TREND, FACTORS AND CONSEQUENCES OF OVERWEIGHT AND OBESITY IN THE MALAYSIAN ARMY

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KUALA LUMPUR

2019

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THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PUBLIC HEALTH

FACULTY OF MEDICINE
UNIVERSITY OF MALAYA
KUALA LUMPUR

2019

UNIVERSITY OF MALAYA

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Matric No: **MHC 130015**

Name of Degree: **Doctor of Public Health**

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TREND, FACTORS AND CONSEQUENCES OF OVERWEIGHT AND OBESITY IN THE MALAYSIAN ARMY

ABSTRACT

The prevalence of overweight and obesity has been on the rise since decades affecting all nations across the world in both the general population and military organisation. The objectives of this study were to determine the trend and prevalence of overweight and obesity, factors associated with it, and their consequences on sickness absenteeism and physical fitness in the Malaysian Army. This study was divided into two phases. Phase 1 was a retrospective cohort study involving extraction of secondary data from 2275 army personnel medical and service records. Socio-demographic and occupational information was gathered from the service record, while information on Body Mass Index (BMI) and sickness absenteeism were extracted from the medical record. Phase 2 was a cross-sectional study involving 836 personnel. Phase 2 involved anthropometric measurement, body composition analysis, and Basic Military Fitness Test (BFMT), as well as questionnaires on smoking, physical activity (IPAQ) and dietary intake (24-hour dietary recall). The trend of overweight and obesity in the Malaysian Army has been increasing from 1990 to 2015. In 2015, the prevalence of overweight and obesity was 34.0% and 7.7% respectively. BMI had a high sensitivity but low specificity in classifying overweight especially in males. Around 62% of overweight males had a normal body fat percentage (BF%). Univariately, increasing age and duration of service, married, senior rank, household income >RM3000, and less frequent intake of food from home and high energy intake were associated with overweight and obesity. However, in the multivariate analysis, only the duration of service was significant. Compared to those who had served less than 5 years, the odds of being overweight and obese among those who had served between 5 to 10 years, between 10 to 15 years, and more than 15 years were 5.45 (95% CI: 1.71,8.30), 5.70 (95% CI: 1.44,12.64), and 9.87 (95% CI: 1.12,17.00) respectively. Overweight and obesity, increasing age, and females were significantly associated with higher sickness absenteeism and presenteeism. Overweight and obesity were also significantly associated with failing the BMFT. Compared to the normal weight personnel, the odds of failing the BMFT among the overweight and obese personnel were 1.60 (95% CI: 1.07, 2.39) and 2.11 (95% CI: 1.01, 4.43) respectively. The increasing trend of overweight and obesity, together with their consequences on productivity and performance should be concerning to the Malaysian Army. Intervention and preventive measures should start early in their career before they reached the overweight status. BF% should be used together with BMI to give more accurate classification of obesity and to avoid discriminating overweight personnel with high lean muscle mass. BFMT should be incorporated in the overall assessment together with BMI and BF% to ensure that the personnel are serious about maintaining their health and fitness.

(450 words)

Keywords: Overweight and obesity, military, sickness absenteeism, physical fitness, body mass index

TREND, FAKTOR DAN KESAN BERLEBIHAN BERAT BADAN DAN OBESITI DALAM TENTERA DARAT MALAYSIA

ABSTRAK

Prevalen berat badan berlebihan dan obesiti telah meningkat sejak berpuluh tahun yang lalu, melibatkan semua negara di seluruh dunia di kalangan orang awam dan juga tentera. Objektif kajian ini adalah untuk mengenalpasti trend dan prevalen bagi berat badan berlebihan dan obesiti, faktor-faktor yang berkaitan, dan kesan ke atas ketidakhadiran disebabkan oleh masalah kesihatan dan kecergasan fizikal dalam Tentera Darat Malaysia (TDM). Kajian ini terdiri daripada dua fasa. Fasa pertama adalah kajian retrospektif kohort melibatkan pengekstrakan data sekunder daripada rekod perubatan dan perkhidmatan 2275 anggota. Maklumat sosio-demografi dan pekerjaan diperoleh daripada rekod perkhidmatan, manakala Indeks Jisim Badan (BMI) dan ketidakhadiran disebabkan oleh masalah kesihatan diperoleh daripada rekod perubatan. Fasa kedua adalah kajian keratan rentas melibatkan 836 anggota. Fasa kedua melibatkan pengukuran antropometrik, analisa komposisi badan, dan Ujian Kecergasan Asas Tentera (BMFT), serta soalan berkaitan merokok, aktiviti fizikal (IPAQ) dan amalan diet (rekod diet 24 jam). Trend berat badan berlebihan dan obesiti dalam TDM telah meningkat semenjak 1990 sehingga 2015. Pada tahun 2015, prevalen berat badan berlebihan dan obesiti masing-masing adalah 34.0% dan 7.7%. BMI mempunyai tahap sensitiviti yang tinggi tetapi spesifisiti yang rendah dalam mengklasifikasikan berat badan berlebihan terutamanya di kalangan lelaki. Lebih kurang 62% lelaki yang mempunyai berat badan berlebihan mempunyai peratus lemak badan (BF%) yang normal. Secara univariat, umur dan tempoh perkhidmatan yang meningkat, berkahwin, pangkat senior, pendapatan isi rumah >RM3000, dan kurang pengambilan makanan dari rumah berkait dengan berat badan berlebihan dan obesiti. Walau bagaimanapun, hanya peningkatan tempoh perkhidmatan sahaja yang signifikan dalam analisis multivariat.

Berbanding dengan anggota yang berkhidmat kurang daripada lima tahun, kebarangkalian untuk berat badan berlebihan dan obesiti di kalangan anggota yang berkhidmat antara lima ke sepuluh tahun, antara sepuluh ke lima belas tahun, dan lima belas tahun ke atas masing-masing adalah 5.45 (95% CI: 1.71,8.30), 5.70 (95% CI: 1.44,12.64), dan 9.87 (95% CI: 1.12,17.00). Berat badan berlebihan dan obesiti, usia yang meningkat, dan wanita mempunyai kaitan signifikan dengan ketidakhadiran disebabkan oleh masalah kesihatan yang lebih tinggi. Berat badan berlebihan dan obesiti juga mempunyai kaitan yang signifikan dengan kegagalan BMFT. Berbanding dengan anggota yang mempunyai berat badan normal, kebarangkalian untuk gagal BMFT di kalangan anggota yang mempunyai berat badan berlebihan dan obes masing-masing adalah 1.60 (95% CI: 1.07, 2.39) dan 2.11 (95% CI: 1.01, 4.43). Peningkatan trend berat badan berlebihan dan obesiti, dan juga kesan terhadap produktiviti dan prestasi seharusnya mendapat perhatian daripada TDM. Intervensi dan langkah pencegahan sepatutnya bermula pada peringkat awal kerjaya sebelum anggota mencecah berat badan berlebihan. BF% juga perlu digunakan bersama dengan BMI untuk memberikan klasifikasi berat badan berlebihan dan obesiti yang lebih tepat untuk mengelakkan diskriminasi terhadap anggota yang mempunyai berat badan berlebihan disebabkan jisim otot yang tinggi. BMFT juga seharusnya digabungkan di dalam penilaian keseluruhan anggota bersama-sama dengan BMI dan BF% bagi memastikan anggota serius dalam mengekalkan tahap kesihatan dan kecergasan mereka.

(464 perkataan)

Kata kunci: Berlebihan berat badan dan obesiti, tentera, ketidakhadiran disebabkan masalah kesihatan, kecergasan fizikal, indeks jisim badan.

ACKNOWLEDGEMENTS

To mention a few is unfair for some would be left behind
To name all of you is impossible for the list will be endless
To everyone that we have crossed paths
from the day I decided to take on this journey
This thesis is dedicated to you
For you have inspired me in one way or another
My heartfelt gratitude goes to all of you

To my passionate co-supervisor, Associate Professor Dr Moy Foong Ming; your persistent encouragement have kept me on the track, and your endless motivation always makes me believe that this day will come, the knowledge you shared without holding back, and the friendship that flourished over the years, I cannot thank you enough.

To my enthusiastic co-supervisor, Professor Dr Victor Hoe Chee Wai Abdullah; your constructive criticisms did not just help to improve my work, but your thoughts and ideas always push me out of my box. You always see things from a different perspective but never hold back. I am indeed fortunate and thankful for all that.

To all the charismatic lecturers from the Department of Social and Preventive Medicine (SPM); thank you for all the knowledge passed on, the wisdom shared, and the doors and minds that you have opened up for all of us. With a special mention goes out to Associate Professor Karuthan Chinna; the statistics guru, who has made statistics believable, more straightforward and doable. Your way of teaching has helped me throughout this journey and has inspired many others. I am forever grateful to be part of the SPM Department.

To the Malaysian Armed Forces, the Malaysian Army and the Malaysian Armed Forces Health Services; thank you for granting me the opportunity to pursue my post-graduate study in Public Health, and for all the assistance given in completing my research. Above all, to all the participants, without whom this research would not be materialised, may the outcomes of this study served for the betterment of the organisation.

To my MPH and DrPH colleagues; I cherish all the moments, I appreciate all the support and encouragement, I admire the strength some of you have displayed, and above all, I treasure this friendship and hope it will last forever. My prayers go out for all of us that we all will cross the finish line.

To my wife; thank you for your patience and sacrifice for all these years, your support and believe when the going gets tough, and for being by my side. I am blessed. This is for you.

Thank you for being part of my journey

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LIST OF SYMBOLS AND ABBREVIATIONS

ACSM	:	American College of Sports Medicine
ADP	:	Air Displacement Plethysmography
AHA	:	American Heart Association
ATP	:	Adult Panel Treatment
BF%	:	Body Fat Percentage
BIA	:	Bioelectrical Impedance Analysis
BMI	:	Body Mass Index
CI	:	Confidence Interval
CDC	:	Centers for Disease Control and Prevention
CPD		Cigarette per Day
CPG	:	Clinical Practice Guidelines
CT	:	Computed Tomography
DEXA	:	Dual Energy X-ray Absorptiometry
DM	:	Diabetes Mellitus
FFM	:	Fat Free Mass
FM	:	Fat Mass
HQ	:	Headquarters
IDF	:	International Diabetes Federation
IHD	:	Ischaemic Heart Disease
IASO		International Association for the Study of Obesity
IPAQ	:	International Physical Activity Questionnaire
IPH	:	Institute for Public Health
IQR	:	Interquartile Range
Kcal	:	Kilocalories

LTPA	:	Leisure Time Physical Activity
METs	:	Metabolic Equivalent of Tasks
MM%	:	Muscle Mass Percentage
MRI	:	Magnetic Resonance Imaging
NHANES	:	National Health and Nutritional Examination Survey
NCDs	:	Non-Communicable Diseases
NCEP	:	National Cholesterol Education Program
NHMS	:	National Health and Morbidity Survey
NPV	:	Negative Predictive Value
OR	:	Odd Ratio
OSA	:	Obstructive Sleep Apnoea
PPV	:	Positive Predictive Value
PTI	:	Physical Training Instructor
QALYs	:	Quality Adjusted Life Years
QAT	:	Quality Assessment Tool
QOL	:	Quality of Life
RNI	:	Recommended Nutrient Intake
SD	:	Standard Deviation
SES	:	Socio-Economic Status
SOP	:	Standard Operating Procedure
SPSS	:	Statistical Package for Social Sciences
TDM	:	Tentera Darat Malaysia
UK	:	United Kingdom
UMMC	:	University Malaya Medical Centre
US	:	United States
VO_2max	:	Maximum Oxygen Consumption

WC	:	Waist Circumference
WHO	:	World Health Organization
>	:	More than
<	:	Less than
≥	:	More than or equal to
≤	:	Less than or equal to
%	:	Percentage

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

Overweight and obesity have emerged as a public health epidemic across the globe for decades (NCD-RisC, 2016; Popkin & Doak, 1998). There is extensive evidence of rising prevalence of overweight and obesity in both the general population (Stevens et al., 2012) and the military context (Fear, Sundin, & Rona, 2011; McLaughlin & Wittert, 2009). Military personnel are expected to maintain an optimum health and fitness level to perform their physically demanding tasks. Studies have shown that overweight and obesity affect military productivity and performance (Bustillos, Vargas, & Gomero-Cuadra, 2015; Sudom & Hachey, 2011). Thus, the increasing prevalence of overweight and obesity in the military setting and their consequences for military readiness are an imminent threat to the overall workforce.

This chapter highlights the growing trends in overweight and obesity in both the general population and the military organisation. Factors associated with overweight and obesity and their consequences in the military setting are also discussed in establishing the rationale for this study. This chapter also outlines the study objectives and describes the contribution of this research.

1.1 Background

1.1.1 Trend and prevalence of overweight and obesity

Within the three decades between 1980 and 2008, the World Health Organization (WHO) reported that the prevalence of overweight and obesity doubled from 5% to 8% among men and 10% to 14% among women (WHO, 2013). In 2005, it was estimated that almost one billion adults were overweight and around 400 million were obese

(Kelly, Yang, Chen, Reynolds, & He, 2008). The number of overweight and obese adults is expected to exceed two billion and one billion respectively by 2030 if no effective public health intervention in place.

This trend has spread across all regions of the world with the higher and upper-middle-income countries being worse off, and the low and lower-middle-income countries fast approaching. Although the prevalence of obesity among Asian countries is relatively lower compared to other regions (Ramachandran, Chamukuttan, Shetty, Arun, & Susairaj, 2012b), the prevalence of overweight and obesity is rising at a much faster rate (Ramachandran & Snehalatha, 2010). Based on the data from the National Health and Morbidity Survey (NHMS) from the Malaysian Institute for Public Health (IPH), the prevalence of obesity in Malaysia increased from 4% in 1996 (IPH, 1996), to 14% in 2006 (IPH, 2006) and 15.1% in 2011(IPH, 2011). These figures continued to surge, reaching 17.7% in 2015 (IPH, 2015). Similarly, the prevalence of overweight has increased from 16.6% to 29.1%, 29.4%, and 30.0% within these periods.

The military population has not been spared from the rising prevalence of overweight and obesity. The United States (US) Army has recorded an increase in the prevalence of obesity among their personnel, from 8.7% in 2002 to 12.9% in 2005 (Smith et al., 2012). Body mass index (BMI) profile in the South Korean Army had shown a 1.55% increment in the proportion of obese personnel from 2002 to 2008 (Bae, Kim, & Cho, 2011). Although the prevalence of obesity among military setting in most countries is slightly lower than their general population, it was the rising trends that created more concerns to the top administrators. There has been only one published study, on the prevalence of obesity among the Royal Malaysian Navy personnel in 2010 (Sedek, Poh, & Noor, 2010). This study reported the prevalence of obesity in 2004 to be 7.2%.

However, to the researcher's best knowledge, there have been no prevalence studies conducted in the Malaysian Army or Royal Malaysian Air Force so far.

Despite the evidence of increasing trend of overweight and obesity, studies in the military population are still limited compared to the general population, especially in Asian countries, and particularly in Malaysia.

1.1.2 Factors and predictors of overweight and obesity

Obesity is a complex multifactorial phenomenon. There is no one simple cause of overweight and obesity. It is an interplay of biological susceptibility, genetic make-up, and social and environmental influence (Nguyen & El-Serag, 2010). Factors strongly associated with overweight and obesity include unhealthy lifestyles such as physical inactivity (Fogelholm & Kukkonen-Harjula, 2000; Hill, 2005) and improper dietary intake (Rosenheck, 2008). Other factors include globalisation and nutritional transition that have increased economic prosperity, population affluent and purchasing power. Indirectly these have shifted the dietary profile from high fibres and carbohydrate diet to high animal fat, added sugar, and refined grains (Malik, Willett, & Hu, 2013). Socio-economic strata (McLaren, 2007; Monteiro, Moura, Conde, & Popkin, 2004), ethnicity (Khambalia & Seen, 2010; Wang & Beydoun, 2007), education level (Gutiérrez-Fisac, Regidor, Banegas, & Artalejo, 2002), and occupational factors (Caban et al., 2005; Cheong, Kandiah, Chinna, Chan, & Sasad, 2010) were also linked to overweight and obesity at varying degree. The dynamics of these interactions have created a public health challenge in managing overweight and obesity.

Studies have shown that despite the military strict entrance selection, and working in a physically demanding environment, overweight and obesity persist and may even post a more significant threat to the military population. The interaction of other internal factors such as genetic predispositions (Blundell et al., 2017; Nguyen & El-Serag, 2010) and external factors such as the environment (Li et al., 2010; Mattes & Foster, 2014) had outweighed the protective effects of physical activity. Modernisation has also taken its toll on the military setting, as urban development has encroached into the military surrounding taking away their 'green' and exposing them to the 'easy and fast' lifestyles. The army camps once used to be in a strategic location secluded from the public are now being surrounded by high-rise and housing estates in the name of development. Along come with these developments are numbers of fast food outlets and 24-hours eateries which always give them an alternatives to home-cook food. Although factors were nearly similar, they need to be evaluated in the context of the military population which somewhat may differ in terms of exposure, resilience, and outcome of overweight and obesity compared to the general population.

1.1.3 Consequences of overweight and obesity

The detrimental consequences of overweight and obesity have been well documented. Overweight and obesity have been proven to be associated with Non-Communicable Diseases (NCDs) such as type 2 diabetes, hypertension, coronary heart diseases, and cancer (Knai, Suhrcke, & Lobstein, 2007). It could affect millions of Quality-Adjusted Life Years (QALYs) (Anandacoomarasamy et al., 2009) and a considerable amount of direct medical costs (Allender & Rayner, 2007). Obesity has also been linked to psychological effects such as stress (Smith, White, Hadden, Young, & Marriott, 2014), stigmatisation (Giel et al., 2012) and discrimination (Sutin & Terracciano, 2013). Indirectly, overweight and obese employees are more likely to incur productivity loss through absenteeism, presenteeism and premature deaths (Wang, McPherson, Marsh, Gortmaker, & Brown, 2011).

In the military population, these consequences were amplified by the nature of their work. Overweight and obese military personnel are at higher risk of injuries and hospitalisation (Cowan, Bedno, Urban, Yi, & Niebuhr, 2011). This prospective cohort study (follow up of 12 weeks) found that even though the participants have to pass the fitness test before to be eligible, those who were over body fat (OBF) still had a risk of injuries and healthcare utilization. Other studies have shown the association between overweight and obesity with sickness absenteeism (Kyrolainen et al., 2008), and early discharge from the service (Packnett, Niebuhr, Bedno, & Cowan, 2011). More importantly, they were found to have lower fitness level and poor health status (Collee, Clarys, Geeraerts, Dugauquier, & Mullie, 2014). However, this was a cross-sectional study using convenience online sampling which maybe not representative of the population.

From the military point of view, these accumulative effects of overweight and obesity were translated into the loss of human resources and could jeopardise the total workforce and fighting strength. The impacts of overweight and obesity in military organisations should be viewed not just as a health threat, but also from the performance and productivity perspectives.

1.2 Research statement and study rationale

The increasing trend in the prevalence of overweight and obesity in the general population has been well established. In the military, most longitudinal studies on the trend of overweight and obesity are from the US Armed Forces and the European countries, such as the United Kingdom (UK) Armed Forces. However, studies on trends in overweight and obesity among the military population from the Asian countries, especially Malaysia are still lacking. Cultural and terrain differences, as well as variation in training doctrine and military technology advancement in Asian countries, may have a different influence on the epidemiology of overweight and obesity in their military populations. Identification of trends in overweight and obesity would enable appreciation of the magnitude of this problem and allow future projection of their prevalence. This information would be beneficial in planning and implementation of obesity-related health policy.

Obesity is a public health issue that has affected the global population, including the military. Due to its complex multi-factorial phenomena, the different population were affected to a varying extent (NCD-RIscC, 2016). Differences in the prevalence and factors associated with overweight and obesity between countries, and even between service branches within the same country, have been observed in the military population (Bae et al., 2011; Fajfrová et al., 2016; Reyes-Guzman, Bray, Forman-Hoffman, & Williams, 2015). Therefore, it is essential to identify factors associated with overweight and obesity within that specific population to enable effective intervention to be implemented.

The consequences of overweight and obesity on military personnel's productivity and performance will generate cumulative effects on the workforce as a whole. Military operational is based on teamwork and every personnel is expected to deliver or otherwise will compromise the whole operation. The organisation cannot afford to have any personnel being debilitated by overweight and obesity. Research on the consequences of overweight and obesity would further emphasise the importance of overweight and obesity in the military, especially in the Malaysian Army where studies are still limited.

Therefore, given these facts, it is imperative that studies on overweight and obesity are conducted in the Malaysian Army context. This proposed research will be the first large-scale cohort study combined with cross-sectional design that includes lifestyle factors associated with overweight and obesity. It will provide a comprehensive evaluation of the 25 years trend in overweight and obesity, their current prevalence, as well as their associations on physical fitness, and sickness absenteeism in the Malaysian Army. The results will be compared to the general population and other nations' Army.

1.3 Research questions and hypotheses

Five research questions and hypotheses have been generated at the start of this study to better understand the overweight and obesity phenomenon in the Malaysian Army.

Phase 1 – Retrospective Cohort study

- *Question 1*: What are the trends and incidence rates of overweight and obesity in the Malaysian Army? Are they comparable to the general Malaysian population and the military setting of other nations?
- *Hypotheses 1*: The trend and prevalence of overweight and obesity in the Malaysian Army are increasing along with the general population and military from other nations.

- *Question 2*: Are socio-demographic factors (age, sex, ethnicity, marital status and education level) and occupational factors (duration of service and rank) significant predictors of overweight and obesity in the Malaysian Army?
- *Hypothesis 2*: Socio-demographic and occupational factors are significant predictors of overweight and obesity in the Malaysian Army.

- *Question 3*: Are socio-demographic and occupational factors and BMI (overweight and obesity) a significant predictor of sickness absenteeism in the Malaysian Army?
- *Hypothesis 3*: Socio-demographic and occupational factors and BMI are significant predictors of sickness absenteeism in the Malaysian Army.

<u>Phase 2 – Cross-Sectional study</u>

- *Question 4*: In the cross-sectional study, are the socio-demographic, occupational and lifestyle factors (smoking, physical activity, dietary intake) significantly associated with overweight and obesity in the Malaysian Army?
- *Hypothesis 4*: There is no significant association between the socio-demographic, occupational and lifestyle factors with overweight and obesity in the Malaysian Army.

- *Question 5*: Are the socio-demographic, occupational, and lifestyle factors, and BMI significantly associated with physical fitness performance in the Malaysian Army?
- *Hypothesis5*: There is no significant association between socio-demographic, occupational, and lifestyle factors and BMI with physical fitness performance in the Malaysian Army.

1.4 Research objectives

1.4.1 General objective

The general objective of this study is to explore the trend and prevalence of overweight and obesity, and associated factors and consequences in the Malaysian Army context.

1.4.2 Specific Objectives

The specific objectives are divided according to the phases of this study.

The specific objectives for Phase 1 are:

a. To determine the trends of BMI changes and prevalence of overweight and obesity throughout military service in the Malaysian Army from 1990 to 2015.

b. To determine the socio-demographics and occupational predictors of overweight and obesity in the Malaysian Army.

c. To determine the implication of overweight and obesity on sickness absenteeism and presenteeism in the Malaysian Army.

The specific objectives for Phase 2 are:

a. To determine the prevalence of overweight and obesity based on BMI and BF% classification and to compare the diagnostic agreement between these two methods

b. To determine the association between socio-demographics, occupational, and lifestyle factors with overweight and obesity in the Malaysian Army.

c. To determine the consequences of overweight and obesity on physical fitness in the Malaysian Army.

1.5 Contribution of this research

Given the limited number of studies on overweight and obesity in the Malaysian Armed Forces generally and the Malaysian Army specifically, this research will explore the magnitude of this problem that has been affecting the military population in many countries around the world. The trends in overweight and obesity revealed from this study will be compared to the military from other countries as well as the general Malaysian population.

Predictors and factors associated with overweight and obesity revealed in this research will facilitate in planning more targeted approaches in preventing and managing overweight and obesity issues in the Malaysian Army. In an institutionalised population such as the military organisation that operates based on a chain of command, a targeted approach would be easier to implement and hence more effective not only in preventing obesity but also maintaining their BMI.

Being physically fit and able to perform the tasks efficiently are essential elements for military personnel. This research will determine how much overweight and obesity and other factors affecting military personnel's physical fitness and also their work productivity in terms of sickness absenteeism and presenteeism. These identified factors will serve as guidelines to policymakers in the Malaysian Army in drafting any recommendations, standards or programmes to maintain the soldier's fitness, productivity, and effectiveness throughout their career.

1.6 Summary of Chapter 1

The prevalence of overweight and obesity has been steadily increasing for decades in both the general and the military population. Multiple factors have been linked to overweight and obesity. Although these factors may be similar, their effects in the military population may have different magnitudes. The consequences of overweight and obesity on physical fitness and sickness absenteeism are among the leading concerns in the military besides its effect on the general physical and mental health. Despite all these, studies on overweight and obesity in the military population are still lacking compared to the general population. This study aims to determine the trend, factors, and implication of overweight and obesity in the Malaysian Army.

CHAPTER 2: LITERATURE REVIEW

This chapter presents the review of the literature covering the scope of different techniques of obesity measurement and its classifications. The review also focuses on the core matters of this research, including the trend and prevalence of overweight and obesity, associated factors, and their consequences in both the civilian population generally but more specifically in the military population.

2.1 Measurements and classifications of adiposity

At the tissue level, human body compositions are made up mainly of muscles, the skeleton and adipose tissues (Duren et al., 2008). Adipose tissues are commonly referred as fat mass (FM), while the skeleton and the muscles are fat-free mass (FFM). Obesity refers to excess fat in the body, and the classification varies depending on the tools used in the measurement of obesity (Burkhauser & Cawley, 2008). The literature review will focus on the most commonly used methods in the assessment of obesity, which are the anthropometric measurements and body compositions. Anthropometric measurements include height, weight, hip and waist circumferences (WC), and skinfold thickness. Body compositions are normally assessed using Bioelectrical Impedance Analysis (BIA) and Dual Energy X-ray Absorptiometry (DEXA). More complex methods rarely used in the clinical setting include Air Displacement Plethysmography (ADP), dilution techniques, hydrodensitometry, Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scan (Beechy, Galpern, Petrone, & Das, 2012).

These techniques have their advantages and disadvantages in terms of accuracy, cost, feasibility, and practicality. The best tools should be able to provide an accurate and reproducible measurement at a minimal cost. choice of tools depends on the objectives of the study, size of the study and ultimately the availability of the method chosen. Cost and time required for each procedure, as well as equipment maintenance, should also be taken into consideration (Mullie, Vansant, Hulens, Clarys, & Degrave, 2008). Among the most commonly used methods in epidemiological studies to assess obesity are BMI, BIA and WC (Duren et al., 2008).

2.1.1 Anthropometric measurements

2.1.1.1 Body mass index

BMI measures the proportions of an individual's weight and height. A Belgian mathematician Adolphus Quetelet first described it in the 19th century (Okorodudu et al., 2010; Quetelet, 1994). BMI can be calculated by dividing weight in kilogram by height squared in meters and expressed in the unit of kilogram per meter squared (kg/m^2) as shown below;

$$\text{Body Mass Index} = \frac{\text{Weight (kg)}}{\text{Height}^2\ (m^2)}$$

The WHO classifies obesity as a BMI $\geq$30 kg/m^2. Detailed BMI classifications according to the WHO are shown in Table 2.1 (WHO, 2004).

Table 2.1: The international classification of adult underweight, overweight and obesity according to BMI

Classification	BMI (kg/m^2)	
	Principal cut-off points	Additional cut-off points
Underweight	<18.50	<18.50
Normal weight	18.50 – 24.99	18.50 – 22.99
		23.00 – 24.99
Overweight	25.00 – 29.99	25.00 – 27.49
		27.50 – 29.00
Obese	≥30.00	≥30.00
Obese Class I	30.00 – 34.99	30.00 – 32.49
		32.50 – 34.99
Obese Class II	35.00 – 39.99	35.00 – 37.49
		37.50 – 39.99
Obese Class III	≥40.00	≥40.00

Adapted from (WHO, 2004)

Additional cut-off points of 23.0, 27.5, 32.5 and 37.5 kg/m^2 were introduced by the WHO (Barba et al., 2004) after researchers from Asian countries found that the prevalence obesity-related mortality and morbidity occurred at a lower BMI cut-off (Wang et al., 2010). Furthermore, the principal cut-off points were developed based on European and the US population mortality and morbidity (Zaher et al., 2009). Additional cut-off points were added as a public health action points while maintaining the principal cut-off point for international classification and reference values for comparison. Malaysia has adopted the additional cut-off points in their Clinical Practice Guidelines (CPG) on Management of Obesity (Ismail et al., 2004).

BMI is the most commonly used obesity proxy, especially in a large-scale epidemiological study, due to being inexpensive and practical. It does not need extensive training or experts' supervision to implement, thus reduce inter-observer discrepancies and require less energy, time and cost. There is voluminous data on BMI available at the national, regional and international levels, thus enabling comparison and trend observation (Beechy et al., 2012; Duren et al., 2008).

Despite these advantages, BMI is highly criticised mainly for its inability to differentiate between the FM and FFM from the total body weight, thus misclassified an individual as obese or non-obese (Burkhauser & Cawley, 2008; Gomez-Ambrosi et al., 2012; Romero-Corral et al., 2008). Furthermore, BMI is not age, gender, and race-specific (Burkhauser & Cawley, 2008; Goacher, Lambert, & Moffatt, 2012). A study has shown that BMI has over-classified African American men who have higher FFM (mainly muscles) as obese although they have substantially lower BF% compared to the White American men. These differences were not so obvious among females (Burkhauser & Cawley, 2008).

Numerous studies have shown that although BMI has high sensitivity, its specificity is quite low when compared to obesity classified by BF% (Collins et al., 2017; Habib, 2013; Okorodudu et al., 2010). The proportions of misclassification are more evident among the intermediate BMI range of 24 to 28 kg/m^2 and in men (Romero-Corral et al., 2008; Wang et al., 2010).

2.1.1.2 Waist circumference

Fatty tissues in the body are distributed under the skin (subcutaneous fat) and around organs (visceral fat). Increased deposition of fatty tissues around the abdominal organs will lead to central obesity or abdominal obesity. WC is among the most reliable and most commonly used measurements to assess abdominal obesity (Shuster, Patlas, Pinthus, & Mourtzakis, 2012), apart from the waist-to-hip ratio (WHR) and more advanced imaging techniques.

There are few methods or reference points where WC is usually measured. WHO in their Report of WHO Expert Consultation on Waist Circumference and Waist-Hip Ratio has summarised few reference points that are commonly used in many studies (WHO, 2011). These landmarks are illustrated in Figure 2.1 below. Most of studies measure WC at the midpoint between iliac crest and the lowest margin of the last rib (reference point 1). Some studies measure at the umbilical level (reference point 2), while other studies measure at the minimal waist point (reference point 3) or at the top of the iliac crest (reference point 4). However, the differences in the techniques used to measure WC do not affect the association between WC and cardiovascular risk and mortality and diabetes (Ross et al., 2008).

