664]	26.64±1.42 [0.000089-0.6061]	32.58±2.90 [0.0000029-0.9969]
	26-35	18.35±0.71 [0.0077-0.0096]	22.69 ±1.44 [0.0025-0.9806]	27.39±1.54 [0.0202-0.8708]	33.96 ±3.43 [0.000018-0.9999]	17.45±0.81 [0.00034-0.0528]	22.45 ±1.59 [0.0062-0.9473]	27.07±1.31 [0.106-0.5313]	33.06 ±2.68 [0.0001-0.999]	17.74±1.07 [0.0051-0.406]	21.56 ±1.82 [0.00039-0.7936]	25.33±0.51 [0.00047-0.3014]	33.16 ±19.23 [0.0787-0.9157]	15.37±4.07 [0.0000017-0.9673]	22.23 ±1.72 [0.000086-0.976]	27.08±1.52 [0.04-0.54]	32.82 ±3.01 [0.00001-0.9992]	17.27±1.92 [0.00042-0.0958]	22.38 ±1.68 [0.0021-0.9702]	27.06±1.40 [0.114-0.4652]	34.08±15.95 [0.00012-0.9992]
	36-45	18.3±0 [0.000000014-0.999.3]	23.27 ±1.05 [0.00000065-1]	28.09±1.10 [0.0021-0.79]	32.27 ±2.84 [0.0082-0.1642]	No measurements	22.47 ±1.88 [0.0019-0.600]	27.37±1.57 [0.049-0.226]	33.02 ±3.64 [0.00005-0.9817]	18.50 [0.00047-0.3014]	21.25 ±2.06 [0.000044-0.9529]	26.25±1.26 [0.000054-0.6203]	33.29 ±19.57 [0.074-0.324]	No measurements	22.81 ±1.60 [0.000095-0.9904]	27.51±1.42 [0.11-0.23]	34.35 ±4.50 [0.00002-0.99]	18.5±11.67 [0.00011-0.0062]	22.48 ±1.79 [0.00027-0.9288]	27.36±1.46 [0.0572-2288]	33.52±3.90 [0.000064-0.9883]
	46-60	No measurements	24.28 ±0.33 [0.15-0.19]	26.69±1.21 [0.0028-0.41]	33.83 ±1.21 [0.00002-0.98]	No measurements	22.73 ±1.56 [0.00081-0.128]	27.20±1.47 [0.00041-0.734]	31.63 ±1.67 [0.00053-0.63]	No measurements	23.46 ±0.85 [.]	27.10±1.12 [.]	33.17 ±3.85 [0.01-0.21]	No measurements	23.26 ±1.74 [0.011-0.17]	28.40±1.37 [0.0014-0.23]	33.43 ±3.15 [0.00004-0.99]	No measurements	23.17 ±1.52 [0.00047-0.2163]	27.44±1.48 [0.00083-0.6485]	32.72±3.32 [0.000081-0.9307]
Chi square test		chi2(9)=12.67 P=0.3733				chi2(9)=98.35 P=0.000				chi2(9)=8.97 P=0.440				chi2(9)=25.90 P=0.002				chi2(9)=153.613 P=0.000			
Gender	Male	No measurements	22.68 ±1.49 [0.00045-0.99]	27.19±1.54 [0.17-0.45]	32.92 ±3.38 [0.001-0.93]	17.8±1.13 [0.0000006-0.97]	22.39 ±1.67 [0.0015-0.99]	27.14±1.44 [0.20-0.51]	32.31 ±2.69 [0.00008-0.99]	17.54±1.07 [0.01-0.29]	21.24 ±1.88 [0.000017-0.99]	26.13±0.99 [0.006-0.06]	34.23 ±19.46 [0.58-0.75]	17.7±3.49 [0.0000026-0.98]	22.56 ±1.62 [0.0011-0.98]	27.29±1.45 [0.042-0.79]	32.80 ±3.12 [0.00028-0.99]	15.96±4.69 (0.6) [0.0024-0.13]	22.35 ±1.74 (35.2) [0.00091-0.99]	27.13±1.41 (44.7) [0.20-0.51]	33.54±14.29 (19.3) [0.00013-0.99]
	Female	18.35±0.71 [0.00026-0.48]	23.02 ±1.57 [0.017-0.37]	27.69±1.44 [0.24-0.51]	35.31 ±4.15 [0.000011-1]	17.25±1.06 [0.00018-0.27]	22.32 ±1.63 [0.0059-0.49]	27.11±1.44 [0.023-0.32]	33.45 ±3.36 [0.00055-0.99]	18.3±6.38 [0.0000074-0.97]	21.9±1.66 [0.02-0.28]	26.33±2.31 [0.0027-0.019]	32.15 ±2.98 [0.00051-0.86]	17.2±12.16 [0.0000011-0.95]	22.29 ±1.89 [0.00016-0.99]	27.27±1.64 [0.057-0.21]	34.46 ±4.19 [0.000000048-1]	17.8±0.64 (0.8) [0.00000083-0.36]	22.34 ±1.81 (30.9) [0.001-0.82]	27.16±1.52 (38.2) [0.06-0.17]	34.04±3.97 (29.9) [0.000016-0.99]
Chi square test		chi2(3)=3.20 P=0.362				chi2(3)=6.033 P=0.110				chi2(3)=6.17. P=0.103				chi2(3)=4.36 P=0.224				chi2(3)=26.69 P=0.000			

BMI: body mass index, SD: standard deviation, CI: confidence intervals

Table 4.4 shows that overall, there were 2349 naval personnel who had valid physical FT outcomes. Significantly more offshore unit - based personnel (60.74%) passed the FT. This pattern was observed throughout the years, where the overall offshore-based personnel who passed the FT in 2019, 2022 and 2023 were 60.18%, 68.07% and 59.54%, respectively, except for the outcomes in 2018. However, the significant differences were only noted in 2019 and 2022 (p values = 0.011 and 0.009, respectively).

Table 4.4: South African naval personnel's physical fitness outcomes by workplace unit per year

		2018 n (%) (CI)			2019 n (%) (CI)			2022 n (%) (CI)			2023 n (%) (CI)			Combined Total (2018-2023)		
		Shore n (%) (CI)	Offshore n (%) (CI)	Total	Shore n (%) (CI)	Offshore n (%) (CI)	Total	Shore n (%) (CI)	Offshore n (%) (CI)	Total	Shore n (%) (CI)	Offshore n (%) (CI)	Total	Shore n (%) (CI)	Offshore n (%) (CI)	Total
Overall Total	SAN	122 (52.58)	110 (47.41)	232 (100)	403 (43.24)	529 (56.76)	932 (100)	279 (36)	496 (64)	775 (100)	205 (41.50)	289 (58.50)	494 (100)	1002 (42.66)	1347 (57.34)	2349 (100)
Fitness Test Results	FFT	63 (51.64) [.538-.627]	54 (49.09) [.461-.552]	117 (50.43)	182 (48.28) [.482-.533]	195 (51.72) [.517-.567]	377 (40.45)	142 (41.04) [.508-.567]	204 (58.96) [.411-.455]	346 (44.65)	82 (43.16) [.400-.468]	108 (56.84) [.373-.431]	190 (38.46)	468 (47.32) [.467-.498]	521 (52.68) [.386-.413]	989 (42.10)
	PFT	59 (48.36) [.513-.603]	56 (50.91) [.486-.578]	115 (49.57)	221 (39.82) [.398-.439]	334 (60.18) [.601-.641]	555 (59.55)	137 (31.93) [.491-.549]	292 (68.07) [.588-.631]	429 (55.35)	123 (40.46) [.600-.664]	181 (59.54) [.626-.680]	304 (61.54)	534 (39.26) [.532-.563]	826 (60.74) [.613-.638]	1,360 (57.90)
Chi-square test		chi2(1) = 0.1503 P = 0.698			chi2(1) = 6.5407 P = 0.011			chi2(1) = 6.8925 P = 0.009			chi2(1) = 0.3504 P = 0.554			chi2(1) = 15.1916 P = 0.000		

FFT: failed fitness test, PFT: passed fitness test, CI: confidence intervals, %: percentages, n: count

4.3 The South African naval personnel outcomes denoting the association between body size and physical fitness

In Table 4.5, overall (i.e., in 2018 to 2023), only 16 SAN personnel had their BMI classified as underweight. Among these, a notably higher prevalence (62.5%) completed (i.e., passed) the FT. Most overweight (40.25%) and obese (71.92%) SAN personnel did not pass the FT. A higher number of SAN personnel who were within the normal range of weight (74.81%) on the other hand, passed the FT. This pattern was evident in all the respective years, where a notably higher prevalence of obese SAN personnel failed the FT, while a significantly higher prevalence of normal-weight SAN personnel succeeded during the FT.