WC classification is based on the risk of developing obesity-related adverse health outcomes, mainly cardiovascular diseases, and Type 2 diabetes. These risks are rated together with BMI as shown in Table 2.2 (WHO, 2011). Some of the Asian countries including Malaysia are using lower cut-off points for WC; <90cm for men and <80cm for women (Ismail et al., 2004).

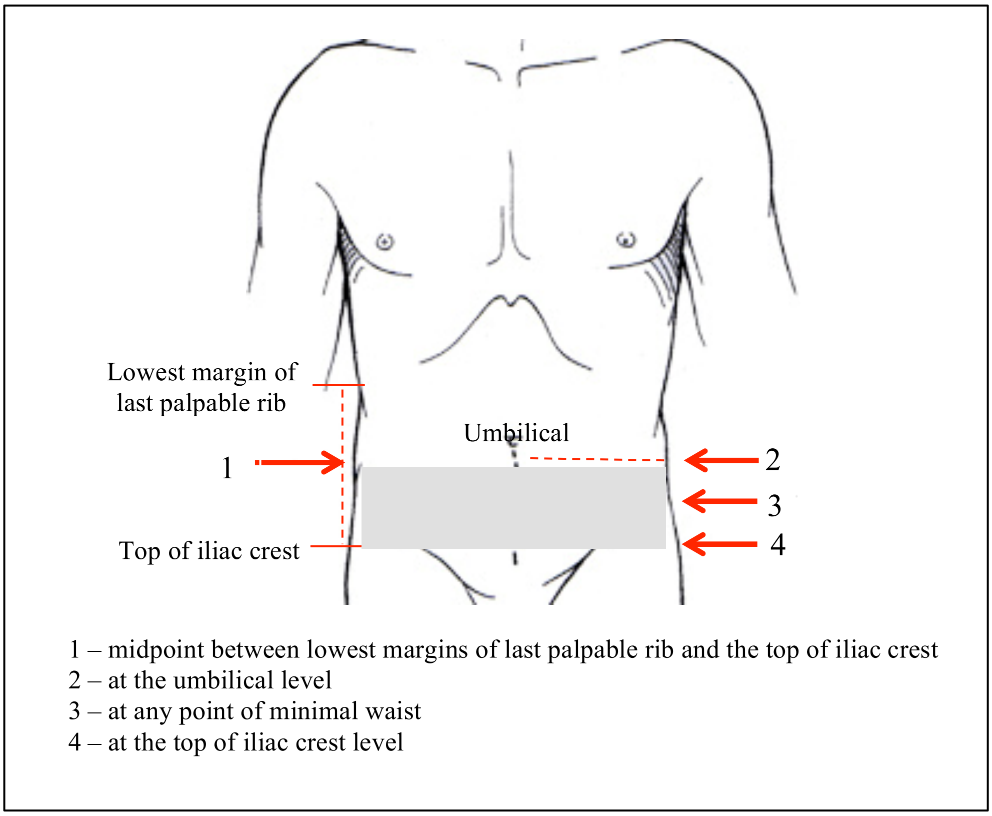


Figure 2.1: Common reference point for waist circumference measurement according to the WHO Expert Consultation of Waist Circumference

Table 2.2: Risk of obesity-related health problems based on waist circumference and body mass index

Classification	BMI (kg/m^2)	Disease Risks	
		WC <102 cm (Men) WC <88 cm (Women)	WC ≥102 cm (Men) WC ≥88 cm (Women)
Underweight	<18.50		
Normal	18.50 – 24.99		
Overweight	25.00 – 29.99	Increased	High
Obese Class I	30.00 – 34.99	High	Very high
Obese Class II	35.00 – 39.99	Very high	Very high
Obese Class III	≥40.00	Extremely High	Extremely High

Adapted from (WHO, 2011)

Several countries and regions use different cut-off points to define central obesity as one of the essential criteria in the diagnosis of metabolic syndrome (Table 2.3). The two most commonly used WC classifications especially in the US and the European countries are the WHO (WHO, 1999) and the National Cholesterol Education Program Adult Panel Treatment III (NCEP ATP III) (Grundy et al., 2002). These two classifications adopted higher cut-off for both males and females. Another classification that is used mostly by the Asian countries and other regions in the world is that of the International Diabetes Federation (IDF) (Alberti, 2006). The IDF classification adopted lower cut-off points and are different between the regions as well. The Japanese and Chinese use an even lower cut-off point specifically for their population (Bei-Fan, 2002; Oka et al., 2008). Some countries are using and reporting different cut-offs for clinical purposes and epidemiological comparisons.

Although measurement of WC is less costly, it requires a skilled and trained individual to ensure accurate, consistent, and reliable measurement. Thus, it is prone to intra-observer and inter-observer differences. Measurement of WC in a severely obese individual is even more challenging due to difficulties in finding the exact landmarks (Beechy et al., 2012).

In terms of clinical consequences, several studies have found that WC shows better correlation with cardiovascular risks compared to BMI (Balkau et al., 2007; Yusuf et al., 2005) and highly reliable in assessing abdominal obesity. Furthermore, data on WC from various countries are widely available for comparison.

Table 2.3: Waist circumference cut-off according regions and ethnic groups

Country/ Region/ Ethnic group	Classification	Waist circumference cut-off	
		Male	Female
Europids	IDF NCEP ATP III	≥94 cm ≥102 cm	≥80 cm ≥88 cm
Caucasians	WHO	≥94 cm	≥80 cm
United States	NCEP ATP III	≥102 cm	≥88 cm
Japan	IDF Japanese Obesity Society	≥90 cm ≥85 cm	≥80 cm ≥80 cm
China	IDF Cooperative Task Force	≥90 cm ≥85 cm	≥80 cm ≥80 cm
Asian, Central and Southern American	IDF	≥90 cm	≥80 cm
Middle Eastern, Mediterranean, Sub-Saharan African	IDF	≥94 cm	≥80 cm
Malaysia	Malaysian CPG IDF	≥90 cm	≥80 cm

IDF – International Diabetes Federation
NCEP ATP III - National Cholesterol Education Program Adult Panel Treatment III
WHO – World Health Organization

2.1.2 Body compositions

2.1.2.1 Bioelectrical Impedance Analysis

BIA works based on the concept of differences in tissue's electrical conductivity. Tissues with high water content such as the muscle tissues are better electrical conductor compared to tissues with low water content such as the adipose tissues (Beechy et al., 2012; Duren et al., 2008). BIA measures the body composition through estimation of total body water and the FFM, while FM is deduced from the difference between body weight and FFM. Percentage of body fat can be calculated from;

$$\text{Body Fat Percentage (BF\%)} = \frac{\text{Fat mass in kg}}{\text{Body weight in kg}} \times 100$$

To date, there is no consensus on the classification of obesity based on BF% (Ho-Pham, Campbell, & Nguyen, 2011). However, most studies have used the BF% cut-offs of $\geq$20 to $\geq$25% and $\geq$30 to $\geq$35% to define obesity for men and women respectively (Collins et al., 2017; Gomez-Ambrosi et al., 2012)

Although BIA is considerably more expensive, it provides a direct evaluation of BF% and therefore gives a more accurate measure of adiposity compared to BMI. The estimation is gender specific and is not affected by individual's weight and height. It is also considered non-invasive, safe and there is no risk from repeated measurements (Beechy et al., 2012). The only disadvantage of BIA is its inability to measure fatness in moderate to severe obesity due to different hydration factors and higher extracellular water content. This issue was overcome by the recent development of fatness specific BIA that consider these factors (Beechy et al., 2012).

2.1.2.2 Other methods

Other methods used to determine body compositions include DEXA, which is considered the new gold standard in body composition analysis as it enables accurate determination of lean body mass (Branski et al., 2010). The participant needs to lie still on the DEXA table while an x-ray beam passes through the whole body. It is useful in detecting intra-abdominal obesity and able to differentiate gynoid and android obesity (Beechy et al., 2012). It requires trained technicians to handle this machine, but once they are trained, the DEXA machine is very user-friendly. It takes less than 20 minutes to complete the scan, and the level of exposure is very low (Duren et al., 2008). The fact that the participants have to lie on the DEXA platform has limited its usage for the extremely obese, heavy and big size participants. The measurement of obesity in these extreme groups is rather inaccurate (Beechy et al., 2012). The other disadvantages of DEXA scanning are its high cost, and requiring proper logistic facilities to accommodate this machine.

MRI is another technique that can be used to analyse body composition. It generates an image from an interaction between the magnetic field and the hydrogen atoms in the body. It can differentiate between muscle and fat, and is able to quantify the total body fat (Beechy et al., 2012). This information can be obtained from a whole-body scan, or sometimes single scan at level T3 is adequate (Schweitzer et al., 2015). However, MRI too cannot accommodate participants with extreme obesity.

The CT scan is another technique with a similar concept to MRI, except that it uses x-ray beams to generate whole body images. CT can differentiate between muscle mass and visceral adipose tissue (Beechy et al., 2012). However, this procedure usually reserved for cases with specific indications as it exposed the participants to a high level of radiation (Duren et al., 2008). Although both MRI and CT scans are among the best techniques available for body composition analysis, their high risk and high cost have limited usage in epidemiological studies.

Other more advanced techniques that are rarely used in large studies include ADP, hydrodensitometry, and dilution technique. These techniques, although able to produce accurate results, are more expensive and require specialised equipment and highly trained technicians. As a result, these advanced techniques are less favourable in a research setting.

2.1.3 Summary of measurements and classifications of adiposity

The WHO BMI classification is the proposed standard despite some concerns raised by the Asian countries due to increases in obesity-related morbidity and mortality at lower BMI in this region. Introduction of public health action points to the existing WHO classification could be used as an additional reference to the Asian countries. However, it is highly recommended that epidemiological studies to adopt the standard classification for comparison and establishing the trend. The same debate surrounded the classification of WC, whereby the cut-off point differed between the countries as well as ethnic groups. The BF% classification using the BIA machine is the other commonly used assessment technique to define adiposity. However, there is still no consensus on the reference cut-off point to define obesity as well.

All of the measurement techniques used in the assessment of adiposity have their advantages and disadvantages. Despite the inability of BMI to differentiate between FM and lean muscle mass, is less expensive and more practical, especially in large epidemiological studies. BMI also has an established and well-accepted cut-off points, and a large repository of data worldwide for comparison. The estimation of BF% using the BIA machine enabled more accurate evaluation of body fat. Thus, this technique has become more popular providing that the researcher has access to the tool. WC is sometimes used when central obesity is the primary outcome studied. However, its high inter-observer and intra-observer discrepancies and the use of single cut-off point may result in a high percentage of error in classifying obesity. More advanced and accurate techniques such as the DEXA, MRI, CT scans and ADP are rarely used in epidemiological or clinical studies. The choice of measurement techniques depends greatly on the objective and the size of the study, time and resources limitations, as well as the availability of tools chosen.

2.2 Trend and prevalence of overweight and obesity in general population

The prevalence of overweight and obesity in general population will be reviewed in the global perspective and narrowed down to the Asian population before specifically focusing on the general Malaysian population.

2.2.1 Global

The prevalence of overweight and obesity has been increasing for decades, affecting all countries across the globe, albeit at different rates (Finucane et al., 2011; Roberto et al., 2015). The global prevalence of overweight and obesity in the mid-1970s and 1980s was around 20% to 30% and 3% to 6% respectively (Table 2.4) (Ng et al., 2014; Stevens et al., 2012; WHO, 2017f). There was not much increase in the prevalence of overweight until 2005, and it remained below 30%. However, the global prevalence of obesity has surged to around 8% to 12% by 2005 (Kelly et al., 2008), and continue to rise to 11% to 15% in 2016 (WHO, 2017f). As for overweight, the global prevalence started to increase and has exceeded 30% by 2008 and almost reached 40% by 2016 (Ng et al., 2014; WHO, 2017c; 2017f).

Table 2.4: Global prevalence of overweight and obesity from 1975 to 2016

Author (Year)	Year Surveyed	Overweight Prevalence (%)			Obesity Prevalence (%)		
		Overall	Male	Female	Overall	Male	Female
WHO (2017) [a]	1975		20.0	23.0		3.0	6.0
Steven (2012) [b]	1980	24.6			6.4		
Ng (2014) [c]	1980		28.8	29.8			
WHO (2017) [d]	1980					5.0	8.0
Kelly (2008) [e]	2005	23.2	24	22.4	9.8	7.7	11.9
WHO (2017) [d]	2008	35.0	34.0	35.0		10.0	14.0
Ng (2014) [c]	2013		36.9	38.0			
WHO (2017) [a]	2016	39.0	39.0	39.0	13.0	11.0	15.0

[a] WHO: Global Health Observatory (GHO) Data – Overweight and obesity
[b] National, regional, and global trends in adult overweight and obesity prevalence (Steven et al., 2012)
[c] Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013 (Ng et al., 2014)
[d] WHO: Global Health Observatory (GHO) Data – Obesity situation and trend
[c] Global burden of obesity in 2005 and projections to 2030 (Kelly et al.,2008)

In 2016, WHO estimated that almost 2 billion (39%) adults worldwide were overweight and more than 650 million (13%) were obese (WHO, 2017g). Countries along the South Pacific Ocean under the WHO Western Pacific region reported the highest prevalence of overweight and obesity (WHO, 2017f). The combined prevalence of overweight and obesity in 2016 of the top five countries were all above 80% (Table 2.5). These include; Nauru (88.5%), Palau (85.1%), Cook Island (84.7%), Marshall Island (83.5%), and Tuvalu (81.9%). These countries had the highest prevalence of combined overweight and obesity overall, male, and female in 2016. These countries also recorded the highest prevalence of obesity with prevalence above 50%. Nauru, Palau, Cook Islands, Marshall Islands, and Tuvalu also had the highest prevalence of combined overweight and obesity and obesity for both males and females. European and South American countries had the highest prevalence of overweight with Italy (38.6%), Andorra (38.1%), and France (37.9%) being the highest three followed by Peru and Spain with 37.8%.

Table 2.5: Countries with the highest prevalence of overweight and obesity in 2016

Ranking	WHO Region	Country	Prevalence
Combined overweight and obesity (BMI $\geq$25 kg/m^2)			
1	Western Pacific	Nauru	88.5
2	Western Pacific	Palau	85.1
3	Western Pacific	Cook Islands	84.7
4	Western Pacific	Marshall Islands	83.5
5	Western Pacific	Tuvalu	81.9
Overweight (BMI 25.0-29.9 kg/m^2)			
1	Europe	Italy	38.6
2	Europe	Andorra	38.1
3	Europe	France	37.9
4	Americas	Peru	37.8
5	Europe	Spain	37.8
Obesity (BMI $\geq$30 kg/m^2)			
1	Western Pacific	Nauru	61.0
2	Western Pacific	Cook Islands	55.9
3	Western Pacific	Palau	55.3
4	Western Pacific	Marshall Islands	52.9
5	Western Pacific	Tuvalu	51.6

Source: WHO Global Health Observatory data repository (WHO, 2017e)

Meanwhile, Asian and African countries recorded the lowest prevalence of overweight and obesity in 2016 (Table 2.6).

Table 2.6: Countries with the lowest prevalence of overweight and obesity in 2016

Ranking	WHO Region	Country	Prevalence
Combined overweight and obesity (BMI ≥25 kg/m^2)			
1	Western Pacific	Viet Nam	18.3
2	South-East Asia	India	19.7
3	South-East Asia	Bangladesh	20.0
4	Africa	Ethiopia	20.9
5	South-East Asia	Nepal	21.0
Overweight (BMI 25.0-29.9 kg/m^2)			
1	Western Pacific	Viet Nam	2.1
2	South-East Asia	Bangladesh	3.6
3	South-East Asia	Timor-Leste	3.8
4	South-East Asia	India	3.9
5	Western Pacific	Cambodia	3.9
Obesity (BMI ≥30 kg/m^2)			
1	South-East Asia	India	15.8
2	Western Pacific	Viet Nam	16.2
3	South-East Asia	Bangladesh	16.4
4	Africa	Ethiopia	16.4
5	Africa	Niger	16.5

Source: WHO Global Health Observatory data repository (WHO, 2017e)

Studies have shown that the prevalence of overweight and obesity continued to rise every year. Although the increments were different in rates and regions, they affected all countries globally regardless of their income and developmental status. Earlier studies revealed that the prevalence of obesity almost doubled from 6.4% in 1980 to 12.0% in 2008, while the prevalence of overweight rose from 24.6% to 34.4% over the similar period (Stevens et al., 2012). A more recent systematic review found that in 2013, the prevalence of overweight globally rose to 36.9% and 38.0% for men and women respectively (Ng et al., 2014). In 2014, WHO estimated that the global prevalence of overweight was 39% and 40%, and the prevalence of obesity were 11% and 15% for men and women respectively (WHO, 2017f). In numbers, there were approximately 2 billion overweight adults and more than 500 million obese adults around the world. It is forecasted that in 2030 the global obesity prevalence would rise to 42%, which is equivalent to 1.12 billion obese adults if no effective preventable measures were taken (Finkelstein et al., 2012; Kelly et al., 2008).

Data from the WHO Global Health Observatory data repository shows that Pacific Islands countries and Asian countries recorded the highest increment of obesity and overweight respectively between 1995 and 2016 (Table 2.7) (WHO, 2017f). The high increment among Asian countries were partly due to the socio-economic and lifestyle transitions that has led to lower physical activity, higher sedentary lifestyle as well as easy access to food with lower nutritional values (Ramachandran, Chamukuttan, Shetty, Arun, & Susairaj, 2012a). While for the highest increase in the combined prevalence of overweight and obesity, there was mixed representative of countries from America, Asian and Eastern Mediterranean. Malaysia recorded the second and the sixth highest increase in the prevalence of combined overweight and obesity and overweight respectively. All countries showed an increasing trend in the prevalence of combined overweight and obesity, and obesity alone between 1995 and 2015. Meanwhile, 15 countries mostly from the Western Pacific Region with the highest prevalence of obesity showed decreasing trends in the prevalence of overweight. However, the reductions were all less than 5%.

Table 2.7: Countries with highest increment in the prevalence of overweight and obesity between 1995 and 2016

Ranking	WHO Region	Country	Prevalence
Combined overweight and obesity (BMI $\geq$25 kg/m^2)			
1	Americas	Haiti	21.6
2	Western Pacific	Malaysia	19.6
3	Americas	Dominican Republic	19.2
4	Americas	Costa Rica	18.4
5	Eastern Mediterranean	Yemen	17.0
Overweight (BMI 25.0-29.9 kg/m^2)			
1	Western Pacific	China	10.1
2	South-East Asia	Maldives	9.6
3	South-East Asia	Indonesia	9.6
4	Western Pacific	Laos	9.6
5	South-East Asia	Bhutan	9.4
6	Western Pacific	Malaysia	9.1
Obesity (BMI $\geq$30 kg/m^2)			
1	Western Pacific	Tuvalu	16.2
2	Western Pacific	Niue	16.1
3	Western Pacific	Kiribati	15.6
4	Western Pacific	Cook Islands	14.9
5	Western Pacific	Tonga	14.6

Source: WHO Global Health Observatory data repository (WHO, 2017e)

All countries listed in the WHO Global Health Observatory data repository recorded a prevalence of combined overweight and obesity of more than 20% in 2016, except for Vietnam (19.7%) and India (18.3%) (WHO, 2017f). Meanwhile, 81% (156 countries) and 55% (105 countries) of the countries recorded a prevalence of more than 20% for overweight and obesity respectively.

2.2.2 Asian

Although the prevalence of overweight and obesity among Asian countries is relatively low, they are rising at a faster rate compared to the other parts of the world, especially in the prevalence of overweight (Table 2.7). The lower rate has allowed a relatively larger margin of increment compared to the already plateauing high prevalence of overweight and obesity in other parts of the world (NCD Risk Factor Collaboration, 2016). Figures 2.2 and 2.3 illustrate the prevalence of overweight and obesity for selected Asian countries under the WHO Western Pacific region (i.e., Malaysia, Singapore, China, Japan and Korea) and the South East Asia Region (i.e., Thailand and Indonesia). In 2016, the prevalence of overweight and obesity in Malaysia was the highest among Asian countries. Although Malaysia recorded the highest prevalence of overweight in 2016 (26.9%), there were not many differences in the prevalence between the selected countries, which ranged around 21% to 27%. However, there was a clear separation between the prevalence of obesity in Malaysia (15.6%) and other countries (4% to 10%). Malaysia also recorded the highest increment in the prevalence of obesity, with a 10.5% increase between 1995 and 2016. Meanwhile, Malaysia ranked third in terms of the highest increment of obesity with a 9.1% increase, after China (10.1%) and Indonesia (9.6%).

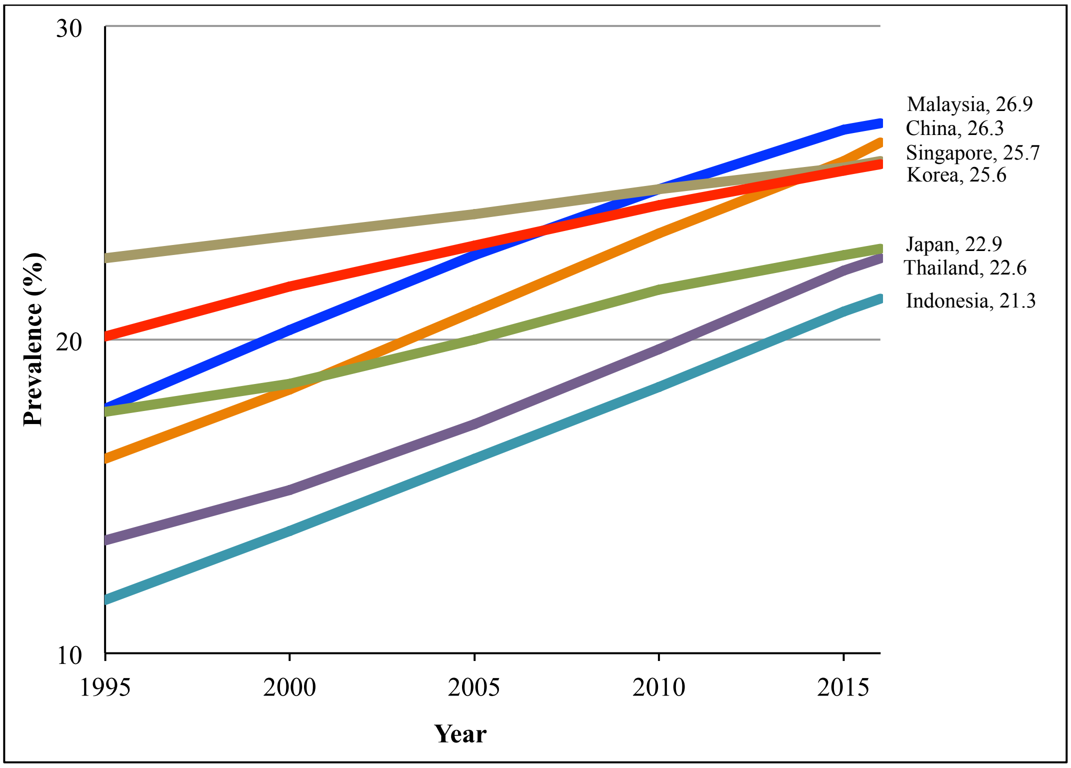


Figure 2.2: Prevalence of overweight in selected Asian countries between 1995 and 2016

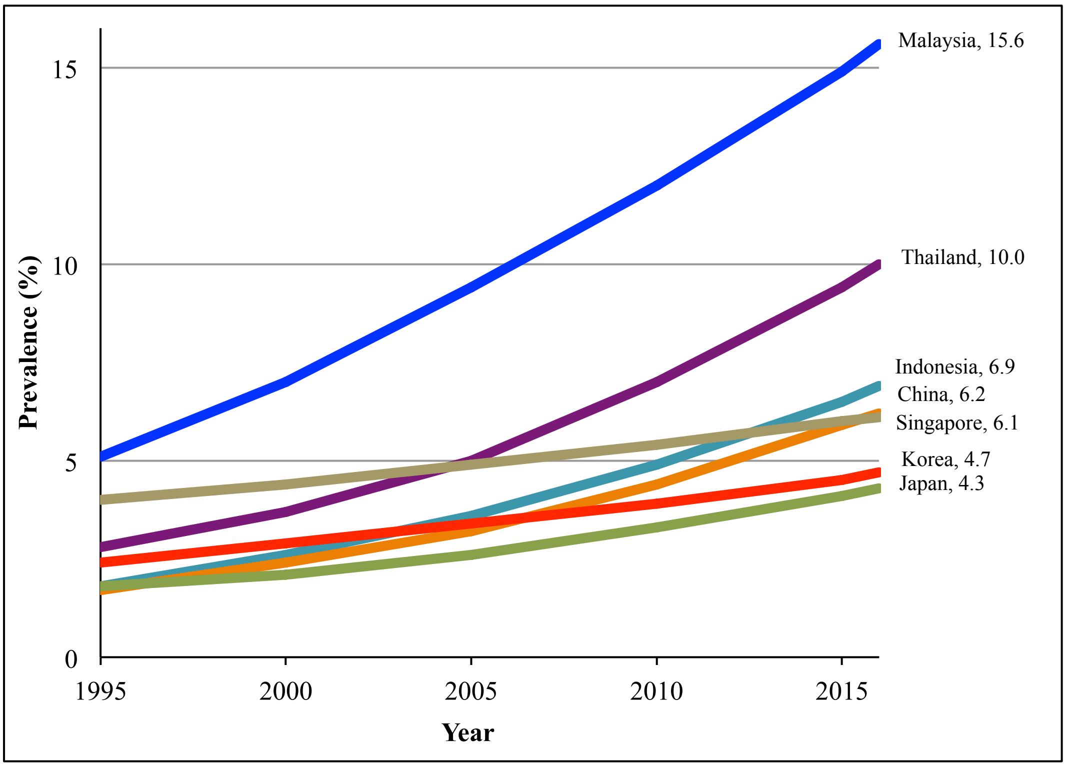


Figure 2.3: Prevalence of obesity in selected Asian countries between 1995 and 2016

NHMS Malaysia also revealed similar findings (Figure 2.4), although with a higher prevalence of overweight and obesity than reported by the WHO. The biggest increase was recorded between 1996 and 2006, with 12.5% and 9.6% increase the prevalence of overweight and obesity, respectively (IPH, 1996; 2006). From 2006 to 2015, the prevalence of overweight seemed to be plateauing around 30%. On the other hand, the prevalence of obesity continued to increase from 14% to 17.7% between 2006 and 2015 (IPH, 2006; 2015).

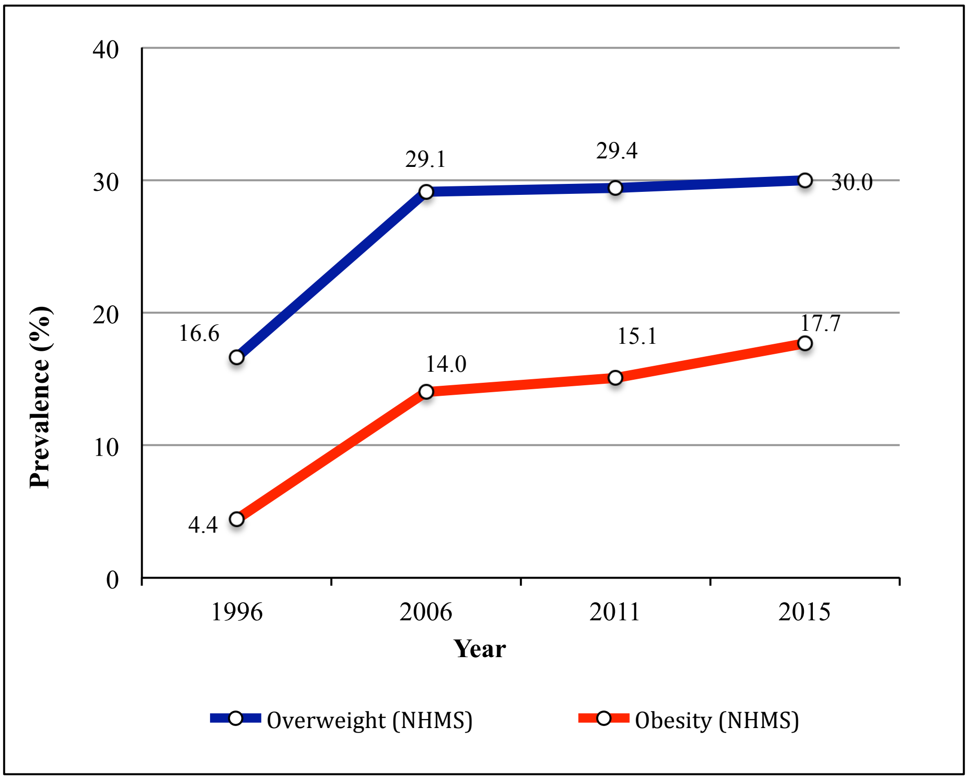


Figure 2.4: Prevalence of overweight and obesity in Malaysia from 1996 to 2015 (NHMS data)

2.2.3 Summary on trend and prevalence of overweight and obesity in general population

The prevalence of overweight and obesity has increased over the past few decades and continue to rise throughout the world. Although the pace varied between and within regions, none of the countries is showing any signs of reversing the trend. The Pacific Islands countries have the highest prevalence and increment of obesity. While the prevalence of overweight was highest in European and Latin American countries, the increase in prevalence is higher in Asian countries. Malaysia not only had the highest prevalence of overweight and obesity among the Asian countries, but also the sixth and second highest increment of overall and male overweight prevalence, respectively, in the world between 1995 and 2016.

2.3 Trend and prevalence of overweight and obesity in military population

2.3.1 Introduction

The increasing trend and prevalence of overweight and obesity in the general population has been discussed. Almost all the countries across the world have shown a rise in both overweight and obesity prevalence, albeit at different rates. However, these studies understandably did not include a sample from an exclusive group or organisation such as the military. The high prevalence of overweight and obesity in the general population, especially among adolescents and young adults, has affected the military recruitments (Cawley & Maclean, 2012). These were evidenced among the Polish conscripts where their prevalence of overweight has risen from 10.5% in 2000 to 15.5% in 2010 (Binkowska-Bury et al., 2013). The prevalence of obesity also showed an increase from 2.5% to 3.8% over the same period. Similar trends were observed among the applicants for the US military, whereby the prevalence of overweight and obesity increased from 22.8% to 27.1% and from 2.8% to 6.8% respectively from 1993 to 2006 (Hsu, Nevin, Tobler, & Rubertone, 2007). Overweight and obesity prevalence among the recruits continued to rise to 37.2% and 8.0% in 2012 (Hruby et al., 2015).