Table 4.5: Fitness test by BMI categories

		2018 n (%) (CI)				2019 n (%) (CI)				2022 n (%) (CI)				2023 n (%) (CI)				2018-2023 n (%) (CI)			
BMI		Underweight	Normal	Overweight	Obese	Underweight	Normal	Overweight	Obese	Underweight	Normal	Overweight	Obese	Underweight	Normal	Overweight	Obese	Underweight	Normal	Overweight	Obese
Physical Fitness	FFT	1 (50.00) [.008-.058]	32 (32.65) [.273-.361]	46 (54.76) [.393-.484]	38 (79.16) [.324-.415]	4 (66.67) [.666-.916]	95 (26.17) [.261-.309]	159 (40.87) [.408-.458]	119 (68.39) [.683-.748]	1 (16.66) [.166-.632]	72 (25.90) [.258-.313]	137 (44.48) [.444-.500]	136 (74.35) [.743-.801]	0 (0)	29 (18.01) [.152-.211]	64 (33.86) [.336-.407]	97 (70.80) [.510-.581]	6 (37.5) [.375-.622]	202 (25.18) [.251-.283]	407 (40.25) [.402-.433]	374 (71.92) [.719-.756]
	PFT	1 (50.00) [.008-.059]	66 (67.34) [.573-.661]	38 (45.23) [.330-.421]	10 (20.83) [.086-.154]	2 (33.33) [.333-.732]	268 (73.83) [.738-.780]	230 (59.13) [.591-.639]	55 (31.61) [.316-.388]	5 (83.33) [.833-.977]	206 (74.10) [.741-.789]	171 (55.52) [.555-.609]	47 (25.68) [.256-.325]	7 (100) [.023-.047]	132 (81.98) [.434-.490]	125 (66.13) [.411-.467]	40 (29.19) [.131-.174]	10 (62.5) [.625-.821]	600 (74.81) [.748-.776]	604 (28.07) [.597-.627]	146 (28.07) [.280-.320]
Chi-square test		chi2(3) = 28.8761 P = 0.000				chi2(3) = 88.8604 P = 0.000				chi2(3) = 106.6280 P = 0.000				chi2(3) = 95.0518 P = 0.000				chi2(3) = 285.3907 P = 0.000			

BMI: body mass index, FFT: failed fitness test, PFT: passed fitness test, CI: confidence intervals, %: percentages, n: count

4.3.1 *The changes in body size and physical fitness*

Table 4.6 shows a significant increase in the SAN personnel’s mean BMI after the COVID-19 lockdown period (2018 & 2019 vs 2022 & 2023) (i.e., 26.84 kg/m² & 26.44 kg/m² vs 27,30 kg/m² & 27.45 kg/m²). Based on the outcome observed indicating a probability of 0.000, we can therefore reject the null hypothesis (H₀) set for the current study that, “*there will be no mean BMI change (increase/decrease) observed before and after the COVID-19 lockdown period among the SAN personnel*”.

Table 4.6: BMI means from 2018-2023

Year	BMI Mean	Standard deviation	Standard Error Mean
2018	26.84	4.787	.314
2019	26.44	4.229	.138
2022	27.30	10.481	.376
2023	27.45	4.945	.223

Bartlett's equal-variances test: $\chi^2(3) = 829.5229$ Prob> $\chi^2 = 0.000$ – showing an overall significant difference.

Table 4.7 presents the outcomes of the paired t-test analyses to denote the comparisons between the observed mean BMI outcomes in 2018, 2019, 2022 and 2023. In this case, while there were no significant differences observed within Pair 1 (2018-2019) and Pair 3 (2022-2023), (i.e., the p-values were = 0.2119 &, 0.7716, respectively); the mean BMI observed in 2022 was significantly higher than the mean BMI observed in 2019 (i.e., for Pair 2 [2019-2022] the Mean: 26.44 vs Mean: 27.30, p value was equal to 0.0223).

Table 4.7: Paired T-test for BMI Means from 2018-2019

		Paired Differences						t	df	Sig. (2tailed)
		N	Mean BMI [kg/m ²]	Std. Error Mean	Std. Deviation	95% CI of the Difference				
						Lower	Upper			
Pair 1	(BMI: 2018) – (BMI: 2019)	232	26.84	.314	4.787	26.22	27.46	1.2492	1160	0.2119
		930	26.44	.138	4.229	26.17	26.71			
Pair 2	(BMI: 2019) – (BMI: 2022)	930	26.44	.138	4.22	26.17	26.71	2.2878	1703	0.0223
		775	27.30	.376	10.48	26.56	28.04			
Pair 3	(BMI: 2022) – (BMI: 2023)	775	27.30	.376	10.48	26.56	28.04	-0.2903	1264	0.7716
		491	27.45	.223	4.94	27.01	27.88			

Table 4.8 shows a significant increase in the SAN personnel’s mean FT outcome after the COVID-19 lockdown period (2018 & 2019 vs 2022 & 2023). Based on the outcomes observed indicating probability outcomes of 0.000, we can therefore reject the null hypothesis (H_0) set for the current study that, “*there will be no mean FT change (decrease / increase) observed before and after the COVID-19 lockdown period among the SAN personnel*”.

Table 4.8: Bartlett's test for equal-variance outcomes for SAN personnel mean fitness scores measured in 2018 to 2023

Year	Fitness Score Mean	Fitness Score Std. deviation	chi2(1)	p-value
2018-2019	2772.83	1001.34	14.6490	0.000
	2964.07	983.54		
2019-2022	2964.07	983.54	51.3010	0.000
	2877.47	1046.87		
2022-2023	2877.47	1046.87	27.4592	0.000
	3012.85	982.63		
2018-2023	2772.83	1001.34	20.0781	0.000
	3012.85	982.63		
2019-2023	2964.07	983.54	70.786	0.000
	3012.85	982.63		

Table 4.9 presents the outcomes of the paired t-test analyses to denote the comparisons between the observed mean FT outcomes in 2018, 2019, 2022 and 2023. In this case, we observed that the mean fitness score of the SAN personnel decreased in 2022 even though no significant difference observed within Pair 2 (2019-2022) (i.e., Mean: 2877.47 vs Mean: 2964.07, $p = 0.0807$). On the other hand, the mean FT outcome observed in 2019 was significantly higher than the mean FT observed in 2018 (i.e., for Pair 1 [2018-2019] the Mean: 2964.07 vs Mean: 2772.83, $p = 0.0084$). Moreover, the mean FT observed in 2023 was significantly higher than the mean FT observed in 2022 (i.e., for Pair 3 [2022-2023] the Mean: 3012.85 vs Mean: 2877.47, $p = 0.0223$). When we took the analysis further and produced Pairs 4 (2018-2023) and 5 (2019-2023), to investigate the significant changes in mean FT outcomes pre- and post-Covid 19 lockdown, significant differences were only observed for Pair 4, where the mean FT outcome observed in 2023 was significantly higher than the mean FT outcome observed in 2018 (i.e., for Pair 4 [2018-2023] the Mean: 3012.85 vs Mean: 2772.83, $p = 0.0024$, denoting an increase in FT outcomes of SAN personnel after the COVID-19 lockdown period.

Table 4.9: T-test outcomes for mean fitness test scores measured in 2018 to 2023

		Paired Differences						t	df	Sign (2 tailed)
		N	Mean FT	SD	Std. Error Mean	95% CI of difference				
						Lower	Upper			
Pair 1	(FT – 2018) - (FT 2019)	232	2772.83	10001.34	65.74	2643.30	2902.36	-2.64	1155	0.0084
		930	2964.07	983.54	32.34	2900.61	3027.54			
Pair 2	(FT – 2019) - (FT 2022)	930	2964.07	983.54	32.34	2900.51	3027.54	1.7476	1684	0.0807
		775	2877.47	1046.87	37.95	2802.97	2951.96			
Pair 3	(FT – 2022) – (FT 2023)	775	2877.47	1046.87	37.95	2802.97	2951.96	-2.288	1250	0.0223
		491	3012.85	982.63	44.35	2925.72	3099.98			
Pair 4	(FT – 2018) – (FT 2023)	232	2772.83	1001.34	65.74	2643.30	2902.36	-3.05	721	0.0024
		491	3012.85	982.63	44.35	2925.72	3099.98			
Pair 5	(FT – 2019) – (FT 2023)	930	2964.07	983.54	32.34	2900.61	3027.54	-0.888	1414	0.3744
		491	3012.85	982.63	44.35	2925.72	3099.98			

FT: fitness test, N: total count, SD: standard deviation, Std. Error Mean: standard error of mean, CI: confidence intervals, t: t-test, df: degrees of freedom, sign: significance difference

4.3.2 Factors that influence physical fitness among the South African naval personnel over the 4 years (2018 to 2023)

Table 4.10 presents the outcomes of the logistic regression for 2018. We observed that the only factors that seemed to influence the SAN personnel to succeed in the PF test were the work settings where they were based, and body size. In this case, while being based in the shore units decreased the likelihood of passing the FT (OR=0.658, p=0.005) when compared to being based at the offshore units, being within the normal range of weight increased the likelihood of passing the FT by almost 7 folds (i.e., OR=6.471, p=0.034) when compared to being underweight. These effects remained even when the confounding effects of age were removed,

with the outcomes further showing that having obesity decreased the likelihood of passing the FT when compared to being underweight.