Recruits with high BMI were more likely to sustained injuries during military training compared to their normal weight comrades, thus incurred higher healthcare costs (Cowan et al., 2011; Peake et al., 2012). Even worse, they were also more likely to be prematurely discharged from the military due to their inability to perform their tasks due to prolonged injuries such as stress fractures and slipped disc, as a consequence of overweight and obesity (Packnett et al., 2011; Poston et al., 2002).

Unlike voluminous publications on overweight and obesity among the general population, studies in the military setting are relatively lacking. The military is synonymous with strict entrance screening, strenuous basic training, and highly physically demanding job. Therefore, they were assumed to be immune from obesity. However, several studies have shown that overweight and obesity are still an issue in the military. This could be due to the multifactorial nature of obesity with complex interaction between genetic predispositions and environmental influences.

2.3.2 Trend and prevalence of overweight in military population

Table 2.8 shows the overweight prevalence gathered from various studies that look into overweight and obesity issues in the military. These data were compared to their respective general population prevalence extracted from the WHO Global Observatory Data (WHO, 2017e). The prevalence of overweight among the military population was higher compared to the general population, except for among the females. Females also had a lower prevalence of overweight compared to males. The overall overweight prevalence ranged from the lowest of 27.1% (2005) in the Royal Thai Army (Napradit, Pantaewan, Nimit-arnun, Souvannakitti, & Rangsin, 2007) to the highest of 54.2% (2009) in US Air Force personnel (Seibert, 2009). The overall overweight prevalence among the military personnel was higher compared to their respective general population. Among males, the Czech Armed Forces and the Greek Army recorded the highest and the lowest overweight prevalence at 57.1% (2009) and 26.6% (1998) respectively. The prevalence of overweight among the Czech Armed Forces was higher than their general population. Meanwhile, the US Active Duty personnel recorded the highest overweight prevalence among females with 41.2% (2010), and the lowest overweight prevalence was reported in the South Korean female Army personnel with 10.7% (2002.). In general, the highest prevalence of overweight recorded among the military population exceeded the general population's overweight prevalence.

Table 2.8: Prevalence of overweight among military and civilian population

		Prevalence of overweight (year)		
		Overall	Male	Female
Lowest	Military	27.2 (2005) [a]	26.6 (1998) [c]	10.7 (2002) [e]
	Civilian [#]	17.3 (2005) [a*]	43.4 (1998) [c*]	19.9 (2002) [e*]
Highest	Military	54.2 (2009) [b]	57.1 (2009) [d]	41.2 (2010) [f]
	Civilian [#]	32.5 (2009) [b*]	42.8 (2009) [d*]	36.6 (2010) [f*]

[#] Civilian data of the respective country (year) for comparison (WHO, 2017f)
[a] Royal Thai Army (Napradit et al., 2007) — [a*] Thailand population
[b] US Armed Forces (Seibert, 2009) — [b*] US population
[c] Greek Armed Forces (Mazokopakis et al., 2004) — [c*] Greece population
[d] Czech Army (Fajfrová et al., 2016) — [d*] Czech Republic population
[e] South Korean Army (Bae et al., 2011) — [e*] South Korean population
[f] US Active Duty Personnel (Eilerman et al., 2014) — [f*] USA population

In terms of the trend in the overweight prevalence, the Belgian Army recorded the highest increment (4.6%) in overall overweight prevalence over 13 years between 1992

(30.5%) and 2005 (35.1%) (Mullie et al., 2009) (Table 2.9). Among males, the South Korean Army showed the highest rise of 7.6% over six year period between 2002 (32.7%) and 2008 (40.3%) (Bae et al., 2011). The highest increment in the prevalence of overweight among females (4.5%) was lower than males, which was recorded by the US Armed Forces between 1995 (21.6%) and 1998 (26.1%) (Lindquist & Bray, 2001). Conversely, only one study by Smith et al. (2012) showed a decreasing trend of 0.9% in the overall overweight prevalence among the US Active duty personnel between 2002 (48.5%) and 2005 (47.6%) (Smith et al., 2012). No other studies show a declining trend in either the prevalence of overall, male or female overweight. The increment in the overweight prevalence among the military personnel was higher compared to their general population. In short, the military population did not just have higher prevalence, but also a higher increment in the prevalence of overweight compared to the general population.

Table 2.9: Trend in the overweight prevalence among the military and their respective general population

Population	Year	Prevalence	Increment
Overall			
Belgian Army [a]	1992-2005	30.5%-35.1%	4.6%
Belgium population [#]	1992-2005	36.6%-37.7%	1.1%
Male			
South Korean Army [b]	2002-2008	32.7%-40.3%	7.6%
South Korean population [#]	2002-2008	22.2%-23.8%	1.6%
Female			
US Armed Forces [c]	1995-1998	21.6%-26.1%	4.5%
US population [#]	1995-1998	32.9%-33.0%	0.1%

[#] Civilian data of the respective country for comparison (WHO, 2017f)
[a] Belgian Army (Mullie et al., 2009)
[b] South Korean Army (Bae et al., 2011)
[c] US Armed Forces (Lindquist & Bray, 2001)

2.3.3 Trend and prevalence of obesity in military population

The highest overall obesity prevalence was 18.9% as recorded by US Active Duty personnel in 2009 (Eilerman et al., 2014) (Table 2.10). Meanwhile, the lowest overall obesity prevalence (4.9%) was reported in the Royal Thai Army in 2004 (Napradit et al., 2007). The Kingdom of Saudi Arabia Army stood out with the highest prevalence of obesity among the males, with 29.9% in 2009 (Horaib et al., 2013). The next highest male obesity prevalence was 20.4%, which was reported among the US Active Duty personnel in 2009 (Eilerman et al., 2014). The South Korean Army recorded the lowest male and female obesity prevalence with 2.1% (2000) and 0.89% (2004) respectively (Bae et al., 2011). The Czech Army recorded the highest female obesity prevalence in 2000 at 14.6% (Fajfrová et al., 2016). The prevalence of obesity among the military population was lower compared to their general population, except for among Saudi Arabian males.

Table 2.10: Prevalence of obesity among military and civilian population

		Prevalence of obesity (year)		
		Overall	Male	Female
Lowest	Military	4.9 (2004) [a]	2.1 (2000) [c]	0.9 (2004) [c]
	Civilian [#]	4.7 (2004) [a*]	3.0 (2000) [c*]	3.7 (2004) [c*]
Highest	Military	18.9 (2009) [b]	29.9 (2009) [d]	14.6 (2000) [e]
	Civilian [#]	31.7 (2009) [b*]	25.7 (2009) [d*]	22.3 (2000) [e*]

[#] Civilian data of the respective country (year) for comparison (WHO, 2017f)
[a] Royal Thai Army (Napradit et al., 2007)
[b] US Active Duty Personnel (Eilerman et al., 2014)
[c] South Korean Army (Bae et al., 2011)
[d] Saudi Arabian Army (Horaib et al., 2013)
[e] Czech Army (Fajfrová et al., 2016)
[a*] Thailand population
[b*] US population
[c*] South Korean population
[d*] Saudi Arabian population
[e*] Czech Republic population

The increase in the prevalence of obesity was relatively lower compared to the increase in overweight prevalence. Data extracted from studies that provided obesity prevalence over several years showed a mixture of increasing and decreasing trend. However, these changes were all less than 3.0% except for the study among the US Armed Forces with 7.7% increment between 1995 and 2008 (Reyes-Guzman et al., 2015). Among other studies that showed an increase in the prevalence of obesity among their military population were the South Korean Army (2002-2008) (Bae et al., 2011), the Belgian Army (1992-2005) (Mullie et al., 2009), and the US Armed Forces (1995-1998) (Lindquist & Bray, 2001). A study by Eilerman et al. (2014) was the only study which showed a reduction in the prevalence of obesity among the US Active Duty personnel between 2009 and 2012 (Eilerman et al., 2014). However, these changes were less than 1%. Meanwhile, a study among the Czech Republic Army between 1999 and 2009 showed an increase in the prevalence of obesity among males (0.3%) but a reduction among females (2.6%) (Fajfrová et al., 2016).

As mentioned earlier, the US Armed Forces showed the highest increment in the prevalence of overall obesity (Reyes-Guzman et al., 2015) with 7.7% rise, recorded between 1995 (5.0%) and 2008 (12.7%) (Table 2.11). The South Korean Army had demonstrated the highest increase in both male and female obesity with 1.6% and 0.3% increment respectively (Bae et al., 2011), recorded between 2002 and 2008. In general, the prevalence and the increase in the obesity prevalence for the overall and females were higher in the military population compared to the general population. However, the opposite was observed among males.

Table 2.11: Trend in the obesity prevalence among the military and their respective general population

Population	Year	Prevalence	Increment
Overall			
US Armed Forces [a]	1995-2008	5.0%-12.7%	7.7%
US population [#]	1995-2008	21.9%-29.8%	7.9%
Male			
South Korean Army [b]	2002-2008	2.1%-3.7%	1.6%
South Korean population [#]	2002-2008	2.5%-3.2%	0.7%
Female			
South Korean Army [b]	2002-2008	1.1%-1.5%	0.4%
South Korean population [#]	2002-2008	3.5%-4.1%	0.6%

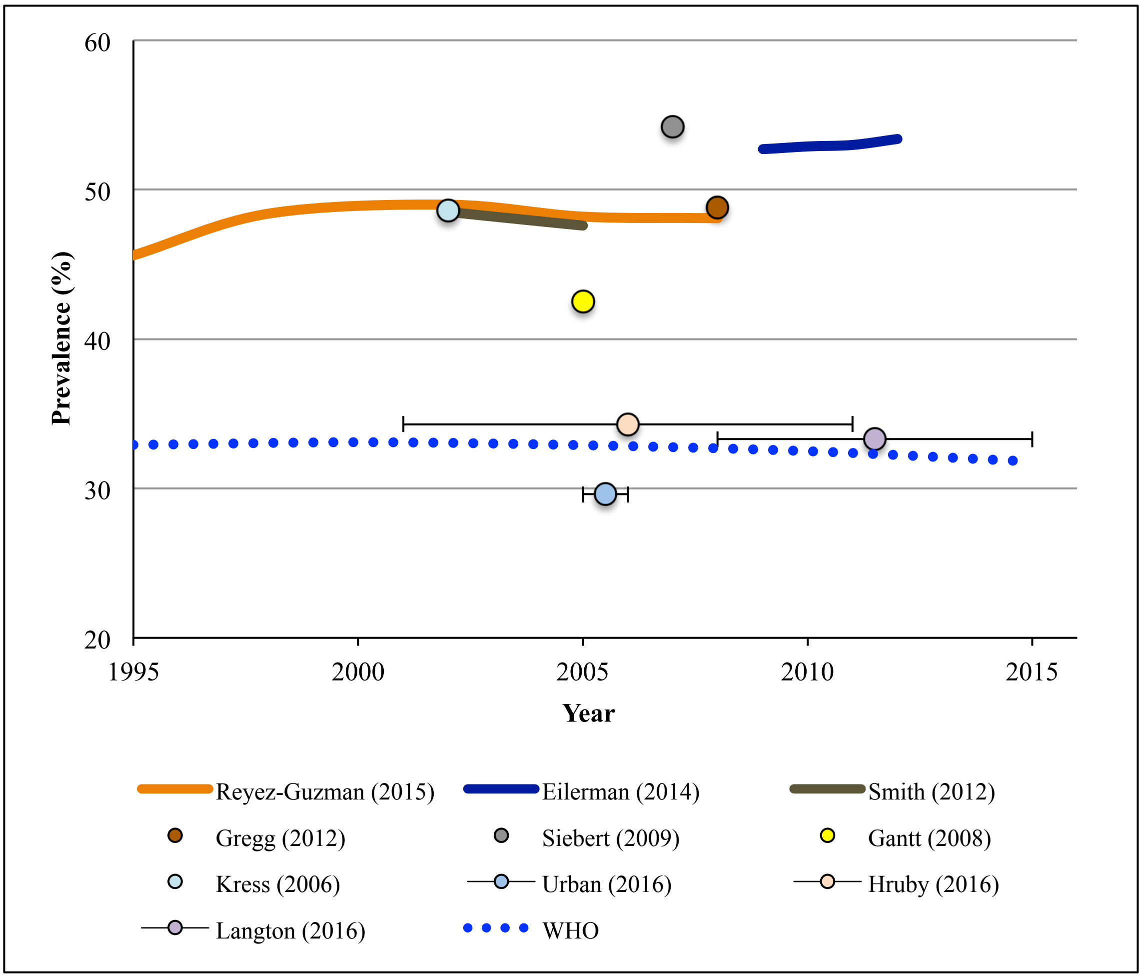
[#] Civilian data of the respective country for comparison (WHO, 2017f)
[a] US Armed Force (Mullie et al., 2009; Reyes-Guzman et al., 2015)
[b] South Korean Army (Bae et al., 2011)
[c] US Armed Forces (Lindquist & Bray, 2001)

2.3.4 Trend and prevalence by regions and countries

(a) The United States of America

A majority of studies on overweight and obesity in the military population are from the US. Figure 2.5 illustrates the prevalence of overweight extracted from various studies among the US military personnel. Prevalence among the US general population gathered from the WHO Global Observatory data was also included for comparison. The prevalence of overall overweight ranged from 54.2% (Seibert, 2009), which was recorded among the US Air Forces in 2007 to 29.6%, which was reported among the US Army between 2005 and 2006 (Urban, Boivin, & Cowan, 2016). Majority of the studies reported an overall prevalence of above 40%. However, several latest publications reported an overall overweight prevalence of less than 35% (Hruby et al., 2016; Langton, Neyra, Downs, & Niebuhr, 2016; Urban et al., 2016). Among the US military personnel, the prevalence of overweight among males was higher (50% to 60%)

compared to females (20% to 40%) (Eilerman et al., 2014; Kress, Peterson, & Hartzell, 2006; Lindquist & Bray, 2001; Smith et al., 2014).

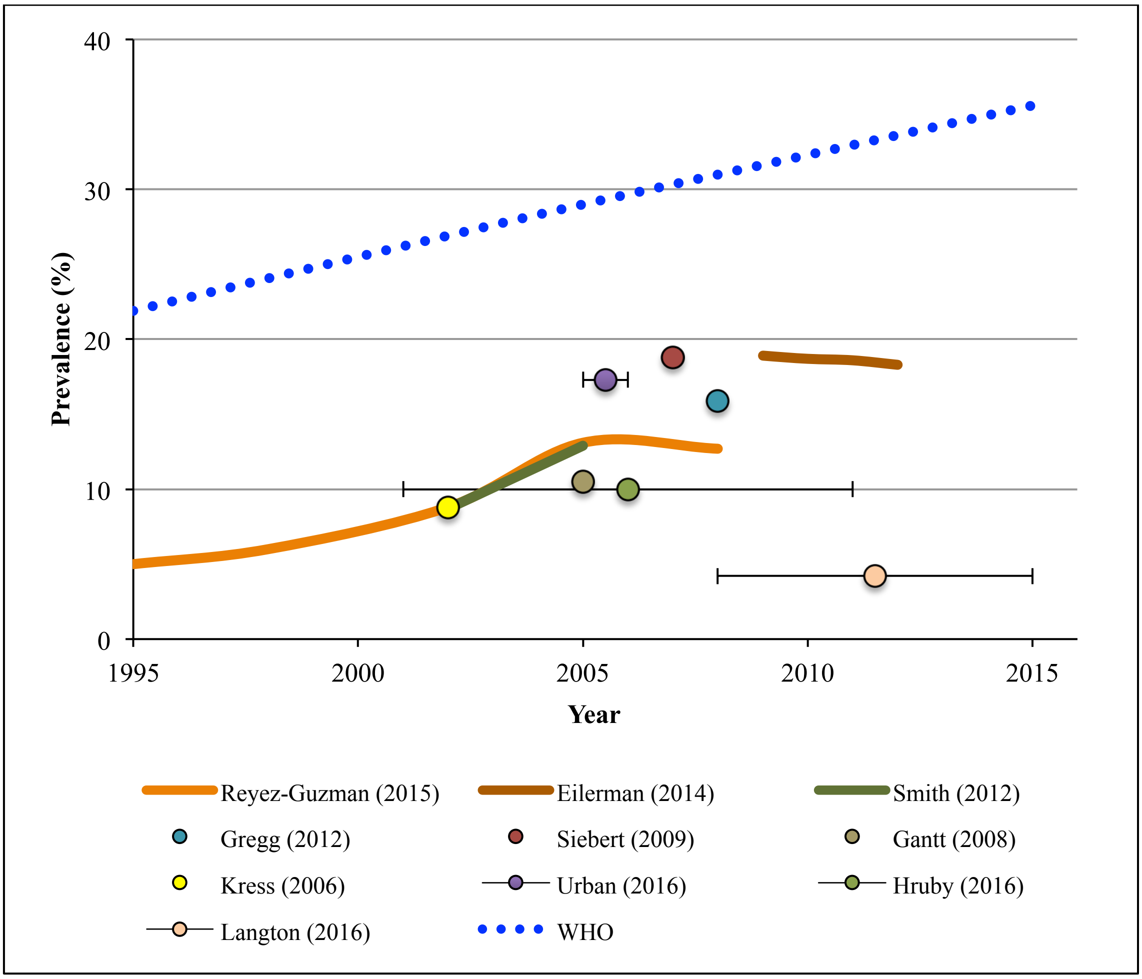


Straight line ( ) and circle (●) represent the US military population
Dotted line (▪ ▪ ▪ ▪) represents the US general population (WHO, 2017f)

Figure 2.5: Prevalence of overweight in the US military and the general US population

In contrast to overweight, the prevalence of obesity among the US military personnel was lower compared to their general population (Figure 2.6). Most of the studies reported the prevalence of obesity between 4% and 20%. The overall prevalence of obesity ranged from 4.2% (2008-2015) (Langton et al., 2016) to 18.8% (2007) (Seibert, 2009). Meanwhile, the prevalence of obesity among the male US military personnel ranged from 9.8% (2002) (Kress et al., 2006) to 20.4% (2009) (Eilerman et al., 2014).

These figures were higher than the US female personnel, whose obesity prevalence was between 3.8% (2002) (Kress et al., 2006) to 10.7% (2009) (Eilerman et al., 2014).



Straight line ( ) and circle (●) represent the US military population
Dotted line ( ) represents the US general population (WHO, 2017f)

Figure 2.6: Prevalence of obesity in the US military and the general US population

(b) The European countries

Among European countries, the overall overweight prevalence was around 40%. The lowest overall prevalence of overweight was recorded in the Belgian Army in 1994 with 30.5% (Table 2.12). However, this figure has increased to 35.1% in 2005 (Mullie et al., 2009). In another study, the Belgian Army recorded the highest overall overweight prevalence of 48% in 2013 (Collee et al., 2014). Meanwhile, the prevalence of overweight among males was around 45%. However, the Czech Army was the only group that consistently recorded an overweight prevalence of more than 50% since 1999, with the highest prevalence of 57.1% recorded in 2008 and 2009 (Fajfrová et al., 2016). Conversely, the female Czech Army recorded the lowest overweight prevalence, with 18.0% in 2002 (Fajfrová et al., 2016). The Czech female Army overweight prevalence has never exceeded 30% since 1999. There were two other studies that reported female overweight prevalence in 2007, with the British Army at 30% (Eilerman et al., 2014) and the UK Armed Forces as a whole at 33% (Sundin, Fear, Wessely, & Rona, 2011).

Table 2.12: Prevalence of overweight among military and civilian population in the European countries

		Prevalence of overweight (year)		
		Overall	Male	Female
Lowest	Military	30.5 (1994) [a]	26.6 (1998) [c]	18.0 (2002) [d]
	Civilian [#]	37.0 (1995) [a*]	43.7 (2000) [c*]	29.5 (2000) [d*]
Highest	Military	48.0 (2013) [b]	57.1 (2008) [d]	32.9 (2006) [e]
	Civilian [#]	27.5 (2015) [b*]	43.1 (2010) [d*]	30.4 (2005) [e*]

[#] Civilian data of the respective country (year) for comparison (WHO, 2017f)

[a] Belgian Army(Mullie et al., 2009) — [a*] Belgian population
[b] Belgian Army (Collee et al., 2014) — [b*] Belgian population
[c] Greek Army (Mazokopakis et al., 2004) — [c*] Greek population
[d] Czech Army (Fajfrová et al., 2016) — [c*] Czech Republic population
[e] UK Armed Forces (Sundin et al., 2011) — [f*] UK population

The overall obesity prevalence among the European countries was around 13% (Collee et al., 2014; Sanderson, Clemes, & Biddle, 2014; Sundin et al., 2011), except the Belgian Army who recorded a lower prevalence of around 5% between 1992 and 2005 (Mullie et al., 2009). Similarly, the prevalence of obesity among male personnel was between 10% and 15% (Fajfrová et al., 2016; Kyrolainen et al., 2008; Rona, Sundin, Wood, & Fear, 2011; Sanderson et al., 2014; Sundin et al., 2011), except the Greek Army, which recorded a lower prevalence of 5% in 1998 (Mazokopakis et al., 2004). The females showed a wider range of prevalence of obesity with 6% to 15% (Fajfrová et al., 2016; Sanderson et al., 2014; Sundin et al., 2011). In general, the prevalence of obesity among the military in European countries was around 10% to 15%. For prevalence of obesity overall, males and females among the military personnel in the European countries were lower than their respective general population during the surveyed years (WHO, 2017f).

(c) The Middle Eastern countries

There were two studies from the Middle Eastern countries, involving the Iranian Army between 2015 and 2016 (Payab et al., 2017) and the Saudi Arabian Army between 2009 and 2011 (Horaib et al., 2013). However, the participants in the Iranian Army study were sampled from hospitalised personnel, which could have introduced a selection bias. This study only reported the male's overweight and obesity prevalence, which was 47.6% and 15.5% respectively. Meanwhile, a study in the Saudi Arabian Army described the overall prevalence of overweight and obesity of 40.9% and 29.0% respectively. There were no data available on female overweight or obesity prevalence from these two studies. Both of these studies also showed that the prevalence of overweight was higher, and the prevalence of obesity was lower in the military population compared to their general population (WHO, 2017f).

(d) The Asian countries

The overall overweight prevalence among the military in Asian countries ranged from 27% (2005) in the Royal Thai Army (Napradit et al., 2007) to 38.8% (2008) in the Korean Army (Bae et al., 2011). Meanwhile, the overweight prevalence for males and females ranged between 30% and 40%, and between 10% and 15% respectively (Bae et al., 2011). The prevalence of overweight overall and male military personnel in these studies were higher compared to their general population (WHO, 2017f). On the contrary, female military personnel showed a lower prevalence of overweight compared to their general population. However, these data were only based on a single study conducted among the Korean Army between 2002 and 2008 (Bae et al., 2011).

The prevalence of obesity overall, males and females obesity were all less than 5% (Bae et al., 2011; Napradit et al., 2007) except for the study in the Royal Malaysian Navy, which recorded 7.2% for the male obesity (Sedek et al., 2010). This figure is comparable to the obesity prevalence among the general Malaysian population of 7.0% (WHO, 2017f). The study among the Korean Army between 2002 and 2008 showed that the prevalence of obesity was slightly higher among males (2% to 4%) compared to females (1% to 1.5%) (Bae et al., 2011).

Table 2.13 summarises the prevalence of overweight and obesity according to country and regions as discussed above. The prevalence of overweight overall, males and females were comparable between the US, Europeans and Middle Eastern countries, although there were no data available for female prevalence from the Middle

Eastern countries. On the contrary, the overweight prevalence among Asian countries was lower for all categories.

Similar patterns were observed for the prevalence of obesity except for the prevalence of overall obesity in the Middle Eastern countries of 30%. However, this was derived from a single study (Horaib et al., 2013). The prevalence of obesity among Asian countries was much lower and did not exceed 5% except for the study among the Royal Malaysian Navy mentioned earlier (Sedek et al., 2010).

Table 2.13: Overweight and obesity prevalence for military personnel from various countries

Country/ Region	Overweight Prevalence			Obesity Prevalence		
	Overall	Male	Female	Overall	Male	Female
United States	40-50%	50-60%	20-40%	10-20%	10-20%	5-10%
European countries	40%	45%	30%	11-13%	10-15%	5-15%
Middle Eastern countries	41%*	48%*	NA	30%*	15%*	NA
Asians countries	30%	35%	12%	2-5%	2-7%	1-4%

NA – Not Available
* Based on a single study

2.3.5 Trend and prevalence by military service branches

(a) The Armed Forces

The Armed Forces encompass all the military branches, including the Army, Navy, Air Force and the Marines. Most of the studies included the three main service branches, i.e., the Army, the Navy, and the Air Force. The overall overweight prevalence among the Armed Forces ranged from 33% among the US Armed Forces, which was recorded between 2008 and 2015 (Langton et al., 2016), to 54% also among the US Armed Forces between 1995 and 1998 (Lindquist & Bray, 2001). The range for female overweight was between 25% and 30%, which is lower than males. The lowest male overweight prevalence was 26.6%, which was recorded in the Greek Army in 1998 (Mazokopakis et al., 2004), and the highest of 58.6% was recorded in the US Armed Forces in 1998 (Lindquist & Bray, 2001). A more recent study among the US Armed Forces persistently demonstrated that the prevalence of overweight among male was more than 50% (Smith et al., 2014).

The overall obesity prevalence among the Armed Forces was mostly below 15%, except for the Saudi Arabia Armed Forces, which recorded the prevalence of 29% between 2009 and 2011 (Horaib et al., 2013). The lowest overall obesity prevalence was 4.2%, which was recorded in the US Armed Forces between 2008 and 2015 (Langton et al., 2016). The male obesity prevalence ranged between 10% and 15%, except for the Greek Armed Forces (4.8%) (Mazokopakis et al., 2004). The highest male obesity prevalence was 25%, which was recorded in the UK Armed Forces in 2007 (Fear et al., 2011). However, this figure was the obesity prevalence for personnel aged between 35 to 44 years old. Very few studies provided prevalence of female obesity. The UK Armed Forces female obesity prevalence was 12.9% in 2006 to 2007 (Sundin et al., 2011), which was higher than the US Armed Forces of 8.2% in 2005 (Smith et al., 2014).

(b) The Army

The Army is the largest service branch in the military in most countries. Thus, there were more studies conducted among the Army compared to other branches. The prevalence of overall overweight was around 30% to 50%, with the highest of 53.4% recorded in 2012 among the US Army (Eilerman et al., 2014). While the lowest overall overweight prevalence was 27.1%, recorded in the Royal Thai Army in 2007 (Napradit et al., 2007). Overall, male Army personnel recorded higher overweight prevalence with an average of 40% to 55% compared to female Army personnel with an average of 20% to 30%. The highest and the lowest overweight prevalence for male Army personnel was 57.1% (Czech Army-2009) (Fajfrová et al., 2016) and 28.3% (Royal Thai Army-2005) (Napradit et al., 2007) respectively. Meanwhile, for female Army personnel, the highest overweight prevalence was 41.2% (US Active Duty Army-2010) (Eilerman et al., 2014), and the lowest was 11.1% (The UK and Germany Army-2007) (Rona et al., 2011).

The overall and male Army personnel obesity prevalence averaged around 10% to 20%. The US Active Duty Army personnel recorded the highest prevalence both overall and for males with 18.9% (2009) and 20.4% (2009) respectively (Eilerman et al., 2014). Meanwhile, the Korean Army recorded the lowest overall and male obesity prevalence with 2.1% in 2002 (Bae et al., 2011). Although this has increased since then, the Korean Army overall and male obesity prevalence has not exceeded 4.0%.

The obesity prevalence among the female Army personnel were all less than 10%, except for the Czech Army that recorded 14.6% in 2000 (Fajfrová et al., 2016). This has declined since then and remained below 10% since 2004. Female Korean Army obesity prevalence was the lowest with 0.9% in 2006 (Bae et al., 2011).

(c) The Navy

There have been few studies conducted among Navy personnel, and most are from the US (Gantt, Neely, Villafana, Chun, & Gharabaghli, 2008; Gregg & Jankosky, 2012; Lennon, Oberhofer, & McQuade, 2015). The overall overweight and obesity prevalence among the US Navy were between 40% and 50%, and between 10% and 15% respectively. The Royal Malaysian Navy recorded a lower overweight and obesity prevalence with 30% and 7% respectively. Lennon et al. (2015) was the only study that reported the obesity prevalence for male and female Navy personnel at 15.4% and 4.6%, respectively (Lennon et al., 2015).

(d) The Air Forces

Compared to the other service branches, the Air Force overweight and obesity prevalence was on the higher side with 54.5% and 18.8% respectively. However, this was only based on a single study (Seibert, 2009).

Overall, the prevalence of overweight and obesity were comparable between different service branches (Table 2.14).

Table 2.14: Estimated prevalence of overweight and obesity for different military service branches

Country/ Region	Overweight Prevalence			Obesity Prevalence		
	Overall	Male	Female	Overall	Male	Female
Armed Forces	40-50%	25-60%	25-30%	5-15%	5-15%	8-13%
Army	30-50%	40-55%	10-30%	10-20%	10-20%	<10%
Navy	30-50%	NA	NA	7-15%	15%*	5%*
Air Force	54%*	NA	NA	19%*	NA	NA

NA – Not Available * Based on a single study

2.3.6 Summary on trend and prevalence of overweight and obesity in military population

The number of studies on overweight and obesity among the military has increased in recent years, reflecting the concerns on its increasing trend and consequences on to the military population. There were variations in the prevalence of overweight and obesity between and within the countries, even within the same service branches. There was no apparent trend of overweight and obesity, somewhat fluctuating between years surveyed. However, most of the studies demonstrated that the prevalence was higher at the end of the study compared to the beginning of the study, if the prevalence was studied over a few years. Compared to their respective general population, the military population has a higher prevalence of overweight, but lower prevalence of obesity. In terms of the trend, the military population also showed a higher increment in the prevalence of overweight. The increment in the prevalence of obesity was comparable between the two populations.

It is possible that the higher prevalence of overweight among the military personnel could be due to the nature of their physically demanding job. In the long run, they tend to develop bigger muscle mass. Several studies have shown that some of the overweight military personnel, especially males, were falsely classified as overweight or obese but actually have normal BF% (Grier, Canham-Chervak, Sharp, & Jones, 2015; Heinrich et al., 2008; Mullie et al., 2008). Overweight personnel may have an advantage in terms of muscular strength, which is very much required for physical jobs such as heavy lifting and load carrying. Meanwhile, there were two possibilities of lower prevalence of obesity among the military personnel. They could have either shred off their fat through routine physical training or those who exceeded the BMI cut-off point has already been terminated from the service. Thus, it is unlikely to see obese personnel still in the service.