Table 4.10 Logistic Regression: 2018

Variable	Coefficient	Unadjusted Odds Ratio (OR)	95% CI for OR	p-value
SAN Unit	-0.418	0.658	0.49-0.88	0.005
Gender	0.0796	1.083	0.77-1.53	0.650
BMI:				
Under	.	.	.	.
Normal	1.867	6.471	1.15-36.39	0.034
Overweight	1.148	3.154	0.56-17.67	0.191
Obese	-0.0433	0.957	0.16-5.48	0.961
Variable		Adjusted for AGE, Odds Ratio (OR)	95% CI for OR	p-value
SAN Unit		0.690	0.52-0.91	0.0074
Gender		0.891	0.65-1.23	0.4870
BMI:				
Under		1.00	.	.
Normal		5.386	1.11-26.04	0.0188
Overweight		2.673	0.45-15.96	0.2614
Obese		0.8311	0.15-4.62	0.000

BMI: body mass index, OR: odds ratio, CI: confidence intervals

Table 4.11 presents the outcomes of the logistic regression for 2019. All the sociodemographic factors included in this analysis seemed to influence the SAN personnel succeeding in the physical FT, except for gender. In this case, while being based in the offshore units and being within the normal range of weight increased the likelihood of passing the FT by almost 2 and 6 folds (i.e., OR values = 1.475 and 5.467, p values = 0.009 and 0.054) when compared to being based at the shore units and being underweight; being within the ages 26 to 35years and 36 to 45years decreased the likelihood of passing the FT (OR values = 0.360 and 0.422 and p values =0.003 and 0.021) when compared to being younger (i.e., 18 to 25 years). The effects of work setting and BMI remained even when the confounding effects of age were removed.

Table 4.11 Logistic Regression: 2019

Variable	Coefficient	Unadjusted Odds Ratio (OR)	95% CI for OR	p-value
SAN Unit	0.388	1.475	1.10-1.97	0.009
Gender	0.108	1.115	0.79-1.57	0.534
Age				
18-25	.	.	.	.
26-35	-1.021	0.360	0.18-0.71	0.003
36-45	-0.860	0.422	0.20-0.88	0.021
46-60	-0.164	0.848	0.35-2.03	0.711
BMI:				
Under	.	.	.	.
Normal	1.698	5.467	0.97-30.69	0.054
Overweight	1.060	2.889	0.52-16.12	0.226
Obese	-0.120	0.887	.015-5.06	0.892
Variable		Adjusted for AGE, Odds Ratio (OR)	95% CI for OR	p-value
SAN Unit		1.384	1.048-1.83	0.0212
Gender		0.938	0.67-1.29	0.6964
BMI:				
Under		1.000	.	.
Normal		5.044	0.88-28.72	0.0424
Overweight		2.611	0.47-14.63	0.2569
Obese		0.783	0.13-4.57	0.7848

BMI: body mass index, OR: odds ratio, CI: confidence interval

According to Table 4.12, none of the listed sociodemographic factors seemed to significantly influence the SAN personnel passing the physical FT, until the confounding effects of age were removed. In this case, being based at the offshore units significantly increased the likelihood of SAN personnel passing the FT by up to 2 folds (OR=1.457, p= 0.0141) when compared to being based at the shore units. Being the female on the other hand decreased the likelihood of SAN personnel passing the FT (OR=0.606, p= 0.0149) when compared to being the male.

Table 4.12 Logistic Regression: 2022

Variable	Coefficient	Unadjusted Odds Ratio (OR)	95% CI for OR	p-value
SAN Unit	0.332	1.393	0.88-2.19	0.154
Gender	-0.469	0.625	0.37-1.06	0.080
Age				
18-25				
26-35	-0.323	0.724	0.38-1.37	0.318
36-45	-0.167	0.846	0.39-1.79	0.664
46-60	0.219	1.244	0.38-4.04	0.715
BMI:				
Under				
Normal	0.739	2.094	0.48-9.11	0.325
Overweight	-0.448	0.638	0.13-3.11	0.579
Obese	-0.699	0.496	0.21-1.18	0.113
Variable		Adjusted for AGE, Odds Ratio (OR)	95% CI for OR	p-value
SAN Unit		1.457	1.08-1.97	0.0141
Gender		0.606	0.43-0.86	0.0049
BMI:				
Under		1.000	.	.
Normal		1.870	0.41-8.51	0.4102
Overweight		0.769	0.14-4.17	0.7598
Obese		0.471	0.19-1.11	0.0799

BMI: body mass index, OR: odds ratio, CI: confidence interval

According to Table 4.13, the only factor that seemed to influence the SAN personnel passing the physical FT significantly was the BMI. In this case, being within the normal range of weight and being overweight increased the likelihood of passing the FT (OR values = 4.222 and 1.284, both p values =0.000) when compared to being underweight. When the confounding effects of age were removed, these effects became stronger denoting almost 13 and 5 likelihood folds, and further suggesting that, being female (OR = 0.626, p=0.0309) significantly decreased the likelihood of passing the FT compared to being male.

Table 4.13 Logistic Regression: 2023

Variable	Coefficient	Unadjusted Odds Ratio (OR)	95% CI for OR	p-value
SAN Unit	-0.123	0.885	0.54-1.43	0.616
Gender	-0.486	0.615	0.38-1.00	0.051
Age				
18-25				
26-35	-0.074	0.928	0.45-1.93	0.843
36-45	-0.119	0.887	0.41-1.90	0.759
46-60	-0.390	0.677	0.23-1.99	0.479
BMI:				
Under	.	.	.	.
Normal	2.563	4.222	6.85-24.55	0.000
Overweight	1.587	1.284	2.92-8.18	0.000
Obese	.	.	.	.
Variable		Adjusted for AGE, Odds Ratio (OR)	95% CI for OR	p-value
SAN Unit		1.032	0.68-1.55	0.8830
Gender		0.626	0.41-0.96	0.0309
BMI:				
Under		.	.	.
Normal		12.970	6.85-24.55	0.000
Overweight		4.889	2.922-8.179	0.000
Obese		.	.	.

BMI: body mass index, OR: odds ratio, CI: confidence intervals

Finally, according to Table 4.14, it seems as though overall, work setting, age and BMI are important in determining the outcomes of FT among the SAN personnel participating in this research. In this case, being based at the offshore unit seems to increase the likelihood of the SAN personnel succeeding in the physical FT (OR=1.386, p=0.000) when compared to being based at the shore unit. On the other hand, being within the age group 26-35 years (OR=0.631, p=0.005) and having obesity (OR=0.188, p=0.001) seem to decrease the likelihood of the SAN personnel succeeding in the physical FT when compared to being within the age group 18 to 25 years and being underweight. These effects seem to remain even after removing the confounding effects of age, and further showing that being female decreases the likelihood of succeeding in the physical FT (0.696, p=0.000) when compared to being male.

Table 4.14 Logistic Regression: 2018-2023

Variable	Coefficient	Unadjusted Odds Ratio (OR)	95% CI for OR	p-value
SAN Unit	0.326	1.386	1.15-1.66	0.000
Gender	-0.151	0.859	0.70-1.05	0.148
Age				
18-25	.	.	.	.
26-35	-0.461	0.631	0.46-0.87	0.005
36-45	-0.174	0.840	0.59-1.19	0.333
46-60	0.185	1.202	0.77-1.88	0.417
BMI:				
Under	.	.	.	.
Normal	0.374	1.454	0.54-3.94	0.462
Overweight	-0.343	0.709	0.26-1.19	0.498
Obese	-1.66	0.188	0.069-0.515	0.001
Variable		Adjusted for AGE, Odds Ratio (OR)	95% CI for OR	p-value
SAN Unit		1.344	1.14-1.59	0.000
Gender		0.696	0.58-0.84	0.000
BMI:				
Under		1.000	.	.
Normal		1.312	0.49-3.51	0.587
Overweight		0.600	0.23-1.61	0.304
Obese		0.165	0.060-0.450	0.000

BMI: body mass index, OR: odds ratio, CI: confidence interval

CHAPTER 5

DISCUSSION

5.1 Introduction

The SAN population (service members) is part of the SA military population and is a subset of the general population, hence this population should not be excluded when investigating the health-related issues associated with body size (BMI). Body mass index that is above the normal range is the main component that affects PF, and it is the most prevalent medical reason for individuals failing to qualify for military service (Sánchez-Chapul *et al.*, 2020). In fact, PF is a very important element of i) health and well-being, ii) military (combat) readiness of service members, iii) costs associated with medical care, and iv) early service member attrition (Sánchez-Chapul *et al.*, 2020).