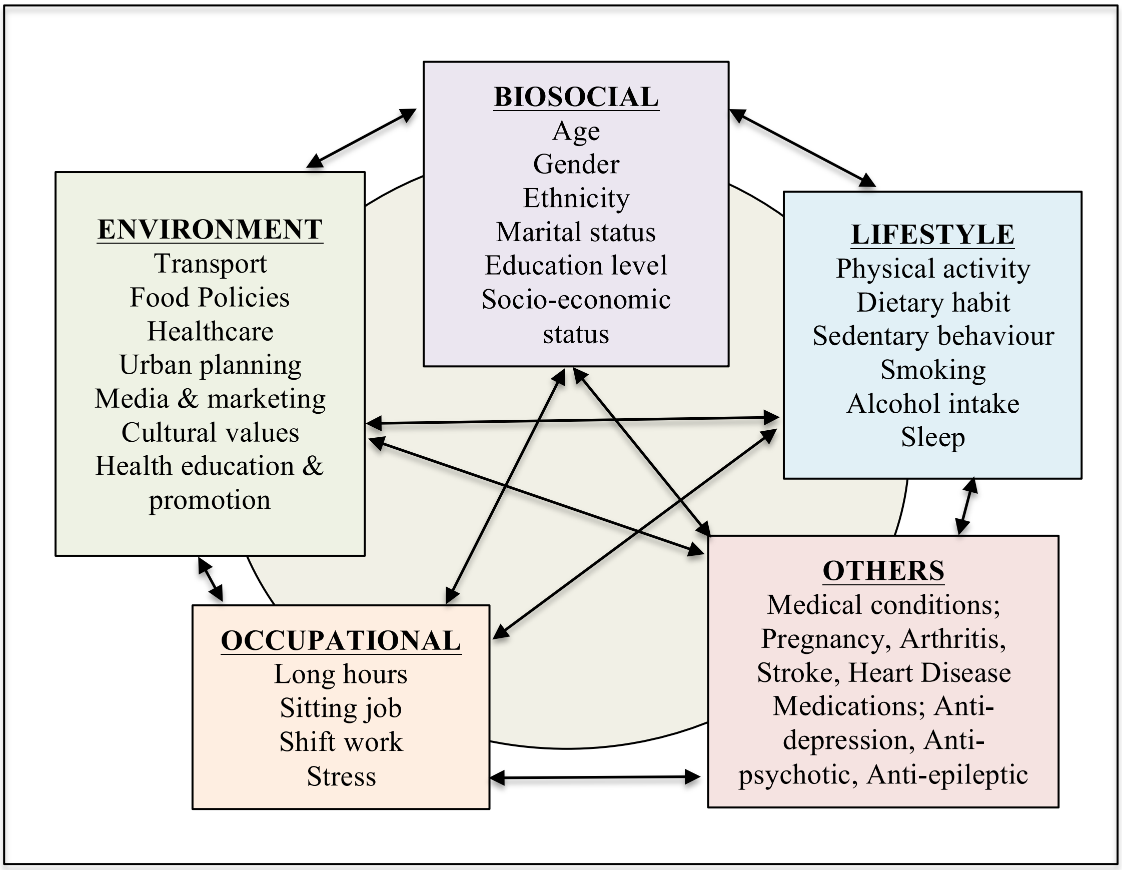
The prevalence of overweight and obesity in the Asian countries were considered relatively low compared to the US and the European countries. However, the increment rates of overweight and obesity prevalence were much faster in Asian countries. The lack of studies among the Asian and Middle Eastern countries may have limited these comparisons.

Contrary to the country and region comparisons, the prevalence of overweight and obesity between the service branches did not differ much. The lower prevalence found in the Asian's Army and Navy may not be generalised, since the majority of the studies were from the US and European countries. Thus, the prevalence of overweight and obesity, especially among the Army and the Armed Forces, reflected more on the prevalence of the US and the European countries. Only the Army and the Armed Forces have an acceptable number of studies and data to allow generalisation of the results. More studies among the Navy and Air Force personnel are needed to enable more meaningful comparisons.

In summary, the prevalence and the increment of overweight among the military population were higher compared to their general population. This could be due to higher muscle mass among the military personnel. However, this was not discussed in the studies reviewed. Although the prevalence of obesity is lower than the general population, the military organisation is not expected to have any obese personnel given their nature of job and training they go through and the image of uniformed body they portrayed to the public. The number of studies on overweight and obesity in the military population remain relatively low compared to the general population, especially among the Asian countries. Given the rapid increase in the prevalence of overweight and obesity in the Asian countries, it is essential to have more studies done in the military population from this region.

2.4 Factors associated with overweight and obesity

Overweight and obesity are the results of a complex interplay between various factors. Based on the objectives of this study, the literature review will focus mainly on the biosocial or socio-demographic, occupational, and lifestyle factors and briefly on the environmental factors associated with overweight and obesity.



The inner circle represents overweight and obesity

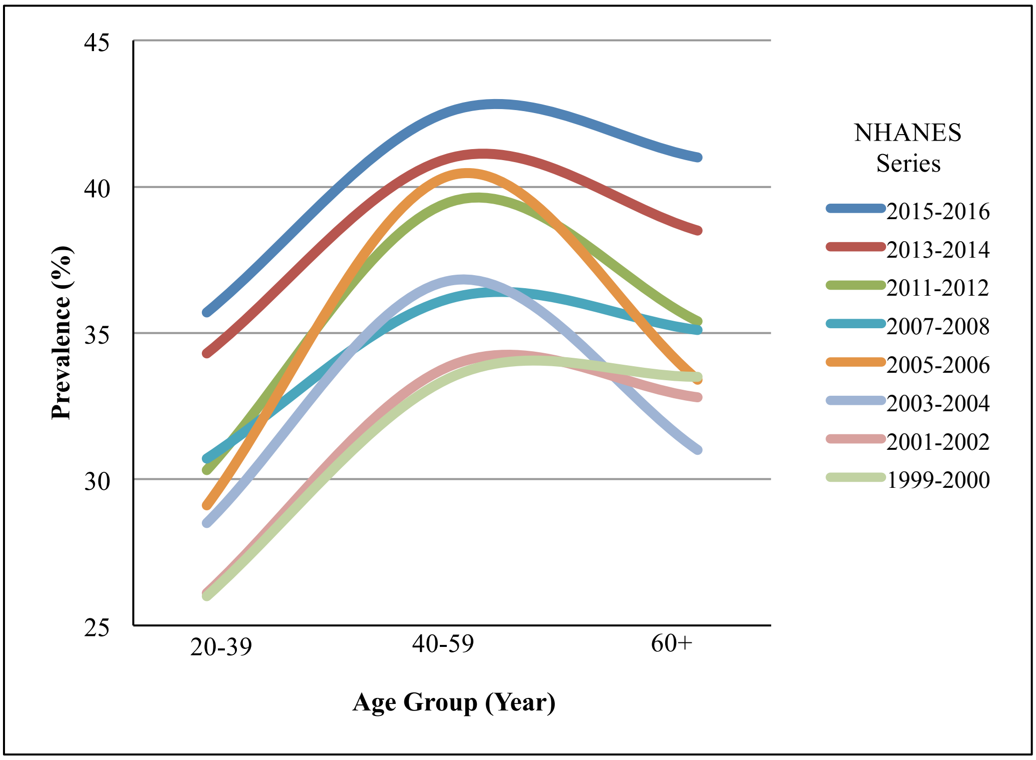
Figure 2.7: Factors associates with overweight and obesity

2.4.1 Socio-demographic characteristics

2.4.1.1 Age

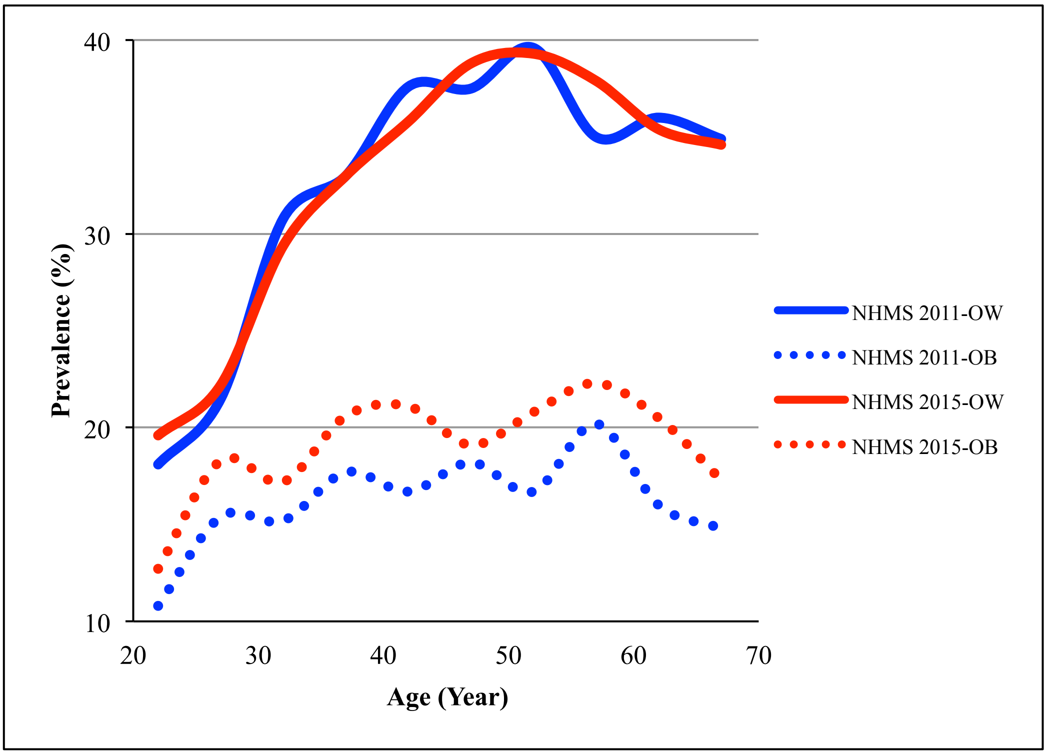
The association between age with overweight and obesity seemed to form a bell-shaped curve that steadily increased from the age of 20 years and peaked at around 50 to 60 years, before coming down (Ng et al., 2014). In the US, a series of National Health and Nutritional Examination Survey (NHANES) from 1999 to 2016 showed that obesity among the US adults has similar age group distribution. The prevalence increased from adulthood, peaked at around 40 to 59 years before gradually decreasing (Figure 2.8) (Fryar, Carroll, & Ogden, 2016; Hales, Carroll, Fryar, & Ogden, 2017). In Malaysia, similar patterns were observed for both overweight and obesity with a relatively earlier peak for overweight at 50 to 54 years compared to obesity, which peaked at the age of 55 to 59 years (Figure 2.9) (IPH, 2011; 2015).

Similar associations were observed in the military population. The odds of overweight and obesity were higher as the age increased, especially after the age of 40 to 45 years compared to younger personnel (Reyes-Guzman et al., 2015; Sanderson et al., 2014; Smith et al., 2012). In the British Army, the odds of obesity among male personnel aged 45 years and above were as high as 14.4 compared to personnel aged between 17 to 24 years (Sanderson et al., 2014). Other studies demonstrated this association in terms of higher mean BMI in the older age group in the Belgian Army (Mullie et al., 2009) and the Royal Malaysian Navy (Sedek et al., 2010). In the Royal Thai Army, the odds of overweight were higher in the older age group (Napradit et al., 2007). However, the odds of being obese were not significantly associated with age.



NHANES – National Health and Nutritional Examination survey

Figure 2.8: Prevalence of obesity in the US general population from 1999 to 2016



NHMS – National Health and Morbidity Survey; OW – Overweight; OB – Obesity

Figure 2.9: Prevalence of overweight and obesity in the general Malaysian population in 2011 and 2015

2.4.1.2 Gender

Despite a substantial difference in the prevalence of obesity between countries and regions (Stevens et al., 2012; WHO, 2017e), females appeared to have higher obesity prevalence in 85% of the countries listed under the WHO Global Observatory data in 2016 (WHO, 2017e). The top 10 countries with the highest female to male obesity prevalence differences were from the African region except for Egypt and Barbados. Meanwhile, 63% of these countries reported a higher male's overweight prevalence with the top 10 highest male to female obesity prevalence differences were all from Europe. However, in China, although females had a higher prevalence of obesity, the rate of increment was faster in men (Du et al., 2013). In Malaysia, men have a higher prevalence of overweight (31.6% compared to 28.3%) but a lower prevalence of obesity (15.0% compared to 20.6%) (IPH, 2015). Around 70% of countries worldwide reported a higher prevalence of obesity in females and overweight prevalence in males (WHO, 2017e).

In the military population, studies among the US Armed Forces (Hruby et al., 2015; Reyes-Guzman et al., 2015; Smith et al., 2012) and the British Army (Sanderson et al., 2014) personnel revealed that males were at higher odds of being overweight and obesity. Although there was no significant association between gender and obesity in the Royal Thai Army, the odds of overweight were still higher in males compared to females (Napradit et al., 2007). One possible explanation for this difference could be that the men were subjected to more physically demanding tasks which require muscular strength, and are thus more likely to build on more muscle over time (Vanderburgh, 2008). Working in a combat unit, normally dominated by males, put them at higher risk of being overweight as well (Napradit et al., 2007).

2.4.1.3 Education level and socio-economic status

Higher education level and higher socio-economic status (SES) were found to be associated with lower odds of becoming obese among women in the middle-income countries (Aekplakorn et al., 2007; Cai, He, Song, Zhao, & Cui, 2013; Dinsa, Goryakin, Fumagalli, & Suhrcke, 2012). On the contrary, men showed an inverse association between education level and SES with obesity. Educated and career women were more committed to maintaining their image and appearance, thus more likely to keep an ideal weight (Mazokopakis, Karefilakis, & Starakis). Men, on the other hand, prioritise their work over their image and are therefore less concerned about their BMI (Mazokopakis et al.). However, in low-income countries, the prevalence of obesity was directly associated with SES, irrespective of gender (Cai et al., 2013; Dinsa et al., 2012). Affluent status, affordability, and epidemiological and nutritional transitions have influenced poor dietary choice leading to a higher prevalence of obesity as the SES improved (Mazokopakis et al.). However, there was no significant association between education level and SES with overweight and obesity among the Malaysian population (IPH, 2015). Affordability, acceptance, and easy access to the fast food restaurants and local food stalls were among the factors that exposed Malaysian to overweight and obesity, regardless of their educational background or SES (Nezakati, Abu, Toh, & Abu, 2011).

Contrary to the civilian population, education level was not significantly associated with being overweight or obese among the military personnel (Smith et al., 2012). One possible reason could be because their entrance academic qualification was almost the same, except for the officers. Furthermore, their education level did not determine their deployment to either combatant or non-combatant units.

2.4.1.4 Marital status

The association between marital status and obesity seemed to go both ways, although more evidence was inclined towards negative association. Even as early as starting a relationship or getting married were found to increase the odds of being obese (The & Gordon-Larsen, 2009). Increased social obligation, decreased physical activity (due to inactive partners) and inclination towards sedentary lifestyle were among the hypotheses behind these changes. In line with this, many studies found that married individual was more likely to be obese than the unmarried one (Janghorbani et al., 2008; Tzotzas et al., 2010). For women, the weight gain was more obvious after giving birth (Brown, Hockey, & Dobson, 2010), especially among those who were overweight before the pregnancy (Gunderson et al., 2004). On the other hand, 'selection and market' hypotheses postulated those single individuals are more likely maintain their body weight to increase their marketability in finding a life partner (Averett, Argys, & Sorkin, 2013). It is also important to note that marital transitions (getting married, getting divorced or getting remarried) could also affect body weight. While getting married and remarried were found to be positively associated with obesity, getting divorced on the other hand had an opposite effect on body weight (Teachman, 2016; Umberson, Liu, & Powers, 2009).

In the military population, married personnel too were found to have higher odds of being overweight or obese (Reyes-Guzman et al., 2015; Sanderson et al., 2014; Sedek et al., 2010; Smith et al., 2012). Although the reason behind this association was not discussed, it is postulated that the married personnel was facing the same situation as in the civilian population. Demand from the workplace and family commitment leaving them limited time for physical activity was among the most commonly cited reasons. However, studies in the military have not explored in-depth the effects of marital transitions (bachelor-married-divorced-remarried) on BMI.

2.4.1.5 Ethnicity

The prevalence of overweight and obesity in a community could be influenced by its ethnic compositions, cultural and social values attached to their community. Kirby et al. (2012) found that the odds of overweight and obesity were higher among the Non-Hispanic White if they were living in a community populated by Hispanics compared to Non-Hispanic Asian community (Kirby, Liang, Chen, & Wang, 2012). The association between ethnicity and obesity is relevant to the Malaysian environment as a multiracial country. The Malaysian NHMS 2015 found that the prevalence of obesity was higher among the Indians compared to the Malays and the Chinese (IPH, 2015). However, there were no significant differences in the prevalence of overweight between these three main ethnic groups.

In the US Armed Forces, the prevalence of overweight and obesity were higher in the African American and Hispanics compared to the Non-Hispanics or Caucasian (Lindquist & Bray, 2001; Reyes-Guzman et al., 2015; Smith et al., 2012). Most studies in the military population that looked into the association between ethnicity and obesity were from either the US or the UK. Studies from other countries such as South Korea, Thailand, and Malaysia did not report this association (Bae et al., 2011; Napradit et al., 2007; Sedek et al., 2010). It is possible that the same ethnic group dominated the military population from these countries.

2.4.2 Occupational factors

Duration of time spent at work and type of work activities were associated with being overweight and obese. Workers who spent more time at the workplace (more than 40 hours per week), and mostly sitting throughout the working hours (clerical, administrative and desk jobs) were more likely to be overweight or obese compared to those who were involved in a high occupational activity (Choi et al., 2010; Luckhaupt, Cohen, Li, & Calvert, 2014; Steeves, Bassett, Thompson, & Fitzhugh, 2012). The modern office design encourages more sitting rather than standing or moving around, does not help in burning calories and reducing obesity (Perry, 2012). A longitudinal study NAHNES data from 1960 to 2008 has shown that reduction in occupation-related energy expenditure accounted for the increasing trend in mean body weight among the US workers (Church et al., 2011). Workers who spent more time at work will have less time for leisure-time physical activities. This was the more important determinant of overweight and obesity compared to the activity at their workplace (Singer et al., 2016).

Studies also have shown that shift work is related to obesity and other cardio-metabolic disorders regardless of gender (Grundy et al., 2017; Son, Ye, Kim, Kang, & Jung, 2015). Disruptions of circadian rhythms, poor quality of sleep, eating in the late hours and environmental stress were among the suggested pathophysiologies behind this association (Antunes, Levandovski, Dantas, Caumo, & Hidalgo, 2010; Ko, 2013). Apart from shift work, other occupational factors such as exposure to chemical and excessive continuous noise at the workplace may also lead to job stress and obesity indirectly (Pandalai, Schulte, & Miller, 2013).

In the military setting, senior personnel and officers typically take over the administrative and supervisory tasks, which are less physical compared to the combatant training (Reyes-Guzman et al., 2015). However, studies have shown that the enlisted and lower rank personnel were at higher risk of overweight and obesity (Sanderson et al., 2014; Sundín, NicolaT.Fear, Wessely, & Rona, 2011) despite the physical nature of their tasks. It is possible that the working environment in the military setting, including their routine physical training, have not put the senior personnel and officers at higher risk. On the other hand, the SES, which is highly correlated to the rank in the military, could have explained why the lower rank personnel was the one at higher risk of overweight and obesity (Sanderson, Clemes, & Biddle, 2011). This could also be due to the greater lean muscle mass among the junior personnel as a result of their physical work and training. Since all these studies used BMI to define obesity, it is not possible to differentiate between the muscle mass and fat mass contribution to body weight (Burkhauser & Cawley, 2008; Gomez-Ambrosi et al., 2012).

2.4.3 Lifestyle Factors

2.4.3.1 Smoking

Nicotine effects from smoking increase metabolic rate, energy expenditures, and fat burning, and decreased appetite thus resulting in lower body weight among smokers (Audrain-McGovern & Benowitz, 2011; Chiole, Faeh, Paccaud, & Cornuz, 2008). Several studies have shown that the odds of being overweight and obese were lower among smokers compared to non-smokers (Patel et al., 2011; Sikorski et al., 2014). Similarly, studies among the general Malaysian population found that the odds of obesity among non-smokers were higher compared to the smokers (Jan Mohamed et al., 2014; Rampal et al., 2007). Other consequences of smoking on body weight are found among the ex-smokers. They tend to put on weight after quitting (Aubin, Farley, Lycett, Lahmek, & Aveyard, 2012; Tian, Venn, Otahal, & Gall, 2015), and this somewhat deterred the smokers from stopping despite the proven adverse health effects of smoking (Mazokopakis et al.). Ex-smokers were found to be heavier than those who never smoke and current smokers (Akbartabartoori, Lean, & Hankey, 2005; Canoy et al., 2005). Despite the increase in weight after quitting, it is worth the benefits of better health without smoking (Kasteridis & Yen, 2012). Among smokers themselves, the amount smoked per day was related to higher body weight (Clair et al., 2011; Gasperin, Neuberger, Tichy, & Moshammer, 2014). In shorts, numerous studies have established differences between smoking and body weight among non-smokers, smokers, and ex-smokers.

Other studies have used indirect measures of establishing the association between smoking and body weight. For example, increasing cigarette tax (Sen, Entezarkheir, & Wilson, 2010) and introducing a smoking ban at the workplace (Liu, Zhang, Cheng, & Wang, 2010) indirectly reduced obesity prevalence. However, other studies have argued that these changes were too marginal to be definitive on the relationships (Flegal, 2007; Gruber & Frakes, 2006). Although smoking does not predispose smokers to a higher risk of obesity, it does influence body fat distribution. Smokers were found to have a higher prevalence of abdominal and visceral obesity (Kim et al., 2012; Tuovinen et al., 2016) and these were more prominent with increasing amount of smoke per day (Clair et al., 2011).

Smoking in the military population is socially accepted as a norm and used as mean to cope with stress, boredom, and sleep difficulty (Poston et al., 2008) especially during operational deployment (Smith et al., 2008). Several studies among military personnel have found that smoking was not associated with obesity. In fact, it was shown to have a protective effect on BMI. In the Royal Thai Army, the OR (95% CI) of overweight and obesity among the current smokers compared to non-smokers were 0.73 (95% CI: 0.61,0.87) and 0.68 (95% CI: 0.47,0.99) respectively (Napradit et al., 2007). Among the Saudi Arabia soldier, smoking was negatively correlated with obesity (Horaib et al., 2013). Although there were no significant differences in BMI between smokers and non-smokers among the Greek Armed Forces personnel, the duration of smoking, amount smoked and age of smoking initiation was significantly correlated with higher BMI (Mazokopakis et al., 2004).

2.4.3.2 Physical activity

WHO defines physical activity as 'any bodily movement produced by skeletal muscles that require energy expenditure. This includes activities undertaken while working, playing, carrying out household chores, travelling and engaging in recreational pursuits' (WHO, 2017b). Physical activity contributes to weight maintenance and weight loss by matching up energy intake and expenditure, thus maintaining the negative energy balance (Chaput et al., 2011). Individuals who participate in regular moderate to vigorous physical activity are less likely to gain weight (Schmitz, Jacobs, Leon, Schreiner, & Sternfeld, 2000) and able to maintain their weight in long-term (Droyvold, Holmen, Midthjell, & Lydersen, 2004). Several studies have shown that regular physical activity was inversely associated with obesity (Bae et al., 2011; Rauner, Mess, & Woll, 2013; Shi et al., 2014). Even the soldiers deployed to conflict area were found to have increased BF%, especially among those who rarely participated in aerobic exercise (Lester et al., 2010). Sedentary lifestyle, on the other hand, was related to obesity, regardless of the amount of physical exercise (Banks, Lim, Seubsman, Bain, & Sleigh, 2011). In short, increasing physical exercise and avoiding sedentary habits would be the best approach to maintain ideal weight.

Amount and intensity of physical activity are important in determining the weight reduction or maintenance. Physical activity for 30 minutes five days a week of moderate intensity, or 20 minutes three days a week of vigorous intensity (or any combinations), are recommended to prevent chronic diseases and maintain good health for an adult (Ainsworth et al., 2000; Haskell et al., 2007). This is equivalent to the WHO recommendation of 150 minutes of moderate physical activity or 75 minutes of vigorous physical activity throughout the week (WHO, 2017a). These amounts should be doubled for extra benefits to improve health. However, this is insufficient to prevent weight gain. The International Association for the Study of Obesity (IASO) suggested that moderate physical activity of 45 to 60 minutes per day is required to prevent transition into overweight and obesity and even more for prevention of weight regain in previously obese individual (IASO, 2013; Saris et al., 2003). Higher amount and intensity of physical activity are justifiable in view of other factors that could affect body weight, including genetics, dietary intake, and environmental influence (Nguyen & El-Serag, 2010).

Apart from its beneficial effect in maintaining body weight, regular physical activity was also proven to improve cardiorespiratory fitness, which is the more important indicator of cardiovascular health than body weight (Mazokopakis et al.). Furthermore, physical fitness is an essential asset for the soldiers to perform their duties. Military personnel who performed additional exercise on top of their obligatory physical training were found to have better fitness level (Anderson et al., 2016). Unfortunately, some personnel relied totally on their routine physical training to maintain their fitness. They cite time constraints and being too busy were among the common excuses for them to not participate in a leisure-time physical activity (Sigrist, Anderson, & Auld, 2005), which was proven to be beneficial in preventing overweight and obesity (Sugiyama, Healy, Dunstan, Salmon, & Owen, 2008).

Among the military personnel, the frequency of physical activities was found to be associated with the degree of weight loss (and hence reduced BMI), especially among the female soldiers (Bae et al., 2011). Similarly, men who exercised regularly during their leisure time had lower mean BMI compared to who did not exercise (Mazokopakis et al., 2004). Furthermore, personnel who could maintain their exercise at least three times a week were found to have lower odds of overweight and obesity (Napradit et al., 2007). However, physical activity was not significantly associated with overweight and obesity in Saudi soldiers (Horaib et al., 2013) and the US Armed Forces (Reyes-Guzman et al., 2015).

2.4.3.3 Dietary intake

Unhealthy dietary intake, especially high in calories and saturated fat, was among the major contributors to the rise in overweight and obesity all around the world (Mazokopakis et al., 2009). Excess calories consumption may cancel out the benefits of physical activities (occupational and leisure-time) in maintaining a healthy weight and preventing weight gain (Sudom & Hachey, 2011). Inadequate knowledge on nutrition was cited among the factors leading to unhealthy eating habits especially among those with a lower educational background (Kullen, Iredale, Prvan, & O'Connor, 2016). However, other studies have shown that despite knowledge and appreciation of healthy diet, this was not translated into the actual intake (Smith et al., 2013; Sudom & Hachey, 2011). Malaysia has experienced an upward shift in the availability of high calories food and increased in the sedentary lifestyle between 1996 and 2006 (Khor, 2012)..

Increasing trend in calories intake was mainly due to the unhealthy food choices triggered by the mushrooming of fast food outlets (Mazokopakis et al., 2009). This has exposed military camps to, among others, fast food outlets that offer quick, attractive, and affordable processed food. Studies have shown that regular consumption of high calories food from takeaways has contributed to the rising of overweight and obesity (Bowman & Vinyard, 2004; Rosenheck, 2008; Smith et al., 2009). On the contrary, a study among the US Air Force personnel found that although the distance between workplace and fast food outlets was linked to higher consumption of fast food, it was not associated with higher BMI (Seibert, 2009). Despite the increasing trend of fast food consumption in the general population (Kant & Graubard, 2004; Powell, Nguyen, &

Han, 2012), not many studies have focused on this issue in the military population. There were no studies on dietary intake and its implication in the Malaysian Army. It is worried that changes towards this unhealthy eating habit would affect the military population to an extent that their energy spent during their training and while performing their duties were no longer adequate to maintain the negative energy balance.

2.4.4 Environmental factors

All the socio-demographics, occupational and lifestyles factors associated with overweight and obesity mentioned above have interplayed with and greatly influenced by the environment. Environmental factors can be viewed as upstream factors (namely the governance and policy), midstream factors (examples; the natural, build, food and societal environment) and downstream factor (the individual themselves) (Glanz, Sallis, Saelens, & Frank, 2005; Rabin, Boehmer, & Brownson, 2007; Wang & Brownell, 2005).

Greater country's stability and effective governance enabled policymakers to enact and enforce public health measures to deal with obesity problem (Rabin et al., 2007). The government has to be the key-player in integrating all sectors including the environment, education and finance as well the health sector to formulate the strategies and translated them into action to combat obesity. The involvement of the international agencies such the WHO and the United Nations would enable the exchange of ideas with other countries. The private sector, especially the food producer and marketing agencies were crucial in influencing the quality and the choice of food to the consumers (Gortmaker et al., 2011). As the media has a significant influence on either healthy or unhealthy food marketing (Eagle, Bulmer, Kitchen, & Hawkins, 2004), the ability of the government to manipulate this medium to the advantage of their population health is crucial.

The 'food environment' was among the major environmental factors contributing to the growing obesity problem (Ogden, Carroll, Kit, & Flegal, 2014; Steeves, Martins, & Gittelsohn, 2014). It has a substantial influence on the population dietary intake and habits. The emergence of fast food industries and the increase in the convenience stores density has led to easier access to high calories and dense-energy food (Khor, 2012; Prince et al., 2012). Fast food products as the name suggest were instantly available, relatively cheap, more varieties and attractive, and taste better to the palate (Mattes & Foster, 2014; Swinburn et al., 2011). However, regular consumption of this high energy and calories food was shown to be associated with obesity (Anderson, Rafferty, Lyon-Callo, Fussman, & Imes, 2011; Rosenheck, 2008; Smith et al., 2009). Even in the military, unhealthy nutritional intake from takeaway food and eating out were among the factors contributing to excess weight gain, despite adherence to a physical activity regime (Smith et al., 2013).

Both high and middle to low-income countries were affected by this shift in dietary patterns to a different extent. The availability and accessibility (in terms of cost and distance) of unhealthy food determined the direction of the association between nutritional intake and obesity. Low-incomes countries were expected to have a lower prevalence of obesity because of their exposure to the fast food industries were much less. Unfortunately, their disadvantages in terms of availability and accessibility to better nutrition and healthier food choices had out-weighted their freedom from the adverse effects of fast food consumption (Sallis & Glanz, 2009). Even in the high-income countries such as the US, the higher prevalence of obesity observed among the low-income communities was partly explained by their limited access to affordable nutritional food (Papas et al., 2007).

The ‘built environment’ refers to the actual physical setting surrounding the community. The community developmental planning should consider the impact on the health of the community together with the environmental aspect. Housing density and housing type, as well as the phase of the developmental project, will incur inconvenience in the surroundings, as well as reducing the available open space for recreational activities (Durand, Andalib, Dunton, Wolch, & Pentz, 2011). Limited availability of recreational facilities and neighbourhood walkability has been shown to affect the level of physical activities and given rise to the prevalence of obesity (Frank et al., 2006; Hoehner, Brennan Ramirez, Elliott, Handy, & Brownson, 2005). Neighbourhoods equipped with various recreational facilities have been shown to increase the participation in the moderate-to-vigorous physical activity and reduce the odds of overweight in that community (Sallis, Floyd, Rodriguez, & Saelens, 2012). On the other hand, the amount of green space was found to have an inverse association with the prevalence of obesity-related health problems such as the metabolic syndrome and premature death from cardiovascular disease (Lachowycz & Jones, 2011; Maas et al., 2009; Mitchell & Popham, 2008).

The ‘natural environment’ is to a certain extent beyond human control. In four-seasons countries, extreme temperature such as too hot summer and too cold winter, were among the deterrent to participate in physical activity (von Hippel & Benson, 2014). Interestingly, von Hipple & Benson (2014) also found that countries that are dark in January and mostly rainy throughout the year showed the same trend of reducing physical activity and increasing obesity. However, other natural factors such as wind, trees, and mountains did not have any influence on this phenomenon (von Hippel & Benson, 2014).

The influence of ‘social environment’ on obesity may also be related to the food, built and natural environments. Being surrounded by obese people, for example friends, siblings, and even obese spouses, may increase chances of being obese (Christakis & Fowler, 2007; Nguyen & El-Serag, 2010).

2.4.5 Summary of factors associated with overweight and obesity

Overweight and obesity are complex phenomena caused by multiple factors that interact with each other. Voluminous studies have established the association between these various factors with overweight and obesity. Thus, factors of overweight and obesity have to be interpreted and critically appraised in the context of the different studies and population involved.

The NHMS data and several studies on factors associated with overweight and obesity in the general Malaysian population were not much different from other countries. These include higher prevalence of obesity in the 40 to 60 years, female, lower level of physical activity, non-smokers, and diet high in calories. However, this study will not cover the environmental factors. To the best of our knowledge, there are no published studies on overweight and obesity factors in the Malaysian Army.

2.5 Consequences of overweight and obesity

Overweight and obesity has been linked to multiple adverse outcomes including NCDs (Guh et al., 2009), loss of productivity, poor job performance (Mondal & Mishra, 2017; Skagen & Collins, 2016) and lower quality of life (Jia & Lubetkin, 2010). Their implications on healthcare utilisation and financial burden were also have been well established (Tran, Nair, Kuhle, Ohinmaa, & Veugelers, 2013). This section of the literature review will focus on two of the most relevant consequences of overweight and obesity to this study: loss of productivity in terms of sickness absenteeism, and poor performance in terms of lower physical fitness.

2.5.1 Sickness absenteeism and presenteeism

Job productivity will be affected when the employers were unable to perform their task up to the required standard. Physical and mental health were among the most common factors contributing to this problem, apart from personal matters (Mazokopakis et al., 2009). Sickness absenteeism refers to the state of an employee being absent from work due to illness or other health problems (Whitaker, 2001). Sickness presenteeism, on the other hand, can be defined as being present at work despite being unwell (Aronsson & Gustafsson, 2005; Hansen & Andersen, 2008). Sickness absenteeism and presenteeism are two terms directly related to job performance and productivity. Sickness absenteeism was linked to lack of job commitment, job dissatisfaction and resulted in the loss of work-hours and decrease productivity (Prater & Smith, 2011; Vignoli, Guglielmi, Bonfiglioli, & Violante, 2016). While sickness presenteeism was associated with job insecurity, job commitment and demand, and sense of guilt (Kinman, Clements, Hart, & Wray, 2017). It is vital to distinguish between these two because both have a somewhat different impact on workers' health, performance, and overall productivity (Kinman et al., 2017).

Several studies have identified obesity as a common factor associated with sickness absenteeism (Bustillos et al., 2015; Merrill et al., 2013; Tsai, Ahmed, Wendt, Bhojani, & Donnelly, 2008) and sickness presenteeism (Bustillos et al., 2015; Christensen, Kongstad, Sjogaard, & Sogaard, 2015; Taloyan et al., 2012). A 10-year follow-up of Shell Oil company employees has shown that overweight and obese workers were more likely to take more days off compared to their normal weight colleagues and had incurred a significant loss to the employers (Tsai et al., 2008). More than one-third of the sickness absenteeism in this company was attributed to either overweight or obesity. The odds of taking sickness absence were also higher as the class of obesity increased from obesity class I to obesity class III (Bustillos et al., 2015). Obese workers also took more long and short-term sickness absence, and the former was associated with obesity-related chronic medical conditions (Harvey et al., 2010).

Sickness presenteeism results in a more challenging issue. While absenteeism is physically visible and stigmatised (Kinman et al., 2017), presenteeism is much harder to observe and quantify. There is a grey area between hard-working and committed employees who still come to work despite their illness, and workers who underperform because of their illness, and a risk of spreading disease (if contagious) to their colleagues (Kinman et al., 2017; Prater & Smith, 2011). Working through sickness may also risk prolonging recovery and absenteeism if the illness gets worse (Kinman et al., 2017; Taloyan et al., 2012). As mentioned above, many studies have shown the association between BMI and sickness presenteeism. Although the association between obesity classes (I – III) was not as strong compared to sickness absenteeism (Christensen et al., 2015), workers in the higher obesity classes were found to be significantly less productive (Gates, Succop, Brehm, Gillespie, & Sommers, 2008).

Few studies have looked at the consequences of overweight and obesity on sickness absenteeism or presenteeism in the military population. Both sickness absenteeism and presenteeism result in the loss of workforce and reduce total force readiness. In Finnish Army, personnel who took longer sick leaves (more than seven days) had higher mean BMI than those who took less or never took sick leaves (Kyrolainen et al., 2008). That study also found that overweight and obese personnel not just took longer sick leaves, they also incurred higher cost in terms of work disability and loss of productivity. Given these serious consequences, more studies are needed in this area.

2.5.2 Physical fitness

Physical fitness is one of the most critical components in selecting individuals best suited for physically demanding military service (Naghii, 2006). On top of that physical fitness is seen as a signal of discipline, professionalism, and also pride and morale booster for the soldiers (McLaughlin & Wittert, 2009). While the general public is more concerned about the health-related fitness, the military embraced both health and performance related fitness (Roy, Springer, McNutty, & Butler, 2010). It is necessary for the soldiers to have optimum cardiorespiratory fitness and muscular strength to be able to accomplish physical tasks such as load carrying and heavy lifting without injuring themselves. Fitness was also the primary determinant of soldiers' capability for deployment (Collee et al., 2014; Sudom & Hachey, 2011).

Maximum oxygen consumption (VO_2max) is considered the gold standard and is widely used in the assessment of cardiorespiratory fitness (Levine, 2008). Higher VO_2max means better cardiorespiratory fitness. However, this method can be costly and required complete laboratory facilities. Some studies used 12-minute Cooper test, which recorded the furthest distance run in 12 minutes. This distance is then converted into

VO_2max using a formula (Nogueira et al., 2016). A more common way of assessing cardiorespiratory fitness is the basic fitness test, which comprises 1.5 miles (2.4 km) run, sit-up and push-up. Some countries used this format to assess the physical fitness of their military personnel (Collee et al., 2014; Crawford et al., 2011).

However, relying on this test alone was criticised given its disadvantages on heavier and larger personnel (Vanderburgh, 2008). Kalantar-Zadeh et al. (2016) argued that 'heavy' individuals might have an advantage by carrying a heavier weight, as long as they are metabolically healthy. Persistent exercise enabled them to develop bulkier muscle mass, and hence increase muscular strength and cardiorespiratory fitness in the long run (Kalantar-Zadeh & Ahmadi, 2016). Most of the soldiers that fall into these groups had the muscular strength to perform physically demanding tasks but were unable to run as fast or do more sit-ups and push ups than lean or underweight personnel. Thus, the compositions of FM and lean muscle mass contributing to their 'heaviness' have to be verified, because studies also have shown that obesity may be inversely related to lower muscular strength (Kjaer, Torstveit, Kolle, Hansen, & Anderssen, 2016; Trudelle-Jackson, Jackson, & Morrow, 2011).

FFM is the primary determinant of individual VO_2max, not FM (Goran, Fields, Hunter, Herd, & Weinsier, 2000). However, heavier weight in terms of excess fat that the obese individual has to carry during aerobic fitness test is the main reason why they easily exhausted and hence have lower fitness level (Krachler 2015). Several studies in the past have shown an inverse relationship between adiposity and aerobic fitness (Dagan, Segev, Novikov, & Dankner, 2013; Laxmi, Udaya, & Shankar, 2014; Mondal & Mishra, 2017). In the US Army, personnel with lower BF% (<18%), performed 70% better in the fitness test (Crawford et al., 2011). BMI and WC also showed strong association with cardiorespiratory fitness in Brazilian military firefighters (Nogueira et al., 2016). Personnel who were overweight and obese had 3.3 and 7.0 higher odds of being unfit compared to their normal-weight counterparts. These odds were 8.1 times higher in those with high WC. Overweight and obesity were also among the main factors identified in passing the physical readiness test in the US Navy (Zajdowicz & McKenzie, 2003). Although many studies have found a strong association between obesity and lower VO_2max, evidence to establish obesity as a sole cause or effect of lower fitness level is still lacking (Rauner et al., 2013).

Another possible explanation for the lower aerobic fitness level among the obese individual is their tendency to develop fluid and sodium imbalance during prolonged exercise. This condition causes higher fluid intake and sweat rate, and lower urine output (Eijsvogels et al., 2011). These physiological responses may force the obese individual to stop their exercise at earlier stages compared to the lean individual.

2.5.3 Other consequences

This section of literature review will also cover other important consequences of overweight and obesity, which are not directly covered in this study. This includes NCDs, quality of life and healthcare utilisation and financial burden.

2.5.3.1 Non-communicable diseases

There is substantial evidence associating overweight and obesity with NCDs including coronary heart disease (CHD), type 2 diabetes mellitus (DM), hypertension, stroke and cancer (Guh et al., 2009). The increasing trend of overweight and obesity across the globe has raised major concern about its effects on NCDs. Ischaemic heart disease (IHD) and stroke were the top two causes of death globally and all income categories (lower-middle, upper-middle and high) except for low-income countries (at number three and four) (WHO, 2015). As the income status of the nation improved, the emergence of NCDs in the top 10 causes of death was more prominent.

Studies have shown that obese individual was more likely to be hypertensive due to increase in arterial pressure from the excess weight gained (Doll, Paccaud, Bovet, Burnier, & Wietlisbach, 2002; Lavie & Milani, 2003). Persistent hypertension exerts extra workload on the heart leading to left ventricular hypertrophy and subsequently congestive cardiac failure and increase the risk of IHD. Excess weight may also increase the circulating free fatty acid released from the adipose tissue, which will accelerate the formation of lipid plaque (atheroma) in the artery (Calle & Kaaks, 2004). Accumulation of atheroma will cause narrowing or blockage of the artery and lead to IHD and ischaemic stroke. Persistent hypertension may also induce cerebral artery aneurysm and haemorrhagic stroke if uncontrolled (Deb, Sharma, & Hassan, 2010).

Insulin is the hormone responsible for regulation of glucose metabolism in the peripheral tissues. Excess calorie intake and weight gain caused the peripheral tissues to become insensitive to insulin leading to insulin resistant and hyperinsulinaemia (Calle & Thun, 2004). Insulin resistant will lead to an adult-onset or Non-Insulin Dependent Diabetes Mellitus (NIDDM) (Lavie & Milani, 2003). A study among European Union countries has shown that obese individual was at higher risk of NIDDM, and 80 to 90% of the increase in the NIDDM prevalence in this region can be attributed to excess body weight, especially abdominal obesity (Astrup, 2007). Similarly, in the US population, a significant association was established between overweight and obesity and DM with odds ratio as high 7.3 among those with BMI $\geq$40 kg/m^2 compared to the normal weight individual (Mokdad et al., 2003).

A prospective study in the US found that 20% of cancer deaths can be attributed to overweight and obesity (Calle, Rodriguez, Walker-Thurmond, & Thun, 2003). Although there were several proposed pathophysiological pathways linking obesity to cancer, the actual mechanism is still unclear (Louie, Roberts, & Nomura, 2013). One of the hypothesised mechanisms was an alteration in the production of peptides and several steroid hormones due to insulin excess and resistant (Calle & Kaaks, 2004). A systematic review and meta-analysis by Renehan et al. (2008) concluded that with even a small increase of 5 kg/m^2 in BMI, the odds of different types of cancer were increased both in males and females (Renehan, Tyson, Egger, Heller, & Zwahlen, 2008). Other studies have also reported the association between overweight and obesity with several types of cancer including colorectal, endometrial, and breast cancer (Calle & Kaaks, 2004; Calle & Thun, 2004).

2.5.3.2 Quality of Life

Studies have shown that overweight and obesity had negative consequences on the quality of life (QOL) (Pimenta, Bertrand, Mograbi, Shinohara, & Landeira-Fernandez, 2015; Ul-Haq, Mackay, Fenwick, & Pell, 2013), and this inverse association could work both ways (Cameron et al., 2012). Overweight and obesity may affect the physical health as well as the mental health (Ul-Haq et al., 2013). These could be worsened by coexisting morbidities such as hypertension (Ucan & Ovayolu, 2010), endometrial cancer (Fader, Frasure, Gil, Berger, & von Gruenigen, 2011), and other NCDs. Obesity is associated with decreased functional mobility (Forhan & Gill, 2013), and difficulty in managing activity of daily living (ADL) (Backholer, Wong, Freak-Poli, Walls, & Peeters, 2012) including limitations in fulfilling family's role especially among females (Tsai, Yang, Lin, & Fang, 2004). All these disadvantages have led to poor QOL among obese individuals. Higher body weight gives an additional burden to the joints, especially the knees and hips. Osteoarthritic pain and generalised joint pain suffered by an obese individual have affected their personal and social life, and their overall QOL (Forhan & Gill, 2013; Stone & Broderick, 2012). Obstructive sleep apnoea (OSA) is common among obese individual and has been linked to decreased QOL (Dutt, Janmeja, Mohapatra, & Singh, 2013; Silva, Goodwin, Vana, & Quan, 2016). Daytime sleepiness, tiredness, and poor job performance are common among OSA sufferers.

Obesity does not just affect the physical health aspect of QOL but also in the mental and psychosocial health domains (Ul-Haq et al., 2013). Obese individuals were stigmatised by the society (Puhl & Heuer, 2010; Sutin & Terracciano, 2013) and marginalised in many aspects such as employment, healthcare, and school (Giel et al., 2012; Puhl & King, 2013). Persistent victimisation subsequently led to depression, low self-esteem and thus poor QOL. Obese individuals may be perceived as lazy and unmotivated (Niederdeppe, Robert, & Kindig, 2011), and therefore are more unlikely to be employed and even given lower wages (Johansson, Böckerman, Kiiskinen, & Heliövaara, 2007). Studies also have shown that obese individuals were less likely to have or maintain personal relationship or friendship (Ali, Amialchuk, & Rizzo, 2012; Boyes & Latner, 2009), mostly due to their low self-esteem and negative perception from their partner and friends. While physical health impacts on QOL are more visible, the psychosocial impacts may cause more detrimental consequences including depression and suicidal risks (Alves et al., 2016; Dutton, Bodell, Smith, & Joiner, 2013).

2.5.3.3 Economic burden

Besides its indirect cost through loss of productivity and premature death, overweight and obesity posed a major threat in consuming large portions of country's annual expenditure through its direct medical cost (Lehnert, Sonntag, Konnopka, Riedel-Heller, & Konig, 2013). Overweight and obesity were among the main risk factors for many NCDs (Guh et al., 2009) and injuries (Kouvonen et al., 2013). As the prevalence of overweight and obesity continued to rise across the globe, the obesity-related health expenditures were expected to increase with it (Knai et al., 2007; Yang & Nichols, 2011). Although obesity incurred lower lifetime healthcare cost due to shorter life expectancy, its total obesity-related healthcare cost was substantially high especially among the severely obese individual in the upper economic strata (Lengerke & Krauth, 2011). In the US, it was estimated that around 5% to 10% of direct health care expenditures were attributed to overweight and obesity (Tsai, Williamson, & Glick, 2011).

It was forecasted that by the year 2030, around 50% of the US adults will be obese (Finkelstein et al., 2012). If the obesity prevalence were to remain as in 2010, the country would have saved more than USD 500 billion in medical expenditures in the next 20 years. Since obesity is linked to lifestyles and environmental factors, implementation of effective prevention programmes could potentially save these costs (Wolfenstetter, 2012) or at least the financial burden would be much lower (Trogdon, Finkelstein, Feagan, & Cohen, 2012). Apart from the direct economic implications, overweight and obesity and their related conditions were estimated to take up to at least 8% of the primary care time (Tsai, Abbo, & Ogden, 2011). These times were spent on consultation and treatment of weight-related illnesses, mainly the NCDs.

Among military personnel, obese soldiers were found to incur higher healthcare cost as well as higher rates of injuries and restricted working days (Peake et al., 2012). Even among the recruits, higher clinic visits were attributed to musculoskeletal injuries during training, which was linked to higher BMI (Taanila et al., 2010). This phenomenon has raised another concern in terms of healthcare cost as well as the cost of training should the recruits being terminated or further healthcare cost resulted from the injuries should the recruits being accepted into the service. The US Department of Defence spent more than USD 1 billion in healthcare costs related to obesity (Dall et al., 2007). These resources could be used to strengthen the workforce and improve their military resources.

2.5.4 Summary of consequences of overweight and obesity

Adverse health effects from overweight and obesity have been described exhaustively in many studies. In the general population, the rising of NCDs attributed to overweight and obesity, leading to poor quality of life as well high healthcare cost would probably be among the most concerning consequences related to overweight and obesity. Apart from these major health effects, the two most related consequences of overweight and obesity, as far as military performance and readiness are concerned, are sickness absenteeism and physical fitness. Despite their importance, studies on these two consequences in the military population are still limited. Therefore, this study will focus on the consequences of overweight and obesity on sickness absenteeism and physical fitness in the Malaysian Army. The scope of this study, however, will not cover the consequences on the health and economic aspects.

2.6 Summary of Chapter 2

The prevalence of overweight and obesity has been increasing in the general population as well as in the military population across the world. Although the prevalence of obesity in the military population in most nations was not as high as their general population, the increment rates were faster. Furthermore, the study on obesity in the military population is still lacking compared to the general population. Exposure to an obesogenic environment, unhealthy lifestyles, and individual risks may have outweighed their presumably fit and active population and predisposed them to overweight and obesity. What should be more concerning to the military population are the impacts of overweight and obesity on the ability of personnel to maintain optimum health and fitness, and able to perform their job efficiently.

CHAPTER 3: METHOD

Chapter 3 discusses the methodology used in this study. There are two phases of this study. Phase 1 is a retrospective cohort study aimed to determine the trend of BMI changes throughout services, socio-demographic and occupational factors associated with these changes and also the association between BMI and sickness absenteeism. Meanwhile, Phase 2 is a cross-sectional study aimed to determine the prevalence of overweight and obesity, and the socio-demographic, occupational and lifestyle factors associated with it. Phase 2 was also set up to determine the implication of overweight and obesity on physical fitness.

3.1 Phase 1

3.1.1 Study design

Phase 1 is a retrospective cohort study of 25 years from 1990 to 2015. It involved data extraction from service and medical records of personnel who are still in service.

3.1.2 Study population and sample

The study population for this phase was the Malaysian Army. There are four Divisions in the Malaysian Army, namely the Northern, Central and Southern in the Peninsular Malaysia and the Eastern Division in East Malaysia (Figure 3.1). The composition of each Division is almost homogenous in terms of:

a. The number of combatant and non-combatant personnel between these states and Divisions.

b. All personnel have an equal opportunity of being relocated within and between the divisions and states.

c. Job specification, regardless of the location.

The 3rd Division was randomly selected as the target population for this study. The 3rd Division commands the southern region covering the states of Negeri Sembilan, Malacca, Pahang and Johor [Figure 3.1). Participants for this study were sampled from the states of Malacca and Negeri Sembilan. Their close geographical location was among the factors why these two states were chosen. Furthermore, the units in these two states are located closer to each other compared to the units in the larger states such as Johor and Pahang, which were scattered. Since the compositions between and within the states and Divisions are almost the same, the states of Malacca and Negeri Sembilan was not much different compared to the states of Pahang and Johor and other states as well.

The non-combatant personnel were chosen because of the anticipated higher prevalence of overweight and obesity in this group. Compared to the combatant personnel, the nature of their job is more sedentary, and their routine physical training is less intense.

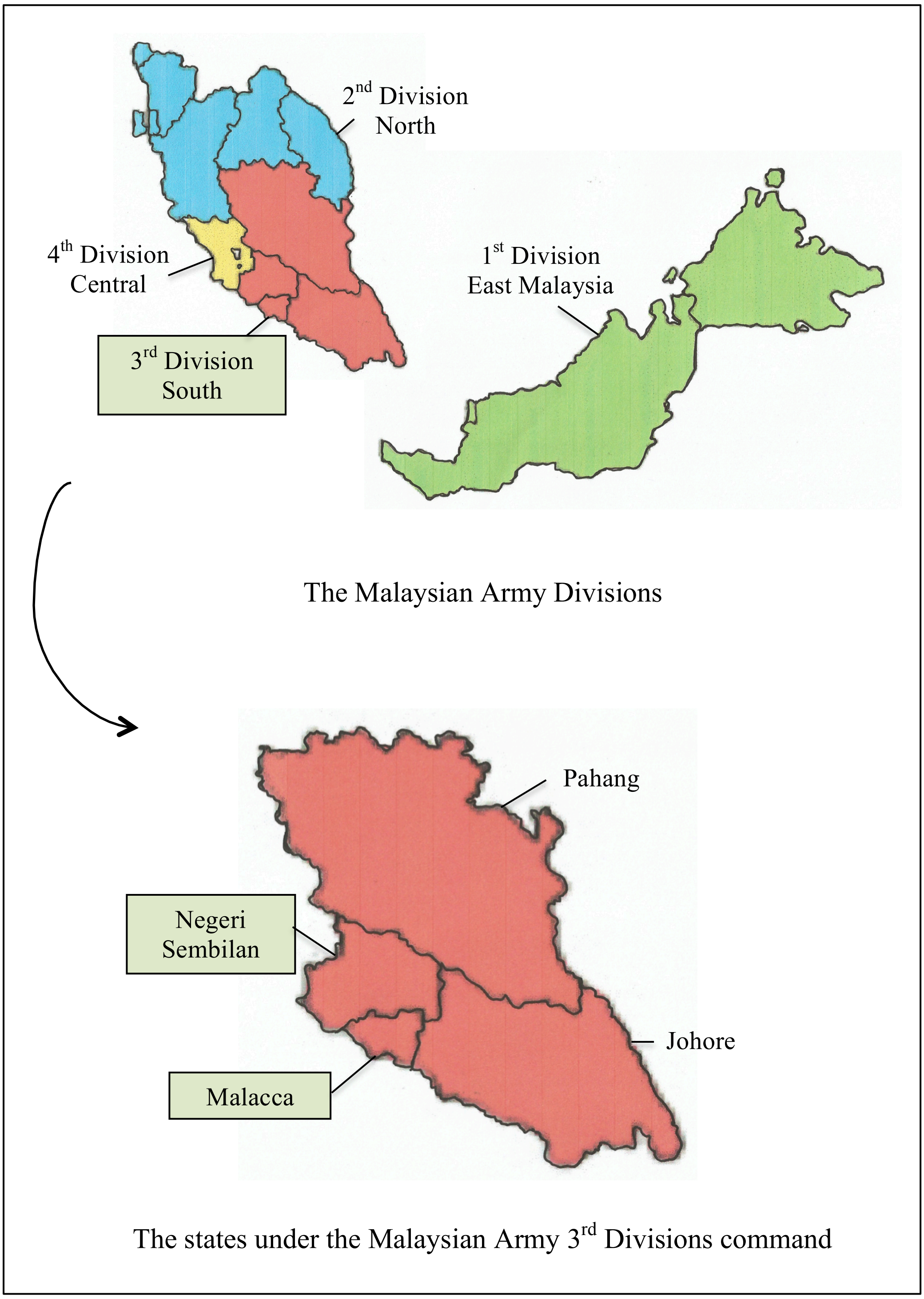


Figure 3.1: The Malaysian Army Divisions

3.1.3 Eligibility criteria

Eligible participants included:

a. Non-combatant Malaysian Army personnel on active duty.

b. Personnel with available medical and service records.

Personnel was excluded from this study if they were:

a. Reserved Army personnel, as they are not full-time in training and service.

b. In the process of retirement (18 months for senior and junior ranks, and 6 months for officers before the actual retirement date).

c. Under detention in military or civil court.

d. Absent from duty without proper documentation.

e. Under military deployment (local or international) for more than six months during the data collection period.

3.1.4 Sampling method and sample size

Studies in epidemiological trend usually adopted very large sample size to demonstrate the trend over time. In this study, it is anticipated that there will be high possibilities or rejection due to unavailability or incomplete records. Furthermore, not all of the personnel complied with the scheduled medical check-up every year or every two years unless they are going for courses or being promoted. Taking this fact into consideration, together with on-the-ground factors such as high turnover rate of personnel in the units, universal sampling was used in Phase 1. This will ensure adequate data are collected to generate the trend of BMI changes from 1990 to 2015. There were around 2600 non-combatant personnel listed in various units in the state of Malacca and Negeri Sembilan.

3.1.5 Study variables

Independent and dependent variables in the context of Phase 1 objectives are shown in Table 3.1.

Table 3.1: Study variables for Phase 1

Study objectives	Variables	Description
1. To determine the predictors of overweight and obesity	Dependent variable i. BMI	Overweight and obesity
	Independent variables	
	i. Socio-demographic and occupational factors	Age, gender, ethnicity, marital status, education level, duration of service and rank
2. To determine the implication of overweight and obesity on sickness absenteeism	Dependent variable i. Sickness absenteeism	Sick report, sick leave and sick excuse
	Independent variables	
	i. BMI	Overweight and obesity
	ii. Socio-demographic and occupational factors	Age, gender, ethnicity, marital status, education level, duration of service and rank

3.1.6 Study instruments

Study instruments used to measure all variables in Phase 1 are summarised in Table 3.2.

Table 3.2: Study instruments used in Phase 1

Study variables	Instrument
i. Socio-demographic and occupational factors	Service Record • Age, gender, ethnicity, marital status, education level, duration of service and rank
ii. Overweight and obesity	Medical Record • BMI measurements taken throughout military career
iii. Sickness absenteeism	Medical Record • Number of sick report, sick leave and sick excuse accumulated throughout military career

3.1.7 Description of study variables and instruments

3.1.7.1 Socio-demographic and occupational factors

Service record contains personnel's socio-demographic and occupational information from the date they joined the service. These records are kept in their respective unit under the control of the unit's Adjutant, and it will be transferred with them whenever they are posted or promoted to a new unit. However, the transfer of this record can sometimes lag behind due to administrative procedures. The information will be updated twice a year or whenever important events take place. Socio-demographics and occupational data extracted from the service record included:

(a) **Age** – calculated from the participant's date of birth to 1st Jan 2016, and recorded to the nearest 0.1 years. Age was treated as a continuous and categorical variable. The age groups were classified into <30 years and ≥30 years for the categorical variable due to the small number of participants aged <20 years (0.7%) and ≥40 years (6.7%).

(b) **Gender** – categorised as 'Male' and 'Female'

(c) **Ethnicity** – Malaysians are predominantly made up of the Malays, Chinese, Indians and natives from East Malaysia (Sabah and Sarawak). However, the majority of the Malaysian Armed Forces personnel are Malays or natives form the East Malaysia with a small number of Indians and Chinese. Thus, the ethnicity was categorised as 'Malays' and 'Non-Malays' for the analysis.

(d) **Marital Status** – categorised as 'Married' and 'Unmarried' if they are single, widowed or divorced.

(e) **Education level** – for those who had not completed secondary school were classified as 'Lower Secondary'. Those who had completed secondary school were categorised as 'Secondary', and those who have attained Diploma or Degree were classified as 'Tertiary'.

(f) **Duration of service** – calculated from their date they joined the service to the 1st January 2016 and recorded to the nearest 0.1 year. Duration of service was treated as continuous and categorical variables (<5, 5-9.9, 10-14.9, and ≥15 years).

(g) **Rank** – classified as 'Junior Rank' (Private, Lance Corporal, and Corporal), 'Senior Rank' (Sergeant, Staff Sergeant, and Warrant Officer), and 'Officer' (those who were commissioned as an officer from the rank of Second Lieutenant and above).

3.1.7.2 Overweight and obesity

BMI was used as a proxy measure of overweight and obesity in this study. Personnel's BMI is recorded throughout their military career in their medical record. Most of the recordings came from their yearly routine medical check-up (for personnel above 40 years old) or every two years (for personnel below 40 years old). Other sources of BMI records included medical check-ups when attending military courses, during promotions or when shortlisted for overseas deployments. BMI was recorded to nearest 0.1 kg/m^2 in this study.

BMI was treated as continuous as well as categorical variables. Mean BMI was calculated as the average BMI recorded throughout their service. BMI was categorised according to the WHO classification as shown in Table 2.1 in Chapter 2 (WHO, 2004).

3.1.7.3 Sickness absenteeism

The Malaysian Armed Forces Hospitals and the Army sickbays are the main healthcare facilities catering for personnel and their dependents. Their medical record contains all the information regarding their health status as well as information every time they accessed the facilities including records on sickness absenteeism. In this study, sickness absenteeism was defined and classified as:

(a) Sick reports –recorded as how many times they accessed the healthcare facilities for treatment of their illness or their routine medical check-up.

(b) Sick leaves – recorded the number of days they were given total leaves and did not have to go back to work until a specified date.

(c) Sick excuses – recorded the number of days they were given light duties with specific excuses because of their illnesses. They still have to go back to work but were excused from certain activities such as a parade or physical training.

However, they can be given neither sick leaves nor excuse if they are considered fit to get back to work or just come in for a routine medical check-up. These will still be counted as sick reports.

3.1.8 Ethical consideration

This study was approved by the University Malaya Medical Centre (UMMC) ethical committee in February 2014 (Reference: MEC ID: 2014020759) (**Appendix A**). Approval from The Malaysian Army Headquarters (HQ) (**Appendix B**) and the 3rd Division HQ (**Appendix C**) was obtained on the 7th August 2014 and 23rd August 2014 respectively. Approval from the Malaysian Army and the 3rd Division Headquarters are sufficient to proceed with the research. However, all commanders of the units involved were briefed about this study during the first meeting before commencing with reviews of the medical and service records.

3.1.9 Setting and procedure

The Phase 1 was conducted in the state of Negeri Sembilan and Malacca under the 3rd Division command (Figure 3.2). Upon obtaining approval from both the Malaysian Army and the 3rd Division HQs, arrangements were made with each unit, starting with the units in Malacca. This included getting the name list and fixing the suitable date and time depending on the unit's activity. Extraction form was created to facilitate and standardise the data collection (**Appendix C**). Assistants from the respective units, the Army Hospital, and the Army Sickbay were recruited and trained to help out in the data collection.