This study aimed to determine the prevalence of overweight and obesity and the association between body size and physical fitness among South African Naval personnel. The objectives were to determine the prevalence of overweight and obesity, physical fitness and sociodemographic factors of body size and PF and assess the changes in body size (BMI) and PF among SAN personnel amidst the COVID-19 pandemic. The main objective was to assess the association between body size and physical fitness among SAN personnel. The previous chapter presented the results of this study in consideration of these aims. As such, the key outcomes of the current study are discussed in this chapter, and they are either substantiated or refuted by pertinent related literature.

5.2 Key study outcomes

In the current study, majority of the SAN personnel were overweight (43%). While the SAN offshore units had a higher prevalence of overweight, the overall mean BMI was higher in shore units than offshore units. Between 2018 and 2023, younger age groups (18-35 years) and (26-35 years) had lower mean BMI in all the body size categories (i.e., underweight, normal weight, overweight, and obese) compared to older age groups (36-45 years) and (45-60 years). Males had lower mean BMI for all the body size categories compared to their female counterparts. This trend remained consistent in all the respective years when the CHAs were conducted. On the other hand, the FT outcomes were higher among SAN personnel based at the offshore units; however, significant differences were observed only in 2019 and 2022. A higher proportion of overweight and obese SAN personnel failed PF assessments, while a higher proportion of normal weight SAN personnel succeeded during the fitness assessments.

According to the outcomes of the current study both the BMI outcomes and FT were significantly different before and after the Covid-19 pandemic lockdown, where the mean BMI was observed to be significantly higher in 2022 than 2019, and the mean FT score outcome was lower in 2022 when compared to the outcomes observed in 2019, though the group differences in this case were not significant. Moreover, in this analysis, the BMI, and work setting seemed to be the strong influencers of the SAN personnel succeeding in FT. This influence seems to be mediated by age, such that when the confounding effects of age were removed, the influences of BMI and work setting became stronger, further magnifying visible gender difference on FT success outcomes.

5.2.1 Body size

Prevalence of body size among the South African Naval personnel

Available literature suggests the global prevalence of overweight to be 43%, while in the African region it is estimated to be 31% (Phelps *et al.*, 2024). Mchiza *et al* (2019) on the other hand, reported an overweight prevalence of 22.3% among the South African population, also suggesting the overall prevalence of overweight to be higher in females than males. The global and South African prevalence of obesity is also estimated to be 16% and 11%, respectively (Phelps *et al.*, 2024; SADHS, 2016). According to the current research outcomes, it seems as though the SAN personnel are tipping the BMI charts such that the proportions of overweight and obesity are way above those for the general global, African, and South African populations. In this case, the SAN personnel participating in this research had overweight and obesity prevalence of 43.04% and 22.14%, respectively as shown in Table 4.2.

The outcomes from the current research magnified a higher prevalence of overweight in offshore units compared to shore units, with this trend seen in all the respective years from 2018 to 2023. Despite a higher prevalence of overweight found in offshore units, the current study also observed that the overall mean BMI for shore units was higher than offshore units (27.24kg/m²) versus (26.75 kg/m²). This indicates that even though most personnel based at the offshore units are overweight, those who are based at shore units (office-bound personnel), which are non-operational, are at an increased risk of gaining weight than those who are at offshore units (operational). According to Havenetidis and Bissas, (2019), the mean BMI values during ship deployment (offshore) among naval personnel are higher than those of personnel ashore. This trend is universal, as it is evident in the US (26.4), European (25.1), and Asian (21.1) crews, even though the latter crews are traditionally characterised by lower BMI values (Havenetidis and Bissas, 2019). In these studies, it is important to note that, naval personnel were deployed to vessels with restricted space, further exacerbating this increasing

BMI trend. It is widely recognised that deployment is a stressful experience. Therefore, it is logical to surmise that deployment to a vessel, with the additional constraints of limited space, can potentially exacerbate the anticipated stress levels because of specific conditions that do not exist on land, hence the weight gain in offshore naval personnel. In addition to the psychological effects of spending an extended period away from familiar environments, numerous potential health risk factors, including inactivity, limited access to nutritious meals, and the expectation of maintaining optimal performance for extended periods, may collectively contribute to a decline in total force fitness (Havenetidis and Bissas, 2019).

Changes in body size pre and post Covid-19 lockdown

According to a study conducted in the United States, changes in BMI among active-duty service members from both the Navy and Marines pre- and post-COVID-19 were observed (Janvrin *et al.*, 2024). This study also found that the percentage of sailors with overweight and obesity increased by 2.1% and 16.5%, respectively; while the percentage of sailors with underweight and healthy weight decreased by 11% and 11.1%, respectively. This was the similar case for SAN personnel participating in the current study, as they presented with a higher prevalence and mean BMI post- when compared with pre-Covid-19 lockdown. In fact, available literature also suggest that it is typical in conditions like during the Covid-19 pandemic, where globally populations had no or restricted access to healthy food and exercise / gym facilities, such that this brought mental distress, a condition that put them at risk of excessive weight gain and other related health conditions including non-communicable diseases (de Backer *et al.*, 2021; Onagbiye *et al.*, 2021).

Despite the previous concern that obesity rates may be overestimate when using the BMI, due to increased muscle mass among service members, recent literature suggests that BMI is more likely to underestimate overweight and obesity among service members (Combating Military Obesity | ASP American Security Project, 2023; Clerc, Mayer and Graybill, 2022). According to Grier *et al.*, (2015), even though generally army soldiers have increased in lean body mass, they also have disproportionate increase in total body fat. These researchers further showed that the standard cutoffs for obesity substantially underestimated excess body fat among both active duty and retired U.S. navy sailors (Grier *et al.*, 2015). The current study found an increased in prevalence of overweight more than obesity pre and post Covid-19 among SAN personnel, which may have been underestimated due to what literature suggests and the true extent of the problem may have been further masked by covid-19 as the prevalence of overweight remained high despite the pandemic.

5.2.2 Physical fitness

Prevalence of physical fitness outcomes among the South African Naval personnel

The current study also showed that a higher percentage of overweight and obese individuals failed their fitness assessments, while a higher percentage of normal-weight individuals succeeded. These outcomes demonstrate that the SAN personnel have a higher failure rate (47.32%) than the U.S. Air Force (30%) (Turner, Wagner and Langhals, 2022). According to Sergi et al., (2023) research conducted on military personnel, a higher BMI was linked to subpar physical performance, and a higher BMI was negatively associated with speed, agility, and endurance, but positively associated with muscular strength. This was similarly observed among firefighters and military personnel (Sergi *et al.*, 2023). Several studies have discovered that a higher BMI in military personnel has both positive and detrimental effects on performance. In terms of muscular strength and power, a higher BMI seems to be beneficial, likely due to the increased muscle mass (Pierce et al., 2017; Teyhen et al., 2016; Sergi et al., 2023). However, a higher BMI is not beneficial in terms of speed/agility and endurance measures, likely due to reduced muscle mass and increased fat mass. As a result, military personnel may benefit from a higher BMI when performing tasks that necessitate strength and power, but it may be detrimental to their occupational performance in terms of endurance, quickness, and agility (Sergi *et al.*, 2023). This therefore may magnify that, the reason why most of the SAN personnel's performance on FT was not par, could be that they had over-accumulation of body fat (demonstrated by obesity), rather than increased muscle mass. In fact, the PF measurements conducted in the current study was to test for endurance, quickness, and agility, with these conditions highly affected by obesity (Sergi *et al.*, 2023).

Changes in physical fitness

The mean FT outcome of the SAN personnel participating in the current study first decreased post-COVID-19 lockdown (i.e., in 2022) and later showed a substantial increase in 2023. This possibly demonstrates that the SAN personnel's PF was reduced by their over-accumulation of body fat mass, shown by the high BMI levels after the Covid-19 lockdown period (i.e. within the 2020/2021 period when all the activities were halted). The SAN personnel's PF only recovered after they shed the body fat, when the military activities were back to normal in 2023. This means it took the SAN sailors longer to become physically active, affecting their FT results. However, further research is needed to justify why this is so. Another possibility could be that it took longer for the SAN personnel to become physically fit than it was to gain weight. Subsequently, dealing with the backlog of work after the Covid-19 pandemic might

have made PA less of a priority which could have further affected the PF among the SAN personnel.

Another important outcome from the current study is that, when the BMI measurements of sailors in this study were compared between pre-pandemic and pandemic conditions, the number of sailors with underweight and healthy weight decreased, while the number of sailors with overweight and obesity increased. These findings are consistent with the research conducted by Restrepo, (2022) which exhibited an increase in the average BMI and obesity prevalence among both U.S. adults and children when comparing pre-pandemic and pandemic BMI. Our findings are also consistent with the research conducted by Legg et al. (2022) and Stiegmann et al., (2023) on active-duty service members, where they showed that the BMI of the military population in all services increased post-pandemic. These findings are also anticipated considering the documented increases in alcohol consumption and protracted sedentary activity that have occurred during the pandemic (Grossman, Benjamin-Neelon and Sonnenschein, 2020; Stockwell et al., 2021).