Data collection started officially in September 2014 with units in Malacca. There are ten non-combat units in Malacca directly under the command of the 3rd Division, which altogether were made up of over 1800 personnel. The number of personnel ranges from 330 personnel for the big units to 50 personnel for the small units. The research team had to return several times to individual units, especially large units, to complete the data extraction from their service records.

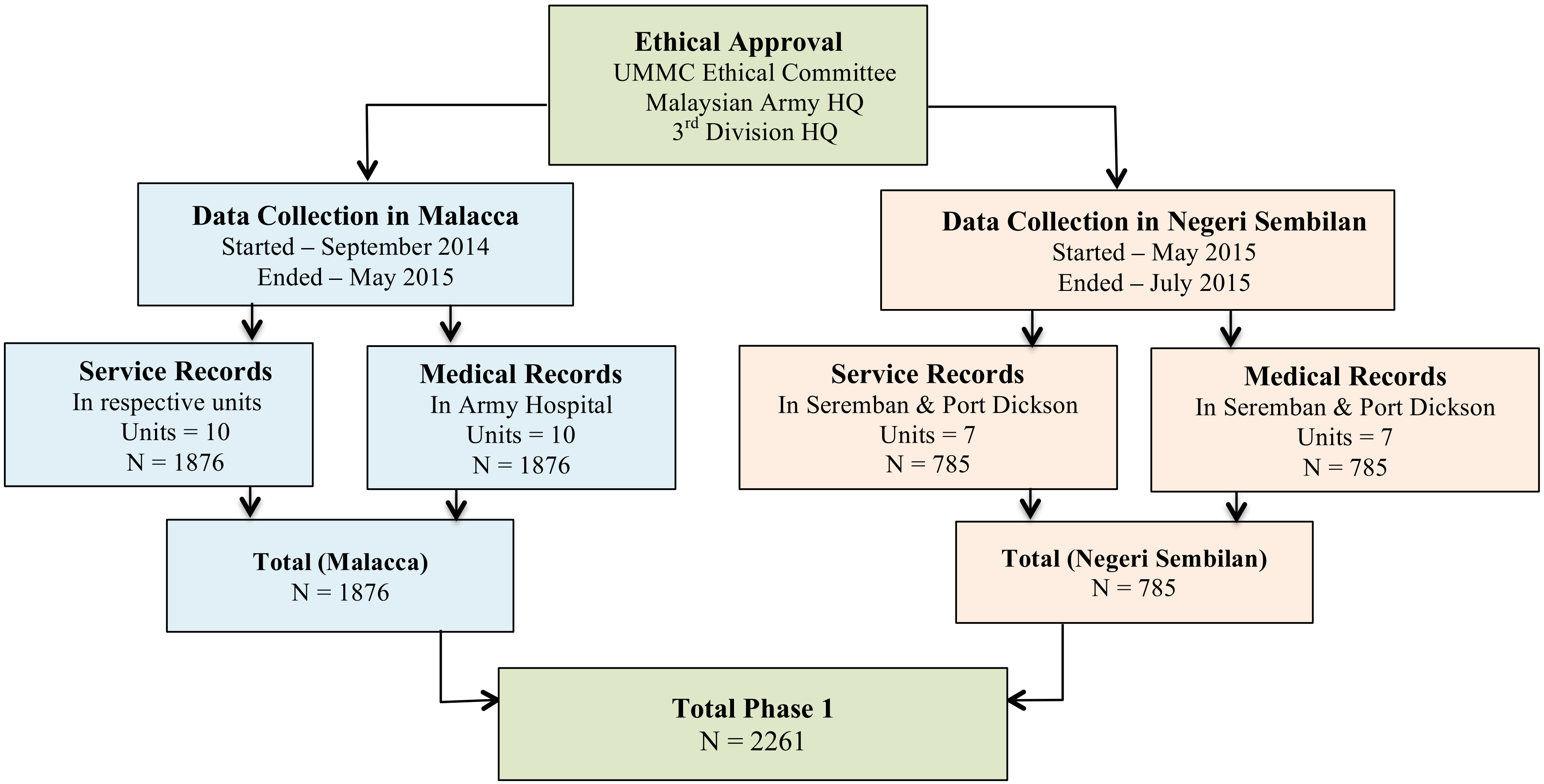


Figure 3.2: Flow chart of data collection for Phase 1

All medical records for the units in Malacca are kept in the Armed Forces Hospital, which is located in the same camp. Thus, reviewing medical record does not depend on the unit's activity and can be assessed at any time. The research team reviewed the medical records whenever none of the units was available, mostly due to local activities. Although medical records can be assessed at any time, the data were complicated, especially the sickness absenteeism. Hence, data extraction from medical records took longer. Three personnel were recruited and trained to help out in the data collection in Malacca to ensure consistency and efficiency.

Data collection then continued with the units in Negeri Sembilan (Seremban and Port Dickson) in May 2015. There are seven non-combat units located in Seremban and Port Dickson with a total of over 700 personnel. Seremban and Port Dickson towns are about 71km and 57km from Malacca respectively, and 30km apart from each other. Medical records for these units are kept in the Army Sickbay in Seremban and Port Dickson. A new team of assistants was recruited and trained due to logistics and administrative reasons. Data collection efforts in Seremban and Port Dickson were completed in July 2015. Cooperation and assistance from all units were excellent.

In total, there were 1876 personnel in ten units in Malacca. After excluding 253 personnel without medical record or service record or both, 1623 personnel's records were reviewed within eight months. As for units in Negeri Sembilan, a total 652 personnel's records were reviewed, and 133 were excluded. Overall, 2275 personnel's records were reviewed, and 386 were excluded. The data retrieval took much longer than expected, especially extracting the BMI and sickness absenteeism from the manually recorded medical records. Although the total number of personnel in Negeri Sembilan was smaller, the units were located in two different cities. Thus, the data collection was slowed down by the constant back and forth travelling to accommodate the unit's availability.

3.1.10 Data management

Since Phase 1 involved a large number of participants, and the data extractions from both the records were not systematic (i.e., based on the unit's availability and not in any particular order), data recording into Microsoft Excel format was done at the end of the day by batches. In some instances where these were not possible due to time constraint, data were entered and saved by the end of the week. Data were saved on a personal laptop, and an external hard disc was used as backup storage. Both of these files were password encrypted to ensure only the researchers had access to these data. Data were entered in Microsoft Excel format and coded for analysis in the Statistical Package for Social Sciences (SPSS) version 20 software.

3.1.10.1 Data coding

All categorical variables for Phase 1 were coded accordingly as shown in Table 3.3.

Table 3.3: Definition and coding for Phase 1 variables

Variables	Operational definition	Coding
1. Socio-demographic		
a. Age	Age was calculated on the 1st Jan 2015 from their DOB and categorised into 2 groups	0: <30 years 1: ≥30 years
b. Gender	Gender was classified into 2 groups	0: Male 1: Female

Table 3.3 (Continued)

Variables	Operational definition	Coding
c. Ethnicity	Ethnicity was classified into 2 groups	0: Malays 1: Non-Malays
d. Marital status	Marital status was classified into 2 groups	0: Married 1: Unmarried
e. Education level	Education level was classified into 3 groups based on highest education attained	0: Lower secondary 1: Secondary 2: Tertiary
2. Occupational factors		
a. Duration of service	Duration of service was calculated on the 1st Jan 2015 from the date of entrance and categorised into 4 groups	0: <5 years 1: 5-9.9 years 2: 10-14.9 years 3: ≥15 years
b. Rank	Rank was categorised into 3 groups based on the Malaysian Army rank classification	0: Junior Rank 1: Senior Rank 2: Officer
3. Body mass index		
a. BMI status	BMI was categorised according to the WHO classification. Underweight and obese were grouped together with normal weight and overweight respectively	0: Normal (BMI <25 kg/m^2) 1: Overweight & obese (BMI ≥25 kg/m^2)

DOB – Date of Birth

3.1.10.2 Data entry and checking

Data collected were initially entered in tables prepared earlier in Microsoft Excel program. Each variable and units were coloured to track the progress of data collection and entry. Coding (Table 3.3) was used to increase efficiency and to avoid errors during the double data entries. The two data sets were then cross-checked. Any discrepancies found were referred back to the data in the extraction forms. Completed data were then copied into another Microsoft Excel file before exported to the SPSS software for analysis.

Initial basic analyses including descriptive, frequency, histogram, and box plot were carried out to identify outliers and missing values, which were then verified from the data collected. Since data collection was done rigorously and the units were revisited several times to ensure completeness of data, there were few missing values or rejected forms. Some of the data collected were not included, mostly because the participants did not have either medical or service records.

3.1.11 Data analysis

All data were analysed using IBM SPSS version 20. The significance level was set at p-value ≤ 0.05. Analyses were conducted based on the research objectives.

3.1.11.1 Descriptive analysis

Descriptive analysis was used to give an overall description of all the variables in this study. Categorical variables were presented as count (n) and percentage (%), and continuous variables were presented as mean and SD. Independent sample t-test and Chi-square test were used to compare mean and proportion (%) respectively between males and females for all variables.

The trend of overweight and obesity were presented as mean BMI from the year 1990 to 2015. The prevalence of overweight and obesity over these years were analysed as proportion (%) and compared to the general Malaysian population. Maximum BMI ever reached by the participants and individual mean BMI were illustrated in proportion (%) using bar graphs.

3.1.11.2 Univariate analysis

Kaplan-Meier survival analysis was used to determine the median survival times of overweight and obesity for each predictor. Time to event was defined as 'time to reach BMI of $\geq$25 kg/m^2. Independent sample t-test and one-way ANOVA were used to determine the factors associated with all the measures of sickness absenteeism (sick report, sick leave and sick excuse). Factors with p-value <0.25 were included in the multivariate analysis, which used 'sick report' as a proxy for sickness absenteeism.

3.1.11.3 Multivariate analysis

Cox regression analysis was used to determine the Hazard Ratio with 95% confidence interval (CI) for predictors of overweight and obesity. For variables with more than two groups with a significant result, the post-hoc Bonferonni pairwise comparison was performed to determine group differences. Generalised Linear Model (GLM) was used to compare the mean sick report with 95% CI for the socio-demographic and occupational factors, and overweight and obesity.

3.2 Phase 2

3.2.1 Study design

Phase 2 is a cross-sectional study designed to complement Phase 1 to acquire a better understanding of overweight and obesity issues in the Malaysian Army. Since Phase 1 concentrated more on socio-demographic and occupational factors, Phase 2 included data on modifiable factors such as smoking, physical activity and dietary habits and intake, which are not available from the medical and service records. Phase 2 also set to determine the consequences of overweight and obesity on physical fitness, to add on to the sickness absenteeism studied in Phase 1.

3.2.2 Study Population

The study population was similar to Phase 1 as reported in 3.1.2.

3.2.3 Eligibility criteria

Inclusion criteria for this phase include:

a) Non-combatant Malaysian Army personnel on active duty.

b) Agreed to participate in the study.

c) Fit for Basic Military Fitness Test (BMFT) as certified by the military medical officer.

Exclusion criteria for this phase are similar to Phase 1. Additional criteria include:

a) Pregnant personnel.

b) Personnel with medical conditions, for example, recent heart attack, poorly controlled diabetes or hypertension or whose health status has been downgraded and advised not participate in a vigorous physical activity. These conditions had to have been certified by a military medical officer.

3.2.4 Sample size calculation

3.2.4.1 Sample size calculation based on prevalence

Sample sizes based on prevalence were calculated using the formula $n = \frac{z^2 p(1-p)}{e^2}$

where; n – the estimated sample size

z – *z* value for corresponding 95% CI; z = 1.96

p – the estimated proportion of the sample with overweight or obesity

e – the margin of error or desired precision; e = 3%

Calculation was made based on the prevalence of overweight and obesity in the general Malaysian population (Institute for Public Health (IPH), 2015) and Malaysian Navy personnel (Sedek et al., 2010) (Table 3.4).

Table 3.4: Sample size calculation based on prevalence

Population	Prevalence	Calculated sample size	Additional 20% (anticipated attrition)
General Malaysian population (IPH, 2015)	Overweight & obesity – 47.7% Overweight – 30.0% Obesity – 17.7%	1065 897 630	1276 1077 756
Royal Malaysian Navy personnel (Sedek et al., 2010)	Overweight & obesity – 36.5% Overweight – 29.3% Obesity – 7.2%	995 879 278	1194 1054 334

The sample size estimation based on the prevalence of overweight and obesity was around 1300.

3.2.4.2 Sample size calculation based on odds ratio

Sample size estimation using odds ratio was performed using Open Epi: Open Source Epidemiologic Statistics for Public Health software for cross-sectional studies (Dean, Sullivan, & Soe, 2013). Physical activity and physical fitness was chosen based on the available studies in the military and the general population (Table 3.5). Apart from odds ratio, other information required for the calculation include:

i. Two-sided confidence interval; set at 95%

ii. Power of the study; set at 80%

iii. Ratio of unexposed/exposed in the sample

iv. Percentage of unexposed and/or exposed with outcome

Table 3.5:Sample size calculation using Open Epi based on Odds Ratio

Population	Prevalence	Calculated sample size	Additional 20% (anticipated attrition)
General Malaysian population (Chan et al., 2017)	Factor: level of physical activity OR 1.14 (95% CI: 1.01,1.30); Unexposed/exposed ratio = 0.94; Percentage of unexposed with outcome = 32.1%	1329	1595
Belgian Army (Collee et al., 2014)	Factor: Physical fitness OR 2.90 (95% CI: 1.01,1.30); Unexposed/exposed ratio = 0.92; Percentage of unexposed with outcome = 5.0%	391	470

The sample size estimation based on the prevalence of overweight and obesity was around 1600. Therefore, 1600 participants are required to establish the prevalence and association with overweight and obesity.

3.2.5 Sampling method

Convenience sampling was used in Phase 2 involving all units in both Malacca and Negeri Sembilan states. Random sampling was not possible due to activities in the units, and personnel were constantly unavailable because of out-of-unit tasks. More often than not, most of the personnel were not available to participate, or the number was too small. Thus, the team had to revisit the units to ensure reasonable participation from that unit.

3.2.6 Study Variables

Independent and dependent variables based on the Phase 2 objectives are shown in Table 3.6.

Table 3.6: Study variables for Phase 2

Study objectives	**Variables**	**Description**
1. To determine the factors associated with overweight and obesity	Dependent variable i. BMI	Overweight and obesity
	Independent variables	
	i. Socio-demographic and occupational factors	Age, gender, ethnicity, marital status, education level, number of children, spouse employment, household income, duration of service and rank
	ii. Smoking	Smoking status, amount and duration of smoking (among smokers and ex-smokers) and duration of quitting (among ex-smokers)
	iii. Physical activity	Level of physical activity; overall, and according to the domain and intensity
	iv. Dietary habit	Source of food and frequency of fast food consumption
	v. Dietary intake	Energy (kcal), protein, carbohydrate, and fat in mass (g) and percentage (%)

Table 3.6 (Continued)

Study objectives	Variables	Description
2. To determine the implication of overweight and obesity on physical fitness	Dependent variable i. Physical fitness	Basic Military Fitness Test results (passed or failed)
	Independent variables i. BMI	Overweight and obesity
	ii. Socio-demographic and occupational factors	Age, gender, ethnicity, marital status, education level, number of children, spouse employment, household income, duration of service and rank
	iii. Smoking	Smoking status, amount and duration of smoking (among smokers and ex-smokers) and duration of quitting (among ex-smokers)
	iv. Physical activity	Level of physical activity; overall, and according to the domain and intensity
	v. Dietary habit	Source of food, frequency of fast food consumption
	vi. Dietary intake	Energy (kcal), protein, carbohydrate, and fat in mass (g) and percentage (%)

3.2.7 Study instruments

The study instruments used to measure all variables in Phase 2 are summarised in Table 3.7. All questionnaires used in this study are in the Malay language, which is the national language. This includes IPAQ, which has been translated into Malay language and validated in the Malaysian population (Chu & Moy, 2012).

Table 3.7: Study instruments used in Phase 2

Study variable	Instrument
i. Socio-demographics and occupational factors	Self- reported questionnaire to gather information on: • Age, gender, ethnicity, marital status, education level, number of children, spouse employment, household income, duration of service and rank
ii. Smoking	Self- reported questionnaire to gather information on: • Smoking status, amount and duration of smoking, and duration of quitting
iii. Physical activity	International Physical Activity Questionnaire (IPAQ) – Malay translated and validated
iv. Dietary habit	Self- reported questionnaire to gather information on: • Source of food for five main meals/day • Frequency of fast food consumption
v. Dietary intake	24-hour Dietary Recall
vi. Overweight and obesity	Anthropometric measurements and body composition analysis using: • Wall mounted stature meter (height) • Soft retractable measuring tape (WC) • TANITA Body Composition Analyser (weight and body compositions)
vii. Physical fitness	Basic Military Fitness Test

3.2.8 Description of study variables and instruments

3.2.8.1 Socio-demographic and occupational factors

A self-reported questionnaire was designed to collect information on:

(a) **Age** – calculated on the 1st Jan 2016 from the participant's date of birth and recorded to the nearest 0.1 years. Age was treated as continuous and categorical variables. The age groups were classified into <30 years and ≥30 years for the categorical variable due to the small number of participants aged <20 years (2.5%) and ≥40 years (3.5%).

(b) **Gender** – categorised as 'Male' and 'Female'

(c) **Ethnicity** – options in the questionnaire include Malay, Chinese, Indian, Native East Malaysia and Others. Due to small numbers in the last four categories, ethnicity was categorised in terms of 'Malay' and 'Non-Malay' for analysis. Non-Malays include the Chinese, Indians, and the native from East Malaysia.

(d) **Marital Status** – categorised as 'Married' and 'Unmarried'. Unmarried personnel include bachelor, widowed and divorced personnel.

(e) **Education level** – categorised as:

i. ‘Lower Secondary’ – those who had not completed Secondary school.

ii. ‘Secondary’ – those who had completed Secondary school.

iii. ‘Tertiary’ – those who had Diploma or Degree qualifications.

(f) **Number of children** (among the married personnel) – categorised as:

i. None

ii. 1-3 children

iii. >3 children

(g) **Spouse employment** (among the married personnel) – categorised as ‘Working’ (Yes) or ‘Not Working’ (No)

(h) **Household income** – categorised as $<$RM3000 or $\geq$RM3000 per month.

(i) **Duration of service** – calculated from their date of enlistment or commissioned to the 1st January 2016 and recorded to the nearest 0.1 years. Duration of service was treated as continuous and categorical variables ($<$5, 5-9.9, 10-14.9, $\geq$15 years).

(j) **Rank** – classified as:

i. ‘Junior Rank’ – from the rank of Private, Lance Corporal, and Corporal

ii. ‘Senior Rank’ – from the rank of Sergeant, Staff Sergeant, and Warrant Officer

iii. ‘Officer’ – those who were commissioned as an officer from the rank of Second Lieutenant and above.

3.2.8.2 Smoking

Smoking information was gathered from a questionnaire on the participant’s smoking habit **(Appendix I)**. Data were treated as categorical as listed below;

(a) **Smoking status** – ‘Smoker’ – if they ever or still smoking; ‘Ex-Smoker’ – if they had quit smoking before this study commenced; and ‘Never Smoke’ – if they never smoked in their entire life. Types of smoking were not assessed in this study.

(b) **Smoking duration** – for smokers and ex-smokers, smoking duration was calculated from the day they started smoking. Participants were asked to give either the year or age they started smoking. The duration was then calculated until 1st January 2016 and rounded up to the nearest one year. Smoking duration is categorised as ‘<5, 5-10, and >10 years’.

(c) **Smoking amount** – for smokers and ex-smokers, smoking duration were categorised according to the number of cigarettes per day (cpd). ‘Light smoker’ if the smoked <10 cpd, ‘Moderate smoker’ if they smoked between 10-20 cpd, and ‘Heavy smoker’ if they smoked >20 cpd. These classifications were also used in a study assessing smoking and overweight and obesity (Clair et al., 2011).

(d) **Duration of quitting** – for ex-smokers, the duration of quitting was calculated from the year they stopped smoking. Participants were asked to give either the year or age they stopped smoking. The duration was then calculated until 1st January 2016 and rounded up to the nearest one year. Duration of quitting is categorised as '<5, 5-10, and >10 years'.

3.2.8.3 Physical activity

This study uses the Long-Version IPAQ (IPAQ Research Committee) as translated into Malay language and validated among a group of Malay employees (Chu & Moy, 2012) **(Appendix J)**. It is a self-reported questionnaire used to estimate the amount and intensity of physical activity at the workplace, home, during transportation and leisure time, and also the amount of sitting time in the last week or the usual week. IPAQ is recommended for measuring the level of physical activity among adults aged 18 to 65 years old, which encompassed the age range for the participants in this study.

Level of physical activity is calculated as the Metabolic Equivalent of Tasks-Minute per week (METs-min/week) and categorised according to the Guidelines for Data Processing and Analysis of the IPAQ (IPAQ Research Committee, 2005). Data is treated as continuous [median-interquartile range (IQR)] and categorical. Classification of the level of physical activity is based on METs-min/week scored by the participants as follows:

(a) Low: <600 METs-min/week
(b) Moderate: 600 – 2999 METs-min/week
(c) High: ≥3000 METs-min/week

Level of physical activity for various intensities is calculated as:

(a) Vigorous: 8.0 METs x minutes of activity/day x days/week

(b) Moderate: 4.0 METs x minutes of activity/day x days/week

(c) Walking: 3.3 METs x minutes of activity/day x days/week

The total level of physical activity was derived from the sum of vigorous, moderate and walking categories and presented as METs-min/week.

3.2.8.4 Dietary habit

A questionnaire was used to assess participants' dietary habits **(Appendix K)**. Questions include their food source [home, workplace, outsides (other than home or workplace), not taken] for the five main meals of the day (breakfast, morning tea, lunch, evening tea, and dinner). The frequency of fast food consumption was calculated based on their frequency of visits to the fast food outlets. Both 'food source' and 'fast food consumption' were treated as mean (SD), and additional classification was used for the frequency of fast food consumption as follows:

(a) Rarely: <1 visit/month

(b) Often: 1 visit/month

(c) Regular: >1 visits/month.

3.2.8.5 Dietary intake

Dietary intake was assessed using the 24-hour Dietary Recall form **(Appendix L)**. The sample for different sizes of plates, bowls, mug and glasses, and utensils together with their estimated measurement were developed with the help of a dietician.

Explanations were given to the personnel on how to fill in the form with the aid of audio-visual materials and sample form that has been filled as a guide. The primary researcher and assistants were present during this session to guide the participants in completing the form.

Data were analysed in the continuous variables for the four main food components using the Nutritionist Pro™ Diet Analysis software. Total energy is presented in terms of kilocalories (kcal). Carbohydrates, proteins, and fats were reported in grams and percentage of intake to the nearest 0.1.

3.2.8.6 Anthropometric measurements and body compositions

Overweight and obesity are classified according to BMI classifications, WC and BF%. Assistants were trained to take the measurements and handle the equipment used in this study. Information on anthropometric measurements and body compositions were recorded on a separate form **(Appendix M)** before transferred to Excel format.

(a) **BMI** – calculated using the formula [BMI = Weight (kg)/ Height^2 (m^2)] and expressed in the nearest 0.1 kg/m^2. Participants were asked to wear light clothing and to take their shoes off during measurement. Weight was measured using the TANITA Body Composition Analyser SC-330P (Figure 3.3) and recorded to the nearest 0.1 kg. TANITA has an acceptable accuracy compared to the dual-energy X-ray absorptiometry in white and African-American adolescents (Barreira, Staiano, & Katzmarzyk, 2013) and has been used in studies among multi-ethnics Malaysian adolescents before (Su et al., 2014). Height was measured using the wall mounted stature meter (200 cm) (Figure 3.4) and recorded to the nearest 0.01

meter. Data were treated as continuous and categorical. BMI was classified according to WHO classifications as shown in Table 2.1 (WHO, 2004).

Figure 3.3: TANITA Body Composition Analyser SC-330P

Figure 3.4: Wall-mounted stature meter (200 cm)

(b) **Waist circumference** – WC was measured using a retractable soft measuring tape (150 cm) (Figure 3.5). The measurements were taken at the midpoint between the lower rib and the upper margin of the iliac crest along the mid-axillary line (WHO, 2012; 2011). The participant was asked to lift up their shirt during measurement. Female personnel measurements were taken by female research team members to ensure privacy and accuracy. Readings were recorded to the nearest 0.5 cm.

WC was analysed as a continuous and categorical variable. In this study, WC is categorised according to gender and the likelihood of developing obesity-related health problems based on WHO classification (WHO, 2011) (Table 3.8) as discussed in Chapter 2. The Malaysian CPG classification on WC (Ismail et al., 2004) was also used for comparison (Table 3.9).

Table 3.8: WHO waist circumference classifications

Category	Men	Women
Low risk	<94 cm	<80 cm
Increased risk	94 cm-102 cm	80 cm-88 cm
High risk	>102 cm	>88 cm

Table 3.9: Malaysian CPG waist circumference classifications

Category	Men	Women
Low risk	<90 cm	<80 cm
High risk	≥90 cm	≥80 cm

Figure 3.5: Retractable soft measuring tape (150 cm)

(c) **Body Fat Percentage** – BF% was measured using the TANITA Body Composition Analyser SC-330P (Figure 3.3). Measurements were conducted based on standard procedures used in many studies before (Haroun et al., 2010) with participants wearing light physical training cloth. BF% is the proportion of body fat from the body weight. As discussed in chapter 2, there is still no consensus on BF% classification due to its variations in age, gender, and ethnicity. In this study, BF% was treated as continuous and categorical variables. The classification of BF% used in this study is shown in Table 3.10 below.

Table 3.10: Body fat percentage classifications

Classification	Men	Women
Normal	<25%	<35%
Obese	≥25%	≥35%

3.2.8.7 Physical fitness

Physical fitness was assessed using BMFT, which is carried out twice a year to assess the personnel's physical strength and cardiorespiratory fitness. It comprises of three tests; 2.4 km run, push-up, and sit-up. 2.4 km run was measured as the time taken (minutes) to complete the run, while push-up and sit-up were measured as repetitions per minute. Personnel have to achieve the Malaysian Army BMFT standard (Table 3.11) in all three tests to pass the overall BMFT. BMFT were conducted at their respective unit. BMFT results were recorded into a separate form **(Appendix L)** before transferred to the excel format. The BMFT results were treated as categorical; either 'Passed' (passed all tests) of 'Failed' (failed even one of the tests).

Table 3.11: Basic Military Fitness Test (BMFT) standard according to age group and gender

(a) Male

Age Group	2.4 km Run (minute)	Sit-Up (repetition/minute)	Push-Up (repetition/minute)
17 – 21	12.00	53	42
22 – 26	12.27	50	40
27 – 31	12.45	45	39
32 – 36	13.16	42	36
37 – 41	13.43	38	34
42 – 46	14.10	32	30
47 – 51	14.37	30	25
52 – 56	14.51	28	20
57 - 61	14.55	27	18

Table 3.11 (Continued)

(b) Female

Age Group	2.4 km Run (minute)	Sit-Up (repetition/minute)	Push-Up (repetition/minute)
17 – 21	14.10	53	19
22 – 26	14.42	50	17
27 – 31	15.22	45	16
32 – 36	16.16	42	15
37 – 41	17.10	38	13
42 – 46	17.46	32	12
47 – 51	18.00	30	10
52 – 56	18.18	28	9
57 - 61	18.36	27	8

3.2.9 Ethical consideration

Participants were briefed at the start of the session and gave consent before participating in this study. Information on research was given in both English and Bahasa Malaysia (**Appendix E** and **F**). They were assured that their results would be kept confidential and only be used for the purposes of this study. Results were not to be discussed with their superior officers or any other irrelevant parties without their permission. Since participation in Phase 2 is voluntary, they were encouraged to answer all the questionnaires and go through the measurements and fitness test as completely as possible.

3.2.10 Setting and procedures

Data collection for this Phase 2 started after completion of Phase 1 in July 2015 with units in Seremban. Although Phase 2 also involved two states (Malacca and Negeri Sembilan), data collection was done simultaneously depending on unit availability.

There were no specific time periods allocated for any states or units. The second phase was more challenging, since it required the total involvement of the personnel and the unit in answering the questionnaires, going through the measurements, and performing the fitness test. There were times when the research team were unable to proceed due to either unit's activity or only a few personnel left in the unit.

The same flow of data collection as in Phase 1 was followed, starting with a courtesy visit to the Brigade's Commander and sending letters to all units under their command (Figure 3.6). Unit commanders were briefed on the research details on the first visit to each unit. A new team of assistants was trained to help with the measurements and data collection. The team went to the unit with all equipment whenever the participants were available. Most of the units were visited at least three times to ensure a higher number of participants from each unit. Some larger units were revisited five times to get the maximum participation. The research team had to be flexible in adapting to whichever units between Malacca and Negeri Sembilan (Port Dickson and Seremban) that were able to gather personnel to participate in this study.

The questionnaires, anthropometric measurements, and body composition analysis were conducted in a single session using a dedicated room in each unit. The personnel were called in a batch of 20 to 30 people per session. The session started off with the height, weight and WC measurement, and body composition analysis followed by answering the questionnaires. They were guided throughout this process especially for the IPAQ and the 24-hour Dietary Recall, to ensure that they understood correctly what each question meant and able to answer appropriately. The research team members were available to assist them should they have any problems. Upon completion, they were given around 30 minutes talk on obesity and healthy lifestyles. While this talk was going on, the research team members screened through all the questions for illegible answers or unanswered questions. The body composition analysis results were discussed briefly at the end of the session to give them a general idea of their health status, especially their body fat percentage. Each session took around two to three hours to complete.

BMFT (described in section 3.2.8.7) was carried out in the evening during their sports session or Friday morning when most units have their physical training. The Physical Training Instructors (PTI) from the respective units and nearby units assisted these sessions. BMFT was conducted according to the Malaysian Army BMFT SOP. The BMFT took about one to one and half hours to complete, accommodating as many as 50 personnel per session depending on how many PTIs were available to assist.

Data collection was withheld during the fasting month and two weeks after the Hari Raya (Eid celebration) and the National Day preparation. Data collection resumed at the end of July 2015 and officially ended in November 2015.