A decrease in PF post-Covid-19 in this study is aligned with a study conducted by do Amaral and dos Santos which found that the performance of these combatants decreased in both cardiorespiratory variables and localized muscular resistance. The number of military personnel who failed the FT also increased (do Amaral and dos Santos, 2021). Several studies showed that the decrease in military personnel's performance that was observed may have been due to a decrease in physical exercise, which was influenced by social isolation. Upon the advent of the pandemic, the practice of physical exercises in groups within the barracks, which was previously prevalent among soldiers, was prohibited. The cessation of the CHA (measurements of the FT and BMI) may have been another factor that could have discouraged the SAN personnel to keep fit and manage their weight, given the fact that the military adhered to it to a lesser extent than in 2019, as it was not mandatory for them. During the pandemic, an increase in sedentary behaviour, such as sitting time, TV viewing, and the use of electronic and social media, was observed in Brazil and other regions, in addition to a decrease in the level of physical activity among adults (Shi et al., 2021; Puccinelli et al., 2021; Da Silva et al., 2021; Schuch et al., 2022). This could have been the same case among the SAN personnel where most of the meetings and engagements were online and virtually.

5.2.3 Factors that influence physical fitness among the South African naval personnel

Body Mass Index by gender and age

The global prevalence of overweight in males is (43%) and (44%) in females. In SA, the prevalence of overweight is (20%) of males and (27%) females (SADHS, 2016). The overall prevalence of overweight in male and female SAN personnel was (44.7%) and (38.2%) as shown Table 4.3. This SAN prevalence of overweight is higher than that of the general SA prevalence in both males and females, specifically male SAN personnel had a higher prevalence of overweight in comparison to females both globally and in SA. Females in the SAN had a higher obesity prevalence and mean BMI than males, which aligns with the SA general population which suggests that obesity is prominent among women, while underweight males are prevalent (Mchiza *et al.*, 2019). In the Mchiza *et al.* (2019) study it was also demonstrated that prevalence of underweight in men was nearly four times that of women in this study (4.2% vs. 11.9% in men), and the prevalence of obesity in women was nearly four times that of men (11.6% vs. 40.1% in women) (Mchiza *et al.*, 2019). This indicated that the majority of SA (51%) inclined to be overweight, as indicated by their BMI (Mchiza *et al.*, 2019). Another outcome of this study that is consistent with the Mchiza *et al.* (2019) study is that a smaller number of middle-aged and older-aged South Africans (25+ and 45+ years, respectively) have a healthy weight than their younger counterparts (<25 Years and <45 Years, respectively).

Prevalence of overweight in the South African Navy versus the South African Airforce and South African Army

It is also important to note that females in the SAN had a higher prevalence of overweight (38.2%) in comparison to SAAF females (23.3%). There was also a higher prevalence of overweight for SAN males (44.7%) compared to SAAF males (42.8%). The SAN had a higher prevalence of overweight compared to SAA females (26.3%) and males (31.3%). The SAN had a higher prevalence of overweight than the SAAF and SAA in both genders. Despite males having a higher prevalence of overweight than females, this is not the trend seen globally and in SA, where females have a higher overweight mean BMI than males (Haasbroek, 2019). This suggests a greater risk of overweight among SAN females than in males.

Prevalence of obesity in the South African Navy versus the South African Airforce and South African Army

The overall prevalence of obesity among SAN personnel for males and females was (19.3%) and (29.9%) respectively. Females in the SAN had a higher prevalence of obesity than males.

The obesity prevalence in SA is (11%) for males and (41%) for females (SADHS, 2016). The SAN presented a higher prevalence of obesity for both males and females in comparison to SA. Women are more susceptible to obesity or overweight than their male counterparts in SA (Bradshaw et al., 2011). Comparatively to SAAF females (46.7%), obese females in the SAN had a lower prevalence of (29.9%). In contrast to SAAF males, who had an obesity prevalence of (33.8%), SAN males had a lower prevalence of obesity (19.3%). Compared to SAA females (42.1%) and males (35.7%), the SAN exhibited a lower prevalence of obesity.

Overall, younger age groups (18-35) and (26-35) had lower BMI means for all BMI categories. This trend remained consistent in 2018, 2019, 2022, and 2023. Older age groups (36-45) and (45-60) showed higher BMI means for underweight, overweight, and obesity, indicating a consistent trend. A review of the Defence Medical Surveillance System's data on soldier medical conditions revealed that the annual prevalence of clinical overweight was highest among soldiers aged 40 or older (12%), while the lowest prevalence was observed among those under the age of 20 (3.1%) (Rappole *et al.*, 2017). A systematic review of correlates and treatment for obesity in the military also discovered a correlation between obesity and the age of 35 or older (Sanderson, Clemes and Biddle, 2011). Based on historical data from the Total Army Injury and Health Outcomes Database for the years 1989–2012, a study discovered that older age was consistently associated with a larger likelihood of being overweight or obese at accession (Hruby *et al.*, 2015). According to Hruby *et al.* (2015) the odds of being overweight or obese were 1.56 higher (95% CI: 1.55–1.57) for personnel aged 20–29, 1.85 higher (95% CI: 1.82–1.88) for those aged 30–39, and 2.32 higher (95% CI: 2.19–2.46) for those aged 40 or older compared to those under 20 years old.

According to de Medeiros et al., (2020) the physical abilities of a military member may be impacted by their age. Consequently, the youngest age group 18-25 were more likely to pass a FT than the 26-35 and 36-45 age group. de Medeiros et al. (2020) study found a substantial disparity in PF that is associated with the ageing process in the areas of strength, muscle, and cardiorespiratory resistance. Therefore, the PFT results of active military personnel in three distinct age groups (20<30 years, 30<40 years, and 40<50 years) varied.

Physical fitness by Workplace setting

According to the current research, there was a lower failure rate and higher pass rate in offshore units in comparison to shore-based units. This could be because offshore units are operational, and the occupational physical demands of offshore naval members require increased physical activity than shore-based units which are less physically active. According to Vaara (2017)

soldiers' fitness substantially impacts their ability to effectively complete operational tasks and recover from both acute and long-term physiological and psychological stressors associated with the military environment. Failure to pass the FT can have a direct impact on workplace injuries, attrition, and mission and deployment capabilities (Turner, Wagner and Langhals, 2022). Furthermore, enhanced PF has been linked to a decreased prevalence of musculoskeletal injuries, which could potentially lead to a reduction in employee absences. Furthermore, the military environment is also impacted by substantial changes in lifestyle characteristics, such as the increase in sedentary and hazardous behaviour at the population level in recent decades (Vaara, 2017). Most studies have shown the effect of sedentary behaviour in occupational settings on PA. Few studies have shown the impact of various occupational settings on PF outcomes, especially in military populations and more research should be done to determine the effect of occupational settings on PF. Most global and SA studies assessed the outcome of PF among young military recruits and/or assessed the PF outcomes post physical training interventions. Therefore, limited literature showed the PF outcomes of ADMP in military populations within the SANDF.

Physical fitness by body mass index

This study found that there were a higher proportion of females based at shore units and that females had higher BMI means for both overweight and obesity. It also showed that the likelihood of SAN females passing a FT was less than males, despite not having determined the prevalence of FFT and PFT in males and females. The pass rates for enlisted women in the United States Army varied from 41% to 52%, while those for males ranged from 83% to 92% (RAND, 2022). The U.S. Air Force failure rate for females was 51%, which was higher than that of males (Turner, Wagner, and Langhals, 2022). The U.S. Air Force, pass rate was within range of the United States Army. These studies show that females have a lower FT pass rate than males.

The current study found that age, BMI, and work setting significantly influence the success of FT among SAN personnel overall (2018-2023). Offshore units had a higher probability of success of FT than those on shore units. Those aged 26-35 and obese had lower success rates. Females also had lower success rates than males. There was a positive association between body size and PF, p-value <0.05 for obesity (OR=0.188, p=0.001), indicating a decreased likelihood of the SAN personnel succeeding in the physical FT. According to Dewi, Rimawati and Purbodjati, (2021) the overall findings of this study indicated that the endurance level decreased as the BMI increased. Conversely, PF is enhanced when physical activity levels are elevated. Not only is an elevated BF percentage associated with inadequate physical activity,

but it also results in a reduction in relative muscle mass (Dewi, Rimawati and Purbodjati, 2021). In general, it seems that underweight individuals experience a detrimental effect on their muscular strength and endurance, while obesity has been identified as a damaging factor in their mobility (Laxy et al., 2017; Ferreira et al., 2013; Hergenroeder et al., 2011). According to Sergi *et al.*, (2023), an increased BMI has positive and negative effects on various aspects of performance. Specifically, it was frequently observed that optimal performance was achieved by being in the normal weight BMI category, and that performance decreased as BMI increased (Sergi *et al.*, 2023).