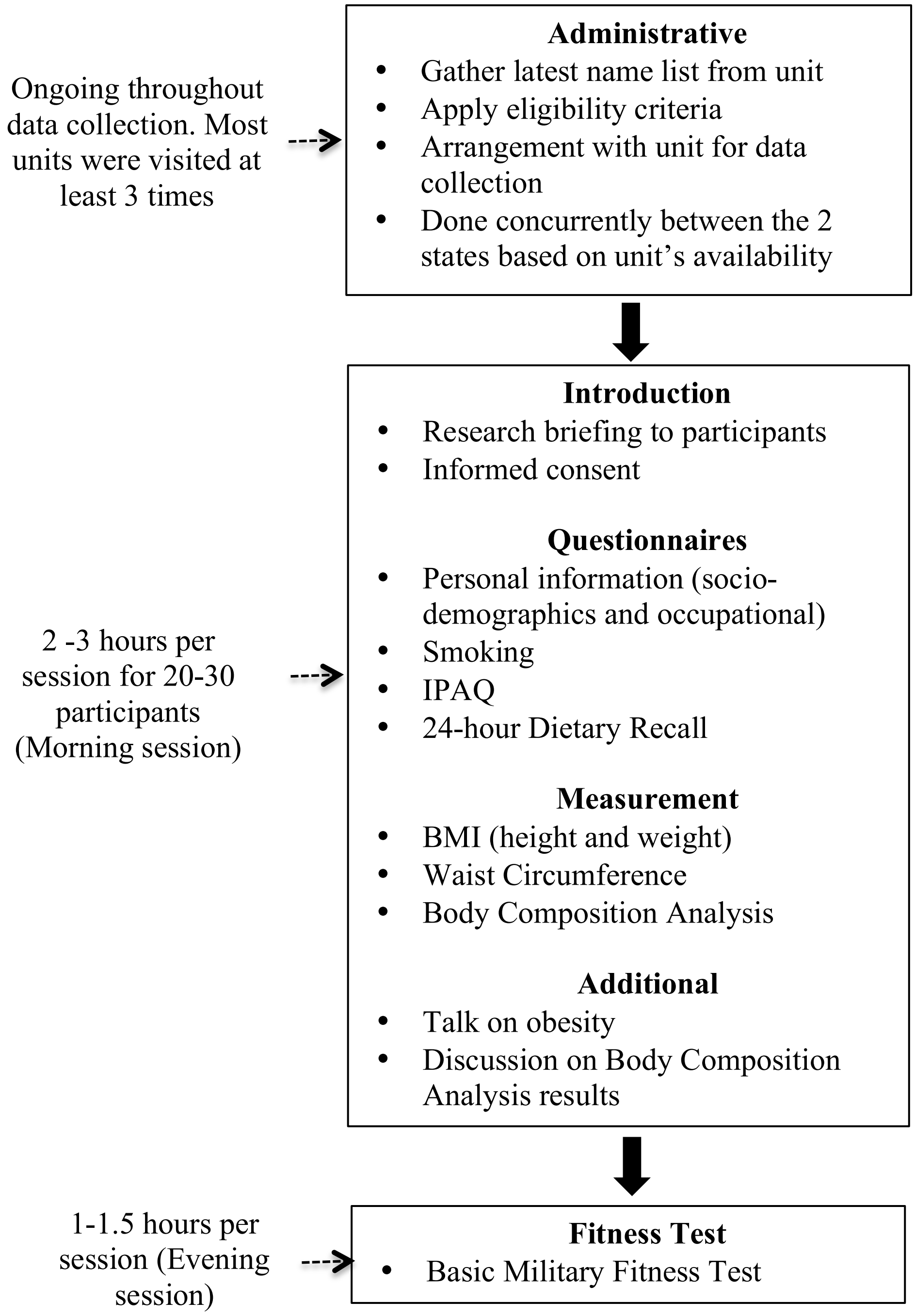


Figure 3.6: Research setting and procedure for Phase 2

3.2.11 Data Management

Similar procedures for data management as in Phase 1 were used in this study. Data were saved in a separate folder from Phase 1 data to avoid mixing up of these data. However, some of the personnel from Phase 1 who participated in Phase 2 would have their data cross-checked to ensure the information was consistent. Data were entered in Microsoft Excel format and coded before transferred to the SPSS file.

3.2.11.1 Data coding

Coding for Phase 2 variables are shown in Table 3.12 below. Some of the coding for variables was not shown since they used the same coding as in Phase 1. These variables include socio-demographic and occupational variables.

Table 3.12: Definition and coding for Phase 2 variables

Variables	Definition	Coding
1. Smoking		
a. Smoking status	Smoking status was based on smoking habits and categorised into three groups	0: Smokers 1: Ex-Smoker 2: Never Smoke
b. Smoking amount	For smokers and ex-smokers, smoking amount was calculated as the number of cigarettes per day (cpd) and categorised into three groups	0: Low (<10 cpd) 1: Moderate (10 – 20 cpd) 2: Heavy (>20 cpd)
c. Duration of smoking	For smokers and ex-smokers, the duration was calculated from the year of smoking initiation to 2016 and categorised into three groups	0: <5 years 1: 5 – 10 years 2: >10 years

Table 3.12 (Continued)

Variables	Definition	Coding
d. Duration of quitting	For ex-smokers, the duration was calculated for the year they stopped smoking to the year 2016 and categorised into three groups	0: <5 years 1: 5 – 10 years 2: >10 years
2. Level of physical activity	Level of physical activity was categorised according to the Guidelines for Data Processing and Analysis of the IPAQ into two groups.	0: Low (<600 METs-min/week) 1: Moderate (600-3000 METs-min/week) 1: High (≥3000 METs-min/week)
3. Frequency of Fast Food consumption	Calculated based on number of fast food visits in a month and categorised into three groups	0: Rarely (<1 visit/month) 1: Sometimes (1 visit/month) 2: Often (>1 visit/month)
4. BMI status	BMI was categorised according to WHO classification. BMI classification in kg/m^2 is shown in Table 2.1. In certain analyses, underweight and obese were grouped with normal and overweight respectively	0: Underweight 1: Normal 2: Overweight 3: Obese 0: Underweight and normal 1: Overweight and obese
5. Waist circumference	WC was classified according the risk of developing obesity-related health problems using both of the WHO and CPG for comparison. Both classifications are shown Table 3.8 and 3.9.	WHO Classification: 0: Low risk 1: Increased risk 2: Substantial risk CPG classification 0: Low risk 1: High risk
6. Body fat percentage (BF%)	BF% was classified into two groups. BF% classifications for male and female are shown in Table 3.10	0: Normal 1: Obese

Table 3.12 (Continued)

Variables	Definition	Coding
7. Physical fitness	Physical fitness was classified into two groups based on their ability to pass each of the BMFTs	0: Passed (Passed all tests) 1: Failed (Failed even one of the tests)

3.2.11.2 Data entry and checking

Data entry and checking followed the same procedures as in Phase 1. Data were stored in separate folders from Phase 1 for both Microsoft Excel and SPSS and backed up on an encrypted external hard disk. Data for participants who were involved in both phases of the study were crosschecked and updated accordingly. Data checking especially at the initial stage of data collection was done more vigorously since there was no room for any missing values unless the BMFT and measurements have to be done for the second time.

3.2.12 Data analysis

3.2.12.1 Descriptive analysis

The descriptive analyses were similar to Phase 1 with continuous data presented as mean (SD), and categorical variables presented as count (n) and proportion (%). The mean and proportion were presented as an overall and comparing males and females. The prevalence of overweight and obesity were reported as a proportion (%) of participants with BMI $\geq$25 kg/m^2 and BMI $\geq$30 kg/m^2 respectively. Obesity prevalence was also reported using BF% of $\geq$25% and $\geq$35% for males and females, respectively.

BMI was later used in the univariate and multivariate analysis as a proxy measure of adiposity. Since data for the level of physical activity were not normally distributed, the results were presented in median and IQR.

Comparisons in terms of proportion (%) were made between the BMI and BF% classification of obesity. Scatter plots with Pearson correlation (r) value were used to illustrate the correlation between BF% and muscle mass percentage with BMI, for both males and females. Independent sample t-test and Chi-Square (χ^2) test were used to analyse all the variables associated with overweight and obesity, and with physical fitness.

3.2.12.2 Univariate analysis

Univariate logistic regression was used to determine factors associated with both overweight and obesity, and physical fitness. Results were presented as crude OR (95% CI) and p-value. Variables with p-value <0.25 were included in the multivariate analysis.

3.2.12.3 Multivariate analysis

Multivariate Logistic regression was used to determine the factors associated with overweight and obesity, and with physical fitness. Results were presented as adjusted OR (95% CI).

3.3 Summary of Chapter 3

This study was divided into two phases. Phase 1 was a retrospective cohort study involving data extraction from personnel medical and service records from the year 1990 until 2015. The main objectives were to determine trends of overweight and obesity, to find an association between socio-demographics and occupational factors with overweight and obesity, and to determine the consequences of overweight and obesity on sickness absenteeism.

Phase 2 was intended to complement Phase 1 with additional modifiable factors such as smoking, physical activity, dietary habits and intake, as well as socio-demographic and occupational factors, in order to determine the association between these factors with overweight and obesity. This was also meant to determine the consequences of overweight and obesity on physical fitness, taking into account all confounders.

This chapter also covered the methods used in both phases where research design, population and sample, setting and procedure, instrument/measurement strategies, data analysis and ethical consideration were described.

CHAPTER 4: RESULTS

Chapter 4 presents the findings for both phases of the study. Phase 1 retrospective cohort study discusses the trend of BMI changes throughout the military career of the participants, factors associated with these changes, and the implication of overweight and obesity on sickness absenteeism. Meanwhile, Phase 2 presents the prevalence of overweight and obesity, its associated factors, and its implication on physical fitness. The sensitivity and specificity of BMI in classifying obesity compared to BF% are also discussed.

4.1 Phase 1

There were a total of 2661 personnel in the initial name list obtained from all units involved, where 1876 personnel were from Malacca and 785 personnel from Negeri Sembilan. After excluding those without either medical or service record or both, 1623 (86.5%) personnel from Malacca and 667 (85.0%) personnel from Negeri Sembilan were included in the analysis (Figure 4.1).

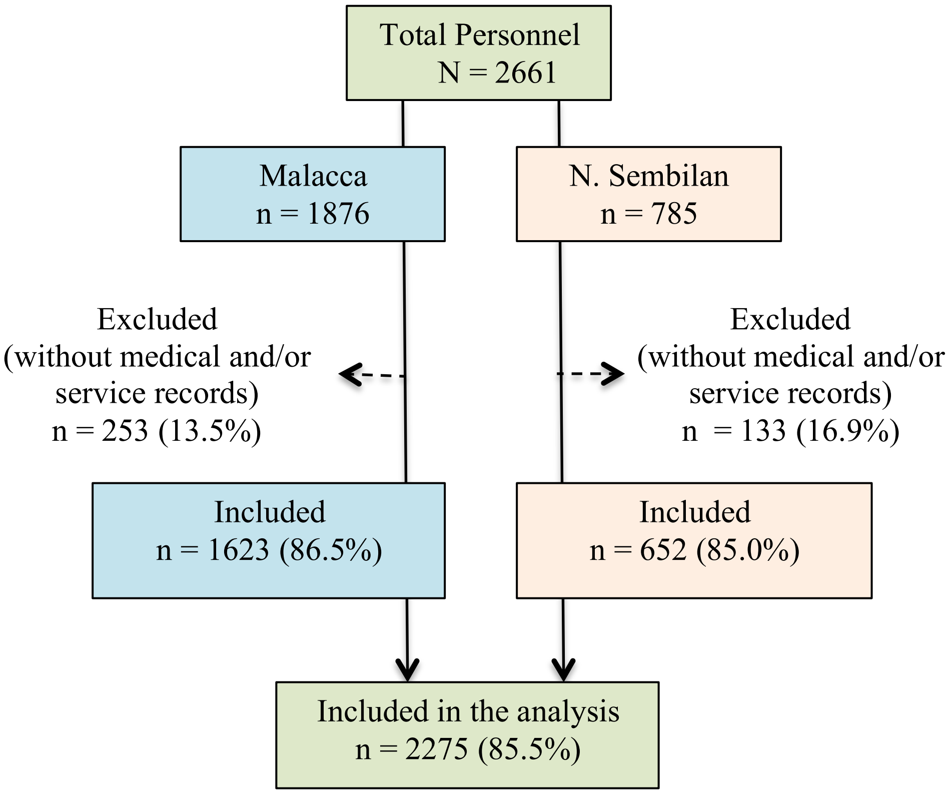


Figure 4.1: Number of participants in Phase 1

4.1.1 Socio-demographic and occupational characteristics

A total of 2275 personnel were included in the final analysis. Males made up 82.7% of the participants (Table 4.1). The mean age of the participants was around 30 years and the proportions of personnel <30 years and $\geq$30 years were almost equal. Majority of the participants were Malays (83.9%), married (71.3%) and had at least completed secondary school (75.6%). There were significantly higher proportions of Non-Malays with lower secondary education, and unmarried personnel among males.

The mean duration of service was around 10 years with slightly shorter duration of service among females. There was an approximately equal proportion of personnel who had served less than 10 years (50.4%) and 10 years and above (49.6%). Only 8.0% of the females who had served more than 15 years compared to around 15% to 22% in the other duration of service groups. Junior rank personnel made up the majority (78.6%) of the participants in this study. Among the officers, 31.2% were females, compared to only 13.8% and 17.2% females in the senior and junior ranks respectively.

Table 4.1: Socio-demographic and occupational characteristics of participants in Phase 1

	Total (n = 2275)	Males (n = 1882)	Females (n = 393)	p
		n (%)		
Age (years) *	30.16 (5.46)	30.28 (5.68)	29.60 (4.21)	**0.025**
Age				
<30 years	1211	1003 (82.8)	208 (17.2)	0.894
≥30 years	1064	879 (82.6)	185 (17.4)	
Ethnicity				
Malays	1909	1550 (81.2)	359 (18.8)	**<0.001**
Non-Malays	366	332 (90.7)	34 (9.3)	
Education Level				
Lower Secondary	556	551 (99.1)	5 (0.9)	**<0.001**
Secondary	1546	1197 (77.4)	349 (22.6)	
Tertiary	173	133 (76.9)	40 (23.1)	
Marital Status				
Married	1621	1312 (80.9)	309 (19.1)	**<0.001**
Unmarried	654	570 (87.2)	84 (12.8)	
Duration of service (years) *	10.17 (5.42)	10.35 (5.63)	9.25 (4.18)	**<0.001**
Duration of service				
<5 years	398	335 (84.2)	63 (15.8)	**<0.001**
5-9.9 years	749	619 (82.6)	130 (17.3)	
10-14.9 years	751	581(77.4)	170 (22.6)	
≥15 years	377	347 (92.0)	30 (8.0)	
Rank				
Junior Rank	1788	1481 (82.8)	307 (17.2)	**<0.001**
Senior Rank	378	326 (86.2)	52 (13.8)	
Officer	109	75 (68.8)	34 (31.2)	

* Mean (SD)

4.1.2 Power calculation based on sample size and participants characteristics

The power of the study was calculated using StatsToDo: Sample Size for Survival (Kaplan-Meier Log Rank Test) program (StatsToDo, 2014), based on the sample size of 2275 and the participants' characteristics shown in Table 4.1.

Data required for power (1- β) estimation (2 tail) using this program are;

Alpha (α) – probability of Type I error (set at 0.05)

SSiz1 and SSiz2 – sample size in Group 1 and Group 2

Sr1and Sr2 – survival rate in Group 1 and Group 2

The power of the study based on the selected variables were all above 80% (Table 4.2)

Table 4.2: Power calculation based on sample size and participants' characteristics

Variable	SSiz1	Sr1	Ssiz2	Sr2	Power (1- β)
Age	<30 years 1211	0.7	≥30 years 1064	0.4	100%
Gender	Male 1882	0.5	Female 393	0.6	93.2%
Ethnicity	Malays 1909	0.6	Non-Malays 366	0.5	96.5%
Duration of service	<10 years 1147	0.7	≥10 years 659	0.4	100%

4.1.3 Body Mass Index classification

Figure 4.2 illustrates the prevalence of normal, overweight and obesity. Underweight (BMI <18.5 kg/m^2) was combined with normal weight due to its small number (n=29). The prevalence of combined overweight and obesity was 55.8%. Out of this, 36.3% was overweight and 8.0% was obese. The prevalence of overweight was higher in males (36.8%) compared to females (33.6%). However, the prevalence of obesity was higher in females (9.2%) compared to males (7.7%). There were no significant differences in the prevalence of overweight and obesity between males and females.

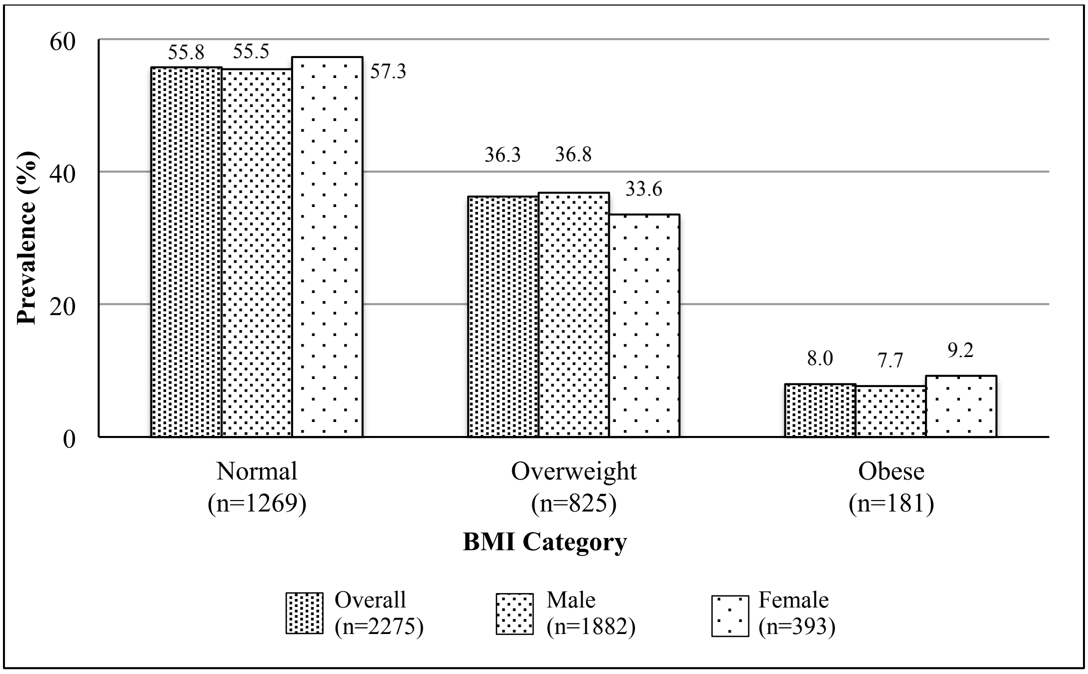
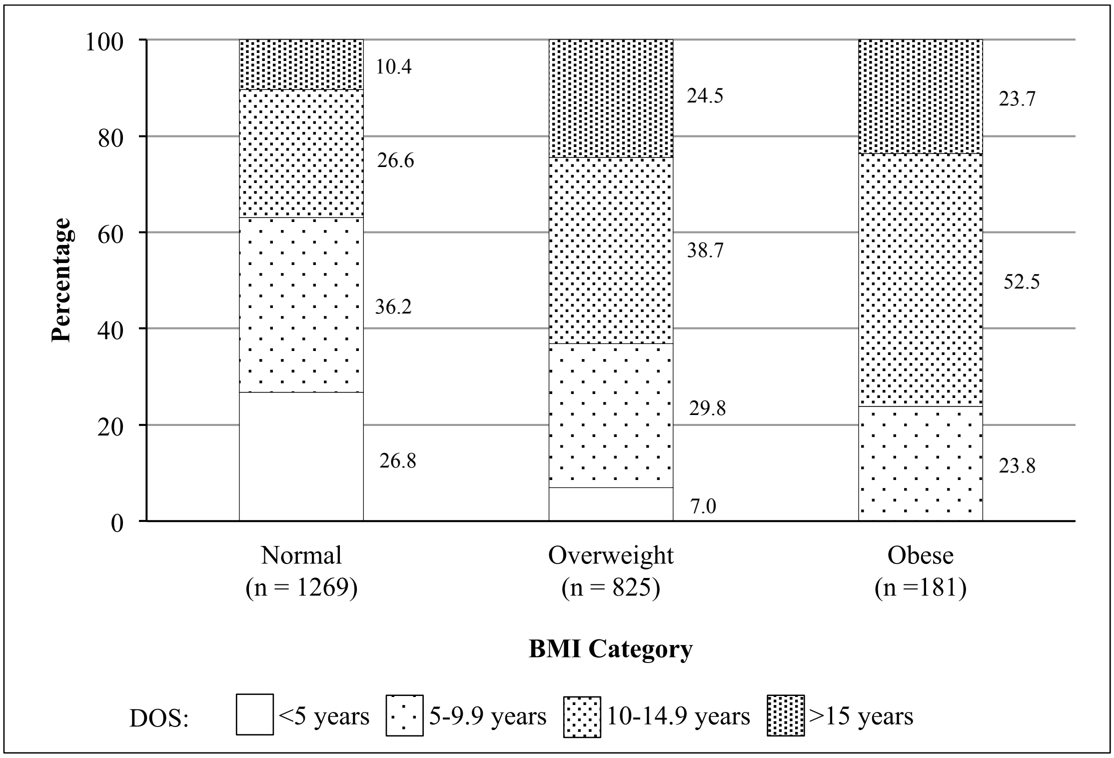


Figure 4.2: Prevalence of normal, overweight and obesity in retrospective cohort study

Around 60% of the normal weight personnel were those had served less than 10 years (Figure 4.3). The proportion of personnel who had served less than 10 years decreased to 36.8% and 23.8% in the overweight and obese group, respectively. On the other hand, the proportion of those who had served 10 years and above increased from 37% to 63.2% and 76.2% from normal to overweight and obese group respectively. Majority of these increments were contributed by the increase in the proportion of personnel serving between 10 to 15 years, with more than half of the obese participants were from this group. There were only 7% of personnel who had served less than 5 years in the overweight group, and none in the obese group.



DOS – Duration of service

Figure 4.3: The proportion of difference duration of service group for normal, overweight and obese BMI

Figure 4.4 presents the proportion of normal, overweight and obesity according to the duration of service. Among those who had served less than 5 years, only 15% were overweight, and none were obese. The proportion of overweight continued to increase as the duration of service increases. Among those who had served for 15 years and above, more than half were overweight. The proportion of obesity followed the same pattern but decreased from 12.6% among those who had served between ten to 15 years to 11.4% among those who had served for 15 years and above. More than half of the participants who had served for more than 10 years were either overweight or obese.

Around one-third of those who had served for 15 years and above were able to maintain their normal weight.

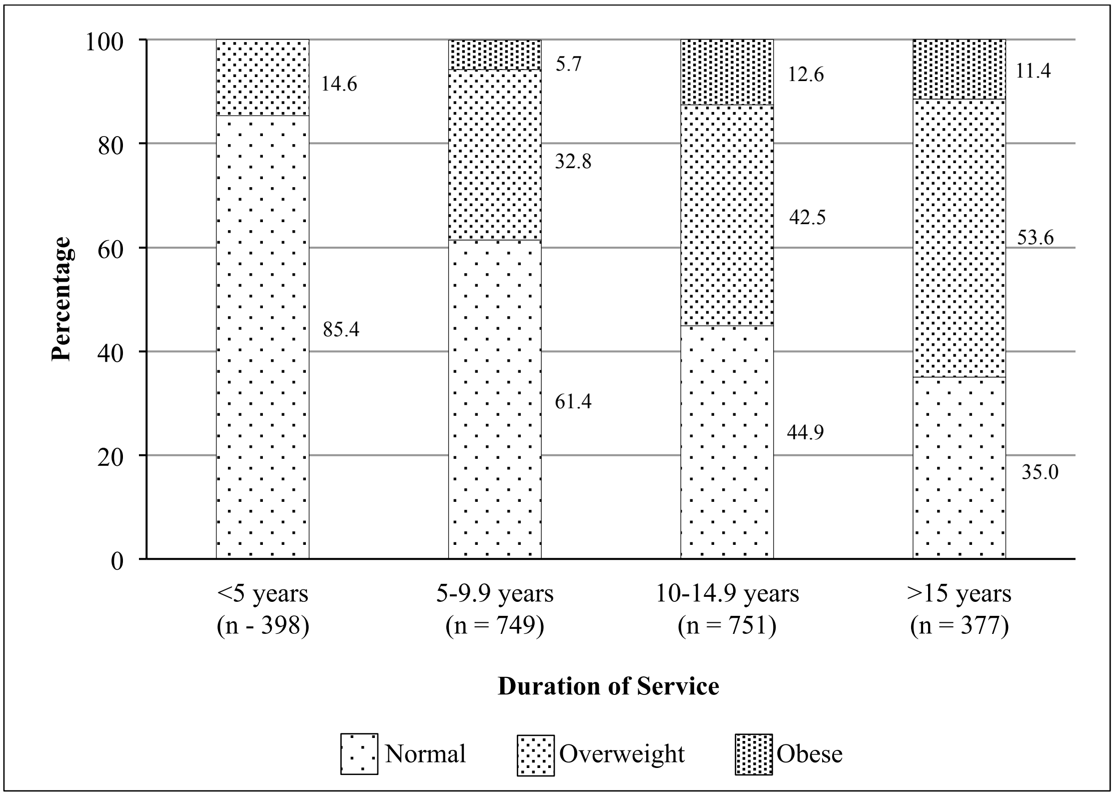


Figure 4.4: The proportion of normal, overweight and obesity according to the duration of service

4.1.4 Trend in overweight and obesity

Trends in overweight and obesity in this study are illustrated by the changes in the mean BMI and the difference in prevalence over 25 years period from 1990 to 2015. The changes in BMI were also analysed against the duration of service.

4.1.4.1 Mean BMI

The mean BMI has been increasing from 1990 to 2015, and the increment was faster in the last 10 years (Figure 4.5). The trend of mean BMI increment seemed to correlate with the trend of increase in the duration of service. Although it was possible that the higher mean BMI could have been contributed by the increase of the duration of service, the mean duration of service was still below 10 years.

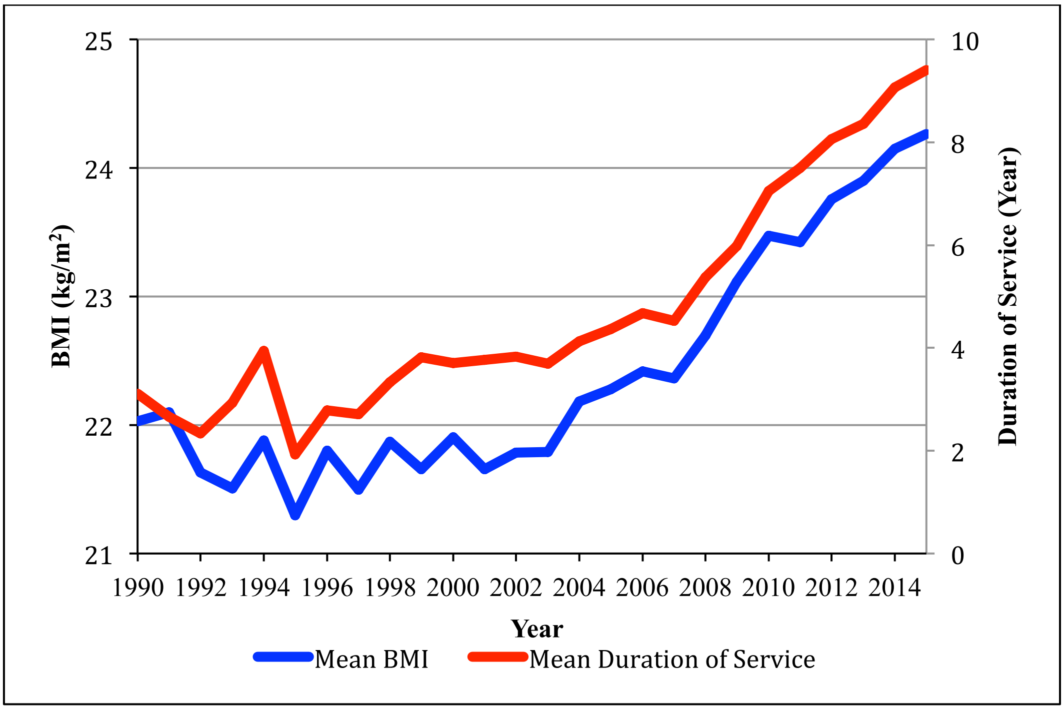


Figure 4.5: Mean BMI and duration of service from 1990 to 2015

4.1.4.2 Prevalence of overweight and obesity

The prevalence of overweight and obesity increased steadily from 1990 to 2015 (Figure 4.6). By the year 2015, 41.7% of the personnel have ever reached either overweight or obese status. On the other hand, the proportion of normal weight personnel dropped significantly, reaching less than 60% in 2015. If this trend continues, it would not be long before there are more overweight and obese than normal weight personnel in the Malaysian Army.

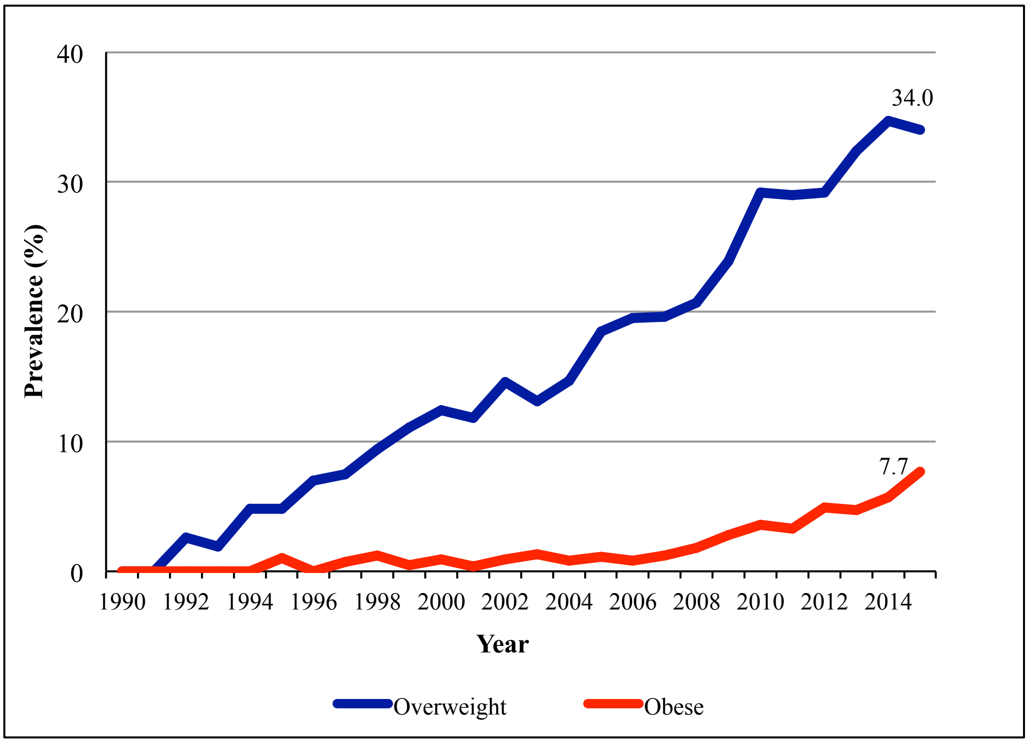


Figure 4.6: Prevalence of overweight and obesity from 1990 to 2015

4.1.5 Predictors of overweight and obesity

Kaplan-Meier survival analysis was used to determine the predictors of overweight and obesity in Phase 1. Time to event was defined as the time taken to reach BMI $\geq$25 kg/m^2. Overall, the median (IQR) for time to reach BMI $\geq$25 kg/m^2 was 11.3 (10.7,12.0) years (Figure 4.7).