5.3 Summary and conclusion of findings

The prevalence of overweight is higher in offshore units; however, the shore units have a higher aggregate mean BMI than the offshore units. In comparison to senior age groups (36-45) and (45-60), younger age groups (18-35) and (26-35) had lower BMI means for underweight, normal, overweight, and obese between 2018 and 2023. The BMI mean for underweight, normal, overweight, and obesity was lower in males, whereas it was higher in females. Throughout 2018, 2019, 2022, and 2023, this pattern persisted. The FT demonstrated a substantial disparity between naval personnel stationed at shore units and those stationed at offshore units, with the biggest disparities occurring in 2019 and 2022. Failing fitness assessments was more prevalent among overweight and obese individuals, while a greater proportion of normal-weight individuals succeeded. Age, body mass index (BMI), and work environment significantly impacted the efficacy of fitness tests administered to SAN personnel from 2018 to 2023. People who are between the ages of 26 and 35 had lower success rates, while offshore units had a higher probability of success. Women also experienced lower accomplishment rates than their male counterparts.

5.4 Study limitations

Retrospective studies are subject to numerous constraints due to the nature of their design, and the method of data collection which was not initially intended for research purposes. It is inevitable that some information will be missing (Talari and Goyal, 2020). The results are also influenced by selection and nonparticipating individuals, the reason of which could not determine, which may result in bias (Talari and Goyal, 2020). Since this was a retrospective study, body fat percentage was not part of the body composition screening at CHA, therefore there was no data. Waist circumference and WHR was excluded from the research due to time constraints of the study. It is important to note that BMI has established cutoff values for body size classification, but according to recent research, central body fat is predictive of the risk of

NCDs in South Africa. Gomwe et al. (2022) found that body fat percentage had significant correlations with all the physical fitness characteristics and metabolic syndrome, muscle mass and body fat accumulation. Confounding factors were not adequately addressed, with obesity increasing year by year a greater impact was not found in the pre and post covid assessment of BMI.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the conclusions drawn from the study and provides key recommendations for reducing overweight, obesity and maintaining health body size, with the goal of improving PF outcomes among the SAN personnel. The recommendations provided in this chapter are based on current industry practice as reviewed in the literature and on the study findings.

The aim of this study was to determine the prevalence of overweight and obesity and the association between body size and physical fitness among South African Naval personnel. The significance of this study is to gain insight on the burden of overweight and obesity and understand the link between body size and PF in the SAN. The findings of this study can enable health professionals at IMM to develop interventions to improve body size status and PF. The findings will be disseminated to top structures in the SAN and SAMHS, which can assist in reducing healthcare costs, increase productivity, and contribute to the body of knowledge on disease burden and PF in the SAN.

The findings of this study revealed that offshore units have a higher prevalence of overweight, but overall mean BMI was higher in shore units. Younger age groups have lower BMI means for underweight, normal, overweight, and obese compared to older age groups. Males have a reduced BMI mean, while females have higher BMI means. Fitness test success among naval personnel is influenced by age, BMI, and work setting, with offshore units having higher success rates.

In conclusion, interventions should target shore-based units, females, older age groups (36-45, 46-60) and sailors which are overweight as these identified groups present with increased risk of becoming obese, developing NCDs and decreased PF outcomes. As a preventative measure to combat the expected increase of NCDs in SA over the next two decades, creative workplace interventions are required (SADoH, 2013). While there are numerous workplace wellness programmes, there is no SA guideline on preventing NCDs in the workplace, and there may be a need for a local evidence-based guideline in this area (Schouw, Mash and Kolbe-Alexander, 2018). Single-component therapies have an insignificant influence on the risk of NCDs (Schouw, Mash and Kolbe-Alexander, 2018). Multicomponent programmes that incorporate healthy food and physical activity into the daily routines of employees should receive special consideration (Schouw, Mash and Kolbe-Alexander, 2018). Reducing overweight and obesity

and improving PF outcomes among SAN personnel can be achieved by following a few key recommendations.

6.2 Recommendations

Health screening

Currently the CHAs conducted on military personnel only assess BMI and WHR as indicators for body composition. It is recommended that body fat percentage be included as a screening tool to assess body composition more accurately. Body mass index and WHR is a first-level screening criterion that can be beneficial; however, it is not an accurate method for determining body composition and does not provide precise information about fat and lean components (Potter *et al.*, 2024). Extensive studies have shown the variation in the relationship between body fat percentage and BMI which is evident for both men and women. This is particularly problematic at both the lower and upper end of the BMI spectrum, as an individual with an apparent healthy BMI (≤ 25 kg/m²) may have excess body fat (metabolically obese normal weight, "skinny fat"). Conversely, individuals with higher BMIs (>25 kg/m²) may have high lean mass but no excess relative fat (e.g., athletes, military individuals) (Potter *et al.*, 2024). Emerging technologies like multifrequency bioelectrical impedance (in Body assessments done in the SANDF) are improving the reliability and affordability of assessing body composition (body fat percentage) for personalized obesity management. However, there is still a wide range of validity and precision compared to criterion methods (Potter *et al.*, 2024).

Interventions to reduce overweight and obesity and improve physical fitness outcomes

The SAN has a current intervention program (The Lifestyle and Weight Management Clinic) which was designed and implemented by SAMHS health professionals working at IMM. The program aims to reduce obesity and improve physical fitness in the SAN. The program promotes healthy weight loss through health education, nutritional, behavioural, and exercise education. It is recommended that the program implemented by IMM become evidence based, so that the data collected be analysed to see if the program is reducing overweight and obesity and improving PF. The US Navy's Ship Shape (SS) program is based on the same intervention strategies as IMM's program but has currently enhanced their program to include acceptance and commitment therapy (ACT). The ACT-enhanced SS program is designed to promote a sense of mindfulness within the present moment, enhance psychological flexibility, and encourage a commitment to behaviour change (Afari *et al.*, 2019). A cohort- randomized trial is currently in progress and no results have been published yet, but this could be a future recommendation to enhance the current program managed at IMM. The ACT intervention

protocol combines ACT principles with standard SS strategies, which addresses the specific needs of active-duty personnel. It focuses on facing challenging situations according to values, aligning with the military's culture and core principles. ACT-consistent strategies enhance military personnel's performance, promoting values-driven commitment to operational goals (Afari *et al.*, 2019). Research suggests that ACT strategies have the potential for improving health behaviours and weight management in active-duty personnel. This study was designed for real-world Navy settings and is aimed at a diverse population. The results could inform the next steps in an evidence-based approach to weight management and physical fitness in the military which can be applied to SAN.

Implement an Artificial Intelligence Weight Management System

The military population, in particular the SAN consists of large cohorts of overweight sailors which are constantly sailing and require intervention, it is best suited and recommended to make use of Artificial Intelligence (AI) to optimize delivery of weight loss treatment even while sailing. Reinforcement learning (RL) is an AI technique that optimizes behavioural weight loss (BWL) by tracking outcomes associated with specific actions. It's increasingly used in medical treatments and has been successfully used in BWL by dynamically choosing treatments based on digital data (Forman *et al.*, 2022). A current randomized trial is underway which is the first full-scale trial of an AI-based system for optimizing weight loss treatment delivery. The system predicts the most effective intervention for a participant at any given time, within resource constraints. The study examines efficacy, cost-effectiveness, moderators, feasibility, and acceptability (Forman *et al.*, 2022).

The current obesity treatment trial focuses on reducing costs without sacrificing outcomes by efficiently allocating resources. RL-based AI algorithms are used to optimize coaching in various behaviour domains but not weight loss. The proposed AI approach re-optimizes treatment continuously and in a fully automated, highly scalable fashion, unlike stepped care (Forman *et al.*, 2022). The AI system will select interventions based on cost and effectiveness, ensuring participants receive the most beneficial option. This system prevents resource withdrawal from suboptimal treatment responses. This approach will aim to optimize use of lower-cost paraprofessionals, optimize counsellor time and training, and evaluate AI intervention selection predictors for future AI systems (Forman *et al.*, 2022).

Stakeholder collaboration

Collaborating with various stakeholders such as gyms, local supermarkets and health insurance companies, can assist in reducing the prevalence of overweight and obesity and improve PF outcomes. It is recommended that SAN and SANDF engage with various stakeholders and agree to a memorandum of understanding for e.g. discounted gym fees and/or premiums, healthy foods and exercise equipment or training gear. The South African Police Service has signed a memorandum of understanding to promote and preserve the health and physical well-being of its personnel. As a result, all police officers received a 20% discount on their monthly membership fee at Virgin Active or Planet Fitness gyms (*South African Police Service*, 2024). The SANDF should follow suit to further incentivise their wellness programs.

Leadership support

Leadership has been identified as a critical success factor for workplace wellness programs. Even though IMM has an intervention program that is comprehensive and appears to contain most of the necessary components to guarantee program success, it was unclear what examples senior ranking officers, divisional officers, and Officer commanders were setting to motivate employees to participate in wellness programs. Leaders actively engaged in wellness initiatives are more likely to generate employee participation. According to Zula (2014), leadership involvement is a crucial factor in the success of workplace wellness programs.

Update and amend policies

It is recommended that the policy for Processes and Procedures on South African Military Health Service's Health Care Delivery review the policy guideline for health classification of obesity. This policy guideline needs to be reviewed per WHO guidelines for BMI cutoff points, especially for operational status that can still be determined as G1N1K1 with a BMI ≥ 30 kg/m² (Department of Defence, 2013). The WHR is the next step in determining obesity in the current policy guidelines, which need to include body fat percentage and assessment of fat and lean body components. Despite having a WHR less than 1 and a BMI greater than ≥ 30 kg/m² members can still be determined operationally cleared with a G1N1K1 status (Department of Defence, 2013). For this reason, this guideline in the policy must be reviewed and recommended to be amended.

6.3 Recommendations for further research

Further similar studies in the South African Navy

The study utilised secondary data, which involved thorough data collection. Considering this, it would be advantageous for the organisation to utilize existing data more routinely to determine the burden of overweight and obesity through ongoing monitoring and evaluation which would be more cost effective and beneficial.

Increase research on overweight and obesity and physical fitness outcomes in SANDF

There are limited data and studies on overweight and obesity prevalence in the SANDF, especially in the SAN. More research is needed to investigate the burden of obesity and overweight and PF to assist in reducing this burden and improving PF outcomes to achieve a healthy and fit SAN and SANDF community.

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Appendix I: Ethics approval



UNIVERSITY of the
WESTERN CAPE

Directorate: DVC: Research and Innovation
Research and Postgraduate Support
Tel: +27 21 959 4111
Email: research-ethics@uwc.ac.za

08 December 2023

MS A Goliath-Mantis
School of Public Health
Faculty of Community and Health Sciences

BMREC Reference Number: BM23/10/13

Project Title: The association between body size and physical fitness amidst the COVID-19 pandemic: A South African naval personnel retrospective longitudinal study

Approval Period: 07 December 2023 – 06 December 2024

I hereby certify that the Biomedical Science Research Ethics Committee of the University of the Western Cape approved the scientific methodology, and ethics of the above-mentioned research project.

Any further amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit an annual progress report at least two months before expiry date. Failure to submit your annual progress report on time will result in the immediate lapse of your ethics approval and you will have to resubmit an entirely new ethics application.

For permission to conduct research using student and/or staff data or to distribute research surveys/questionnaires please apply via: <https://sites.google.com/uwc.ac.za/permissionresearch/home>

The permission letter must then be submitted to BMREC for record keeping purposes.

The Committee must be informed of any serious adverse event and/or termination of the study.

A handwritten signature in black ink, appearing to read 'Patricia Josias'.

*Ms Patricia Josias
Coordinator: Research Ethics
University of the Western Cape*

NHREC Registration Number: BMREC-130416-050

University of the Western Cape, Robert Sobukwe Road, Bellville 7535, Republic of South Africa

Appendix II: Ethics approval from 1MHREC

RESTRICTED

1MH/302/06/01.03.2024

1



sa military health service

Department:

Defence

REPUBLIC OF SOUTH AFRICA

Telephone: 012 314 0013
Facsimile: 012 314 0013
Enquiries: Dr / Col. TG. Mothabeng

1 Military Hospital
Private Bag x 1023
Thaba Tshwane
0143
9 July 2024

CLINICAL TRIAL APPROVAL: STUDY NUMBER: 01.03.2024 "THE STUDY REGARDING THE ASSOCIATION BETWEEN BODY SIZE AND PHYSICAL FITNESS AMIDST THE COVID-19 PANDEMIC: A SOUTH AFRICAN NAVAL PERSONNEL RETROSPECTIVE LONGITUDINAL STUDY"

1. The 1 Military Hospital Research Ethics Committee (1MHREC) registered in South Africa with the National Health Research Ethics Council (NHREC) (REC-111208-019-RA) adhering to GCP/ICH and SA Clinical Trial guidelines, evaluated the above-mentioned protocol and additional documents.

2. The following documents were evaluated:

- a. Personalised Covering Letter from Principal Investigator
- b. Research Proposal
- c. Data Collection Tools Excel Spreadsheet 2018 - 2023
- d. Approval Letter dd 08 December 2023 from the University of Western Cape Faculty of Community and Health Sciences REC
- e. Letter of Permission dd 10 August 2023 from Surgeon General to conduct Research
- f. Letter of Permission dd 14 December 2023 from Defence Intelligence
- g. Declaration of Storage of Research Data and/or Documents
- h. Declaration of Originality and Conflict of Interest
- i. Updated Curricula Vitae with supporting documents:
 - i. A.W. Goliath
 - ii. Z J Mchiza
 - iii. C van Wijk

3. The recommendations are: The study was ethically approved on 9 July 2024. The approved Principal Investigator is Capt. A.W. Goliath.

4. The study is granted research ethics approval for a period of 12 months. At the end of this period the Principal Investigator must apply for re-extension of the study. Failure to re-apply will result in approval expiring and data generated after the 12-month period, not being able to be included as part of the research project.

5. Report back is to be made to the 1MHREC annually. In the event of any serious adverse events the researcher must submit reports every 3 months and on completion or termination of the study. Research ethics approval is granted subject to concurrent ongoing approval from Military Defence Intelligence and the relevant study

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CLINICAL TRIAL APPROVAL: STUDY NUMBER: 01.03.2024 "THE STUDY REGARDING THE ASSOCIATION BETWEEN BODY SIZE AND PHYSICAL FITNESS AMIDST THE COVID-19 PANDEMIC: A SOUTH AFRICAN NAVAL PERSONNEL RETROSPECTIVE LONGITUDINAL STUDY"

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supervisors and overseers.

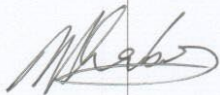
6. The research study was classified as a low-risk study and therefore the PI needs to submit yearly progress reports to the 1MHREC.

7. Should publications result from the study, the relevant manuscripts will also need to be approved by Military Defence Intelligence as well as the 1MHREC before publication or presentations may occur.

8. All funds generated through this research study must be paid into an approved Regimental Fund account.

9. The onus lies with the PI to comply with the abovementioned requirements. Failure to comply with the requirements will lead to approval of the study being revoked. Furthermore, the 1MHREC will inform publishing houses to withdraw presentations and/or publications if the PI failed to obtain permission from 1MHREC and Defence Intelligence before any presentations or publications were made.

10. The 1 MHREC wishes you success with the study.



**(T.G. MOTHABENG)
VICE CHAIRPERSON 1 MILITARY HOSPITAL RESEARCH ETHICS COMMITTEE:
COL**

DIST

For Action

Capt. A.W. Goliath

"Towards Military Health Excellence"

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Appendix III: Permission letter to conduct research

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sa military health service

Department:
Defence
REPUBLIC OF SOUTH AFRICA

NBS/IMMR/103/23/1

Telephone: 021 787 4536
Extension: 021 787 4536
Cellphone: 078 456 8470
E-mail: sw.gofath@gmail.com
Enquiries: Capt A.W. Gofath

Institute for Maritime Medicine
Private Bag X1
Simon's Town
7805
10 August 2023

AUTHORITY REQUESTED TO ANALYSE SECONDARY DATA AT THE INSTITUTE FOR MARITIME MEDICINE FOR THE THESIS ENTITLED: THE PREVALENCE OF OVERWEIGHT AND OBESITY AND THE ASSOCIATION TO PHYSICAL FITNESS AMONG ADULTS IN SIMON'S TOWN

1. The purpose of this letter is to request authorisation to conduct data analysis on secondary data at the Institute for Maritime Medicine (IMM). The abovementioned research study will be conducted as part of a mini-thesis, for the registered degree in a Masters in Public Health at the University of the Western Cape (UWC).
2. The problem identified at IMM is that several naval members are being referred for lifestyle modification due to increased body mass index (BMI) and waist circumference measurements. A dearth of data on the prevalence of overweight and obesity in the South African Navy (SAN) exists and this can affect the combat readiness, productivity and maintenance of staff if not effectively addressed.
3. The aim of this study is to assess the prevalence of overweight and obesity and the association to physical fitness among naval members in Simon's Town. Despite the problem of increased referrals for lifestyle modification due to increased BMI and waist circumference, the prevalence of overweight and obesity in the SAN remains unknown. The problem can only be addressed if the prevalence of overweight and obesity is known, so that effective programmes focused on prevention and health promotion can be developed to address overweight and obesity. This can lead to a reduction in BMI status and increase combat readiness, productivity and maintenance of staff. The reduction in BMI can effectively decrease the burden on the healthcare system and healthcare costs at IMM.
4. The objectives of the study are as follows:
 - a. To assess the prevalence of overweight and obesity in the SAN.
 - b. To assess the sociodemographic factors of overweight and obesity in the SAN.
 - c. To assess the association of overweight and obesity and physical fitness in the SAN.



"Health Warriors Serving the Brave"
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Umsikeko: Ikhosi LaseNingizimu Afrika - Ikhosi LaseNingizimu Afrika - Ikhosi LaseNingizimu Afrika - Ikhosi LaseNingizimu Afrika - Ikhosi LaseNingizimu Afrika - Ikhosi LaseNingizimu Afrika - Ikhosi LaseNingizimu Afrika - Ikhosi LaseNingizimu Afrika - Ikhosi LaseNingizimu Afrika - Ikhosi LaseNingizimu Afrika

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AUTHORITY REQUESTED TO ANALYSE SECONDARY DATA AT THE INSTITUTE FOR MARITIME MEDICINE FOR THE THESIS ENTITLED: THE PREVALENCE OF OVERWEIGHT AND OBESITY AND THE ASSOCIATION TO PHYSICAL FITNESS AMONG ADULTS IN SIMON'S TOWN

REMARKS BY STAFF OFFICER MARITIME HEALTH INSTITUTE FOR MARITIME MEDICINE:

Recommended/~~Not recommended~~

Highly recommended as this research would contribute to future planning and clinical management.


(R. P. TERBLANCHE)
SO1 MARITIME HEALTH IMM: MAJOR

Date: 2023/08/10

REMARKS BY OFFICER COMMANDING INSTITUTE FOR MARITIME MEDICINE:

Recommended/~~Not recommended~~

Strongly Recommended.


(C. ARNOLD)
OFFICER COMMANDING INSTITUTE FOR MARITIME MEDICINE: COLONEL

Date: 2023/08/11

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AUTHORITY REQUESTED TO ANALYSE SECONDARY DATA AT THE INSTITUTE FOR MARITIME MEDICINE FOR THE THESIS ENTITLED: THE PREVALENCE OF OVERWEIGHT AND OBESITY AND THE ASSOCIATION TO PHYSICAL FITNESS AMONG ADULTS IN SIMON'S TOWN

REMARKS BY GENERAL OFFICER COMMANDING TERTIARY MILITARY HEALTH FORMATION:

Recommended/Not recommended

The study is highly recommended


Col (Dr) P. Ngqakamba
85002277PE
SSO MED TMHF
Date: *15/08/2023*

M (L.C. FOSA)
GENERAL OFFICER COMMANDING TERTIARY MILITARY HEALTH FORMATION:
BRIGADIER GENERAL

Date:

REMARKS BY ACTING DIRECTOR ANCILLARY HEALTH:

Recommended/Not recommended

Strongly recommended

Research findings can be implemented in Health Life style projects managed by Dr Health at Level 4


(J. MAGAN GOVIND)
ACTING DIRECTOR ANCILLARY HEALTH: COLONEL

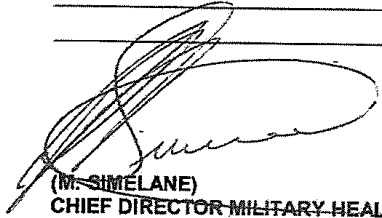
Date: *6/10/2023*

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AUTHORITY REQUESTED TO ANALYSE SECONDARY DATA AT THE INSTITUTE FOR MARITIME MEDICINE FOR THE THESIS ENTITLED: THE PREVALENCE OF OVERWEIGHT AND OBESITY AND THE ASSOCIATION TO PHYSICAL FITNESS AMONG ADULTS IN SIMON'S TOWN

REMARKS BY CHIEF DIRECTOR MILITARY HEALTH FORCE PREPARATION:

Recommended/Not recommended

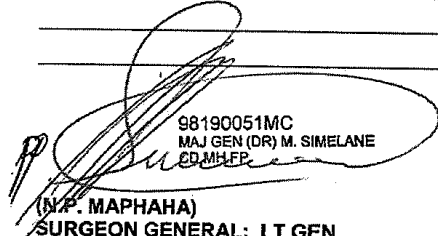


**(M. SIMELANE)
CHIEF DIRECTOR MILITARY HEALTH FORCE PREPARATION: MAJ GEN**

Date:11.OCT.2023.....

REMARKS BY SURGEON GENERAL:

Approved/Not Approved



**(M.P. MAPHAHA)
SURGEON GENERAL: LT GEN**

Date:11.OCT.2023.....

D:\Masters\MPH 2023\Thesis\Letter of Permission.pdf

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For Info

SO1 Ancillary Health TMHF

Internal

File: NBS/IMM/R/103/23/1

Appendix IV: Defence intelligence letter to conduct research

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defence intelligence

Department:
Defence
REPUBLIC OF SOUTH AFRICA

Telephone: 012 315 0502
Extension: 816 0502
Facsimile: 012 326 3246
Enquiries: Maj A.M. van Vuuren

DEF INT/R/202/3/7

Department of Defence
Def Int Division HQ
Private Bag X367
Pretoria
0001

14 December 2023

AUTHORITY TO CONDUCT RESEARCH WITHIN THE DEPARTMENT OF DEFENCE (DOD): 01058957MC CAPT A.W. GOLIATH

1. Receipt of request letter NBS/IMM/R/103/23/1 dated 27 November 2023 to conduct research within the DOD is hereby acknowledged.
2. Security Clearance Status:
 - a. MZ Number: 000534648
 - b. Confidential Issued on 20150626 Expiring on 20250626
3. Permission is hereby granted from a security perspective for 01058957MC Capt A.W. Goliath to conduct research within the DOD on a topic entitled **"The Association Between Body Size and Physical Fitness amidst the Covid 19 Pandemic: A South African Naval Personnel Retrospective Longitudinal Study"** as a requirement for the fulfillment of a degree in a Masters in Public Health at the University of the Western Cape (UWC).
4. After completion of the research, the final research product must be forwarded to Defence Intelligence Division (DI), Sub-Division Counter Intelligence (SDCI) for final authorization before it may be published or distributed to any entity outside the DOD.
5. Approval is granted on condition that there is strict adherence to inter alia DODI 2/99 "Disclosure of Defence Information" and Section 104 of the Defence Act (Act 42 of 2000) pertaining to protection of DOD Classified Information and the consequences of non-compliance.
6. For your attention.

D.E. MHLONYANE
ACTING DIRECTOR-DEPARTMENTAL SECURITY: R ADM (JG)

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Appendix V: Data Collection Tools

Participant Number	Non Operational & Operational	RANK	GEN DER	A G E	2.4 KM TIME	2.4 KM PTS	PUSH-UPS AMOUNT	PUSH-UPS PTS	SIT-UPS AMOUNT	SITUPS PTS	SHUTTLE RUNS TIME	SHUTTLE RUNS PTS	4KM WALK TIME	4KM WALK PTS	TO TAL	REMARKS	WEIGHT	HEIGHT	B MI	W AIST	H I P	W H R	
1	1	CAPT	M	45	11:00	840	22	600	34	590	52	975	N/A		3005	PASS							
2	1	CAPT	F	50	20:16	0	30	648	35	740	N/A		N/A		1388	FAIL							
3	1	WO1	M	43	13:20	500	40	720	43	610	57	725	34:36:00	0	2555	FAIL							
4	1	AB	F	31	19:51	0	10	0	15	440	78	0	38:40:00	0	440	FAIL							
5	1	WO1	M	56	11:08	884	35	792	60	900	N/A		N/A		2576	PASS							
6	1	CO	F	33	16:05	0	34	600	32	610	67	675	34:50:00	620	2505	FAIL							
7	1	PO	M	30	11:25	670	25	420	55	600	70	0	26:58:00	964	2654	FAIL							
8	1	PO	M	30	13:05	470	30	480	30	0	53	775	0	0	1725	FAIL							
9	1	AB	M	22	09:10	940	50	720	70	750	44	490	27:00:00	960	3860	PASS							
10	1	AB	F	24	13:13	754	40	672	40	690	56	950	32:25:00	910	3976	PASS							
11	1	AB	F	24	15:06	528	34	600	33	620	62	800	35:30:00	540	3088	PASS							
12	1	AB	M	24	11:33	654	25	420	30	0	52	800	29:09:00	702	2576	FAIL							
13	1	SEA	M	27	12:00	600	47	684	60	650	53	775	37:00:00	0	2709	FAIL	90	1.75	29,39	103	115	0,89	
14	1	CAPT	M	53	N/A		31	708	26	510	60	775	31:37:00	886	2879	PASS							
15	1	CDR	M	39	11:38	704	31	612	45	660	56	750	30:41:00	758	3484	PASS							
16	1	WO2	F	47	16:20	620	30	648	30	690	N/A		N/A		1958	PASS							
17	1	WO2	M	54	18:44	0	10	456	6	0	69	550	N/A		1006	FAIL							
18	1	LTCDR	M	37	13:35	470	20	480	20	0	58	700	31:24:00	672	2322	FAIL							
19	1	WO2	M	45	12:40	640	25	636	39	640	54	925	N/A		2841	PASS							