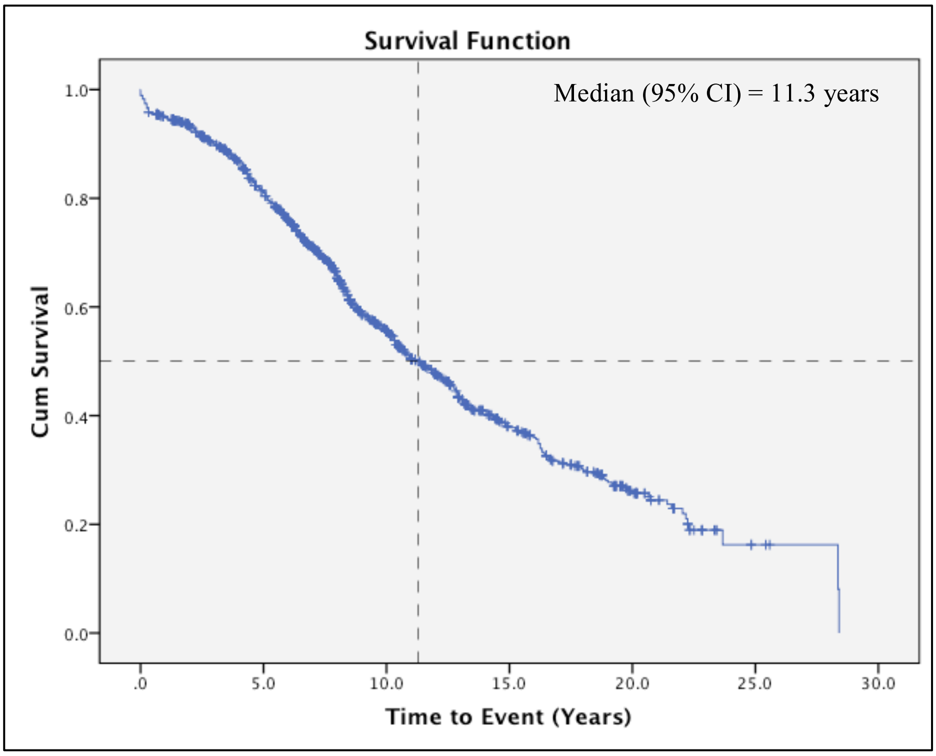


Figure 4.7: Overall survival function curves for time to reach BMI $\geq$25 kg/m^2

4.1.5.1 Time to reach overweight and obesity - Univariate analysis

(a) Socio-demographic factors

Figure 4.8 to 4.12 illustrate the median time taken to reach overweight and obesity (95% CI) for socio-demographic predictors of overweight and obesity. The median survival time increased significantly with age. Personnel aged 30 years and above had a significantly longer median survival time of 12.6 (11.8,13.3) years compared to those aged less than 30 years with 9.3 (11.8,13.3). Married personnel had a significantly shorter median survival time [11.4 (10.8,12.1)] compared to the unmarried personnel [12.17 (9.1,15.30] years. Personnel with lower secondary education also had a significantly longer median survival time [12.9 (12.0,13.8)] years compared to those with secondary [10.7 (9.9,11.4)] years and tertiary [10.4 (7.8,13.0)] years. However, there were no significant differences in the median survival time between those with secondary and tertiary education. Gender and ethnicity showed no differences in the median survival time.

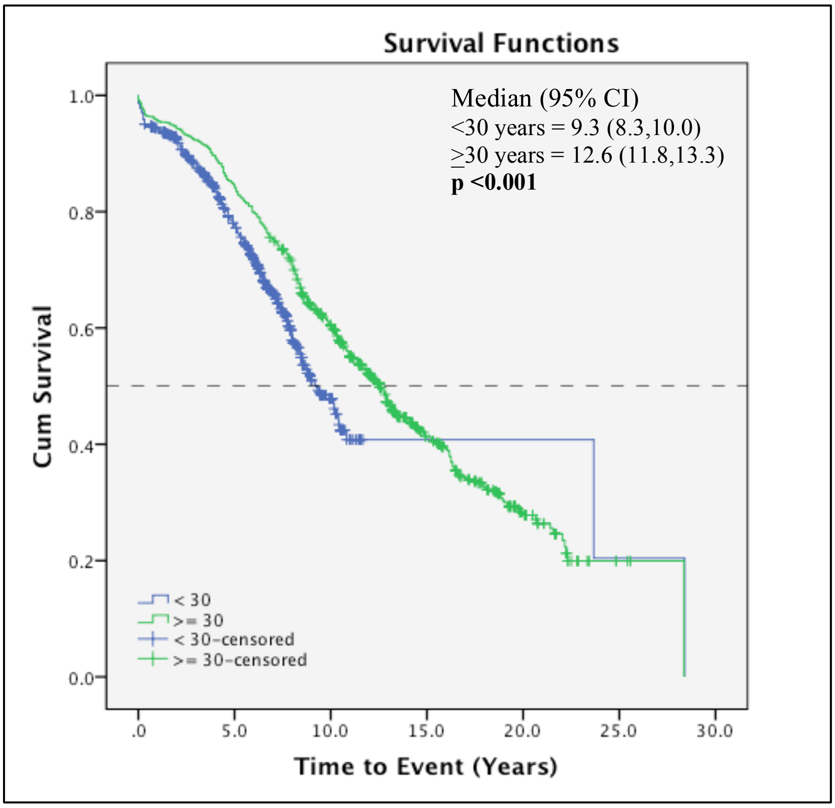


Figure 4.8: Survival function curves for age groups

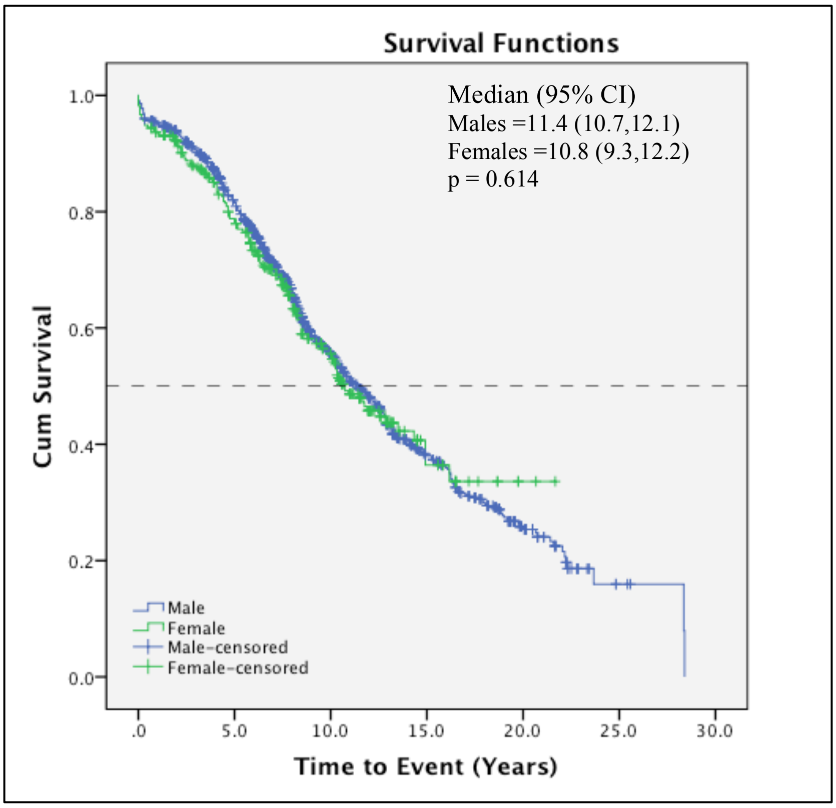


Figure 4.9: Survival function curves for gender

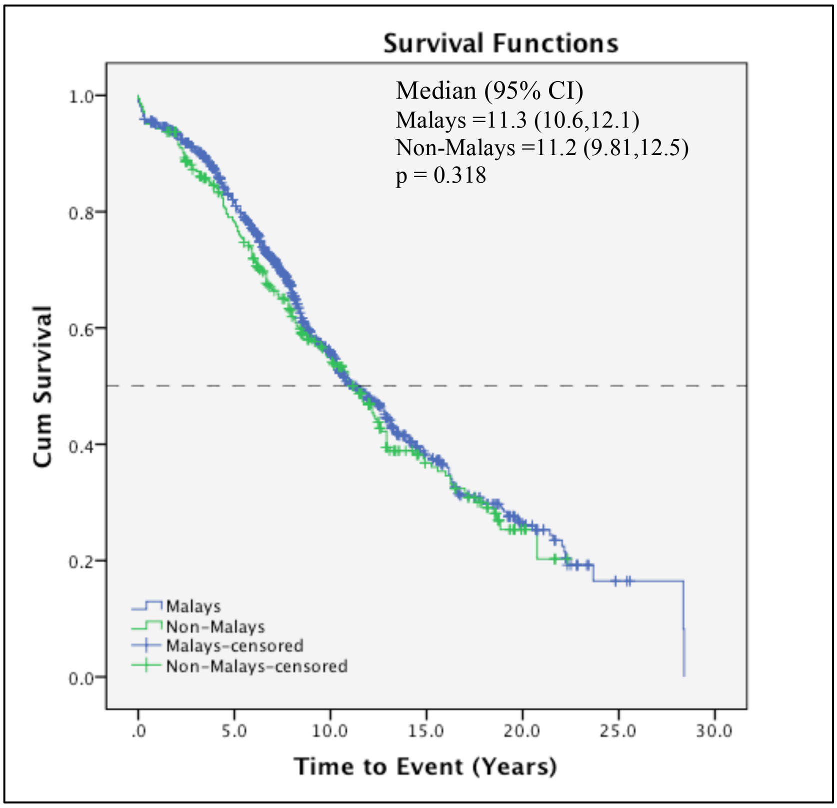


Figure 4.10: Survival function curves for ethnicity

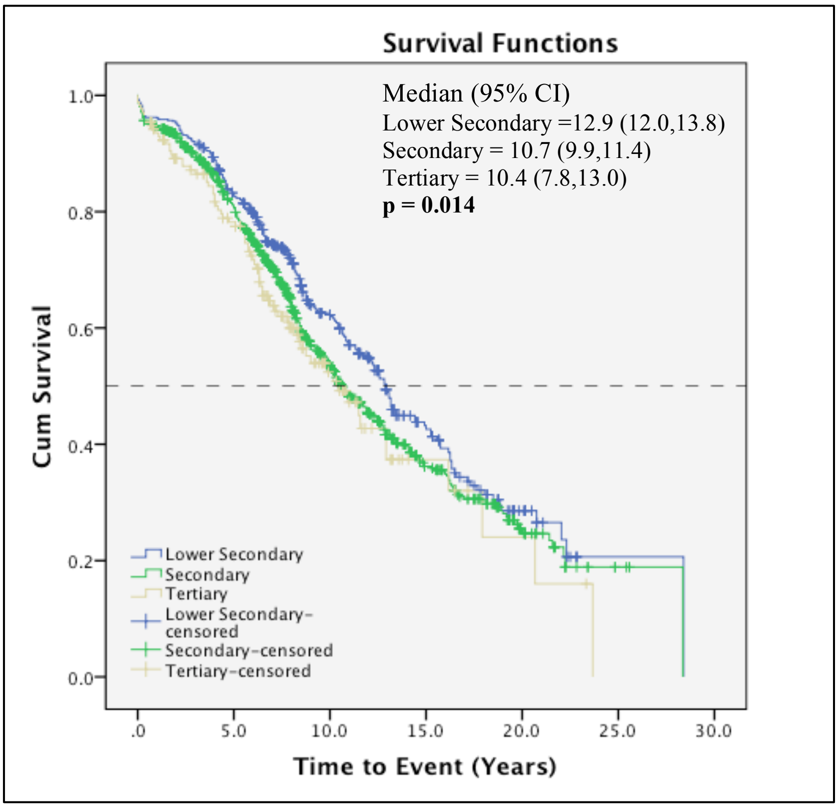


Figure 4.11: Survival function curves for educational levels

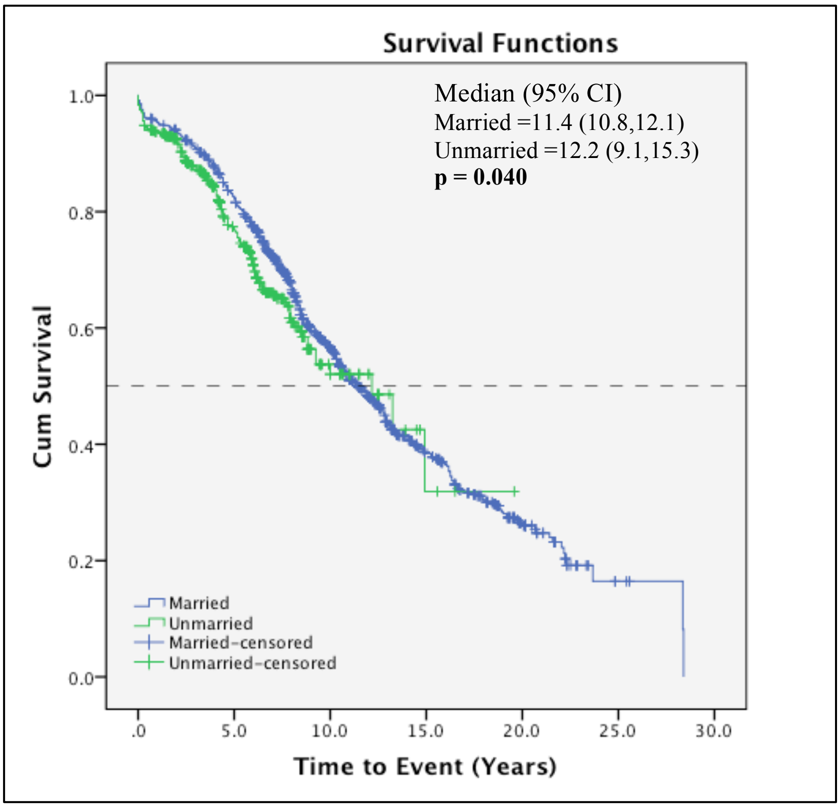


Figure 4.12: Survival function curves for marital status

(b) Occupational factors

Among occupational factors, both duration of service and rank were significant predictors of overweight and obesity. As duration of service increased, the median survival time increased significantly. Those who had served at least 15 years had a median survival time of 14.9 (13.5,16.3) years compared to 6.3 (2.9,8.8) years for those who had served less than 5 years (Figure 4.13). Senior rank personnel had a significantly higher median survival time [13.5 (12.1,14.9) years] compared to junior rank personnel [10.4 (9.7,11.2) years] and officers [10.9 (6.9,14.9) years] (Figure 4.14). These senior ranks must have at least served for 10 years to achieve this level. However, there were no significant differences in the median survival time between junior rank and officers.

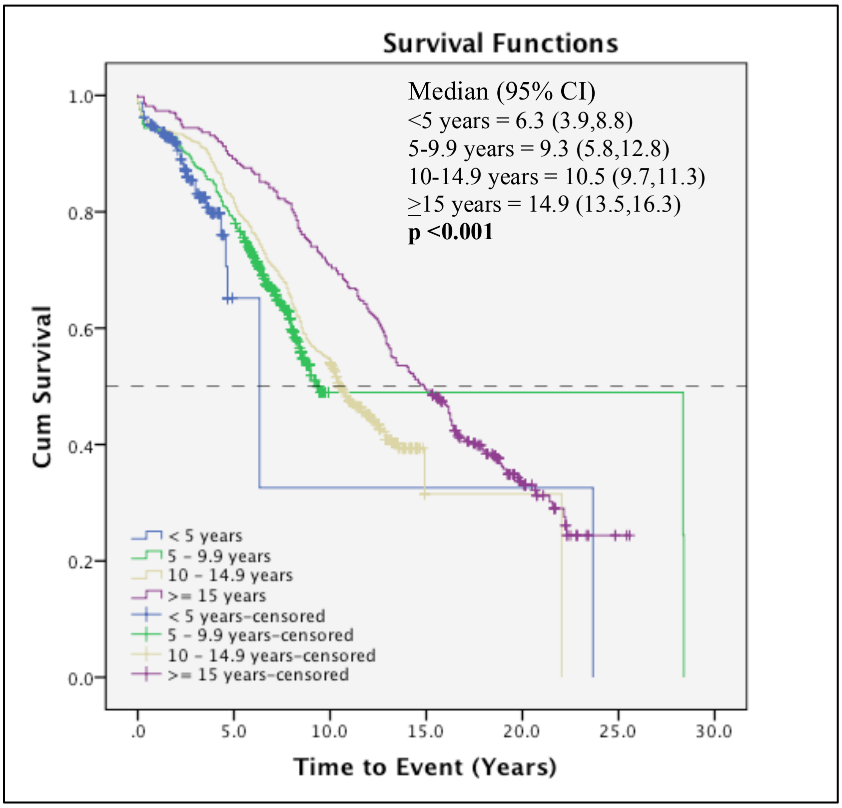


Figure 4.13: Survival function curves for duration of service

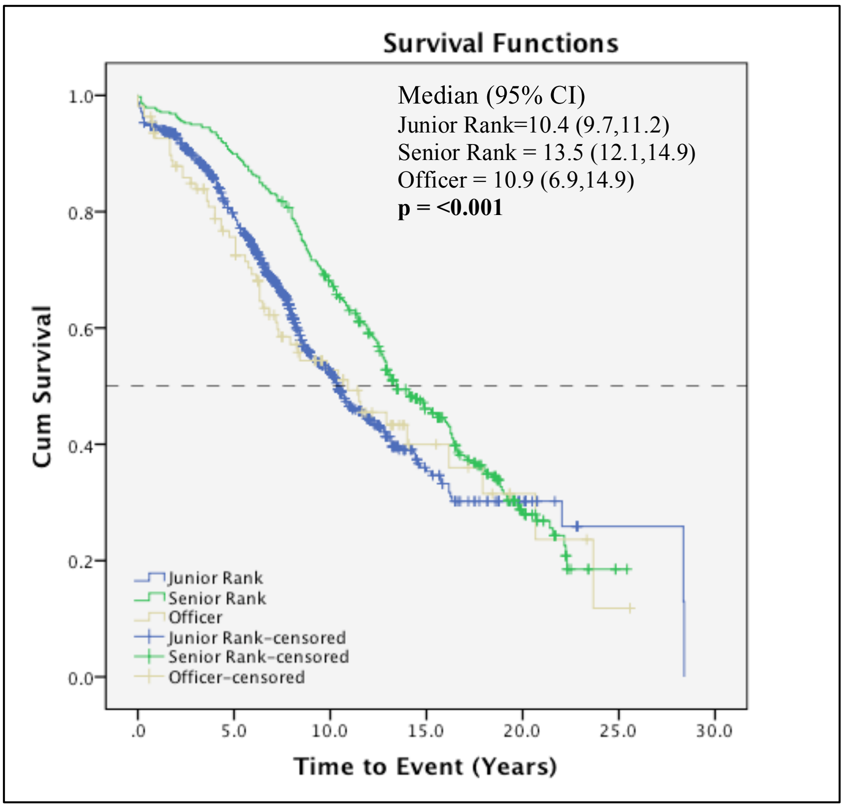


Figure 4.14: Survival function curves for ranks

4.1.5.2 Predictors of overweight and obesity - Multivariate analysis

In univariate analysis, all variables were significant predictors except for ethnicity (Table 4.3). However, in the multivariate Cox Regression analysis, only duration of service and rank remained significant predictors of overweight and obesity. The Hazard Ratio (HR) of becoming overweight and obese was reduced by 17% for every year of increase in the duration of service. The HR of overweight and obesity among senior rank was 18% lower compared to junior rank. On the contrary, the HR among officer was 7% higher compared to junior rank personnel.

Table 4.3: Cox regression analysis for predictors of overweight and obesity

Variables	Univariate	Multivariate
	HR (95% CI), p	HR (95% CI), p
Age	0.85 (0.85,0.86), <**0.001**	1.00 (0.96,1.05), 0.882
Gender		
Males	Reference	Reference
Females	1.35 (1.14,1.60), **<0.001**	0.89 (0.75,1.07), 0.212
Education		
Lower Secondary	Reference	Reference
Secondary	1.19 (1.03,1.39), **0.018**	1.12 (0.96,1.31), 0.138
Tertiary	1.46 (1.13,1.90), **0.004**	0.98 (0.66,1.44), 0.886
Ethnicity		
Malays	Reference	
Non-Malays	0.92 (0.79,1.08), 0.295	Not included
Marital Status		
Married	Reference	Reference
Unmarried	2.66 (2.23, 3.17), **<0.001**	1.22 (0.92,1.45), 0.059
Duration of service	0.82 (0.81,0.84), **<0.001**	0.83 (0.79,0.87), **<0.001**
Rank		
Junior Rank	Reference	Reference
Senior Rank	0.33 (0.28,0.39), **<0.001**	0.82 (0.67,0.99), **0.040**
Officer	0.78 (0.59,1.03), 0.084	1.70 (1.08,2.70), **0.023**

4.1.6 Sickness absenteeism

Sickness absenteeism was analysed using non-parametric test and presented as median (Table 4.4). The total median sick reports, sick leave and sick excuse were 7, 4, and 4 days respectively. Females had significantly higher median sickness absenteeism with 11, 9, and 8 days compared to males with 6, 3, and 3 days for sick report, sick excuse and sick leave respectively.

Table 4.4: Descriptive characteristics of sickness absenteeism and presenteeism

		n	Median	U	z	p
Sick Report	Total	2275	7	492247.50	10.357	**<0.001**
	Male	1882	6			
	Female	393	11			
Sick Leave	Total	2275	4	488933.00	10.099	**<0.001**
	Male	1882	3			
	Female	393	9			
Sick Excuse	Total	2275	4	434907.00	5.639	**<0.001**
	Male	1882	3			
	Female	393	8			

4.1.7 Implication of overweight and obesity on sickness absenteeism and presenteeism

4.1.7.1 Univariate analysis

Non-parametric Kruskal-Wallis test was used to determine the implication of overweight and obesity on sickness absenteeism, represented by the sick report, sick leave, and sick excuses (Table 4.5). Overweight and obese personnel had a significantly higher median sick report, sick leave and sick excuse compared to normal weight personnel. Obese personnel also had a significantly higher median sick report and sick leave, but nor sick excuse, compared to overweight personnel.

Table 4.5: Implication of overweight and obesity on sickness absenteeism

	BMI [a]	n	Median	χ^2	df	p
Sick Report	Normal	1269	5	165.14	2	**<0.001**
	Overweight	825	9 *			
	Obese	181	13 *#			
Sick Leave	Normal	1269	3	80.819	2	**<0.001**
	Overweight	825	5 *			
	Obese	181	8 *†			
Sick Excuse	Normal	1269	2	71.149	2	**<0.001**
	Overweight	825	7 *			
	Obese	181	10 *			

* p <0.001 compared to normal weight in post hoc test
# p <0.001 compared to overweight in post hoc test
† p <0.05 compared to overweight in post hoc test
[a] Categorised based on the highest BMI ever reached in their career

4.1.7.2 Multivariate analysis

The sick report was used as a proxy for sickness absenteeism in the multivariate analysis (Table 4.6). Overweight and obesity explained 4.9% of the variations in the sick reports. Addition of age further contributed to 20.4% in the R^2 change. However, the addition of other socio-demographic variables explained very little to the variations in the sick report, and rank did not contribute to any changes in the R^2. Even after adjusting for socio-demographic variables and rank, overweight and obesity remained significant with Unstandardized B of 2.112 and R^2 of 29.5%.

Table 4.6: Multivariate analysis of predictors of sick reports

	Unstandardized B				
	Model 1	Model 2	Model 3	Model 4	Model 5
BMI	5.611*	1.985 *	1.982 *	2.110 *	2.112 *
Age		1.099 *	1.118 *	1.180 *	1.170 *
Gender			5.909 *	5.547 *	5.552*
Ethnicity				-2.582 *	-2.577 *
Education level				0.770	0.698
Marital status				0.757	0.739
Rank					0.186
R^2	4.9%	25.3%	28.4%	29.2%	29.2%
R^2 change		20.4%	3.1%	0.7%	0.0%

* $p < 0.05$
Model 1 – Crude OR
Model 2 – adjusted for age
Model 3 – Model 2 + adjusted for gender
Model 4 – Model 3 + adjusted for ethnicity, education level and marital status
Model 5 – Model 4 + adjusted for rank

4.2 Phase 2

Out of 2275 participants form Phase 1, 524 (23.0%) were available and agreed to participate (Figure 4.15). The characteristics of participants (n = 524) and non-participants (n = 1729) are shown in Table 4.7. Compared to the non-participants, those who were involved in the Phase 2 were significantly younger and had a shorter duration of service. Almost 60% of them were below 30 years old, and more than 50% served below than 10 years. There were also higher proportions of females and junior rank participants. Otherwise, there were no significant differences in the proportions of ethnicity, education level and marital status between the participants and non-participants.

The response rate for physical activity, smoking and anthropometric measurements and body compositions analysis was 100%. However, only 75% of the participants were available to participate in BMFT and 24-hour dietary recall. At least three attempts were made to revisit each unit to ensure maximum participation in all the variables measured. Data collection was stopped due to time and financial constraints. Although the sample size was adequate to have enough power to establish the implication of overweight and obesity on physical fitness, it might not be enough to determine the association between lifestyle factors and overweight and obesity.

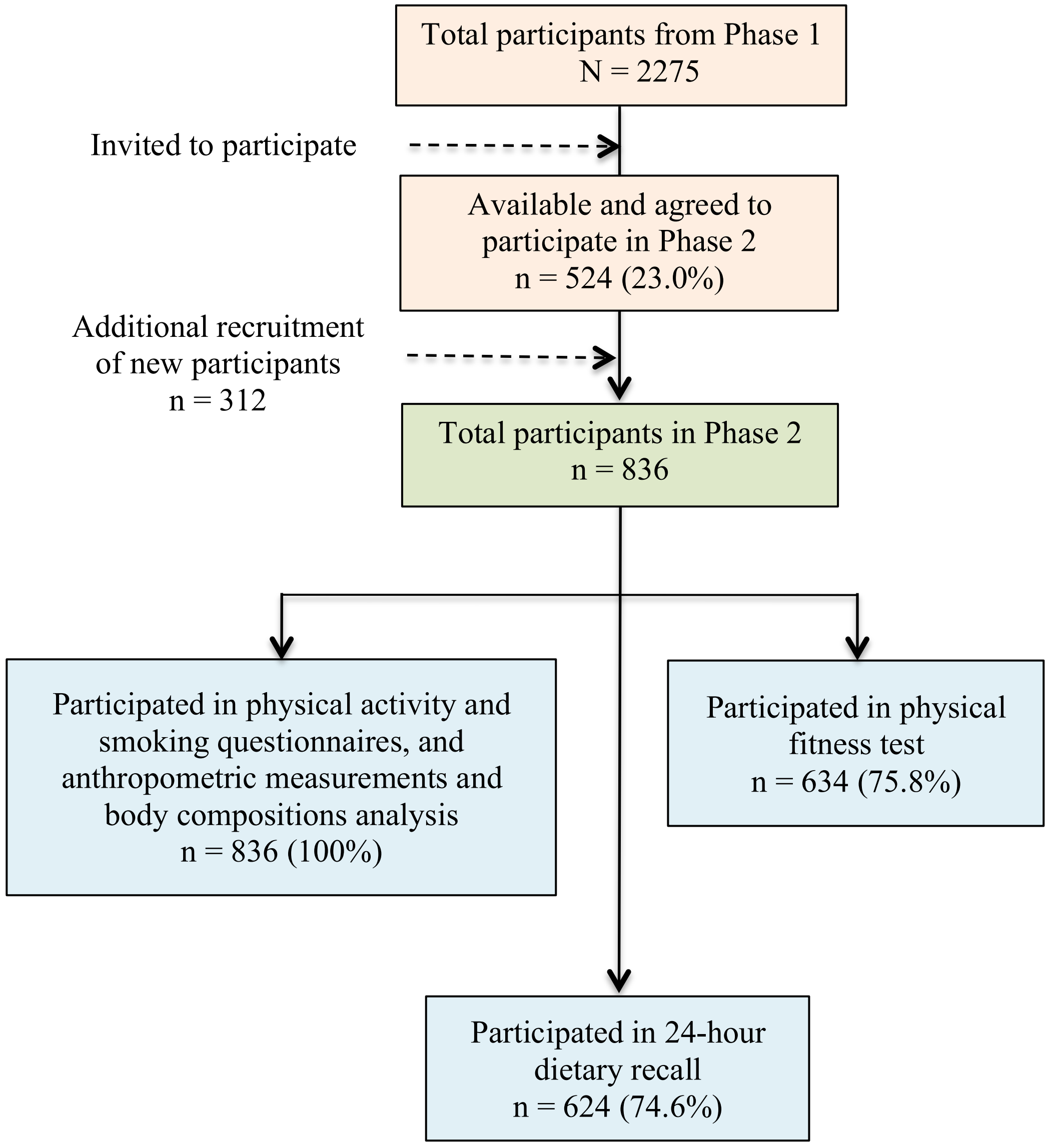


Figure 4.15: Number of personnel participated in different variable measurements for Phase 2

Table 4.7: Characteristics of participants and non-participants in Phase 2

	Total (n = 2275)	Non-Participants (n = 1729)	Participants (n = 546)	p
		n (%)		
Age (years) *	30.16 (5.46)	30.42 (5.63)	29.33 (4.77)	**<0.001**
Age				
<30 years	1211	887 (73.2)	324 (26.8)	**0.001**
≥30 years	1064	842 (79.1)	222 (20.9)	
Gender				
Males	1882	1471 (78.2)	411 (21.8)	**<0.001**
Females	393	258 (65.6)	135 (34.4)	
Ethnicity				
Malays	1909	1449 (75.9)	460 (24.1)	0.806
Non-Malays	366	280 (76.5)	86 (23.5)	
Education Level				
Lower Secondary	556	427 (76.8)	129 (23.2)	0.153
Secondary	1546	1161 (75.1)	385 (24.9)	
Tertiary	173	141 (81.5)	32 (18.5)	
Marital Status				
Married	1619	1222 (75.5)	397 (24.5)	0.360
Unmarried	656	507 (73.3)	149 (22.7)	
Duration of service (years) *	10.17 (5.42)	10.44 (5.60)	9.29 (4.71)	**<0.001**
Duration of service				
<5 years	398	305 (76.6)	93 (23.4)	**<0.001**
5-9.9 years	749	542 (72.4)	207 (27.6)	
10-14.9 years	751	560 (74.6)	191 (25.4)	
≥15 years	377	322 (85.4)	55 (14.6)	
Rank				
Junior Rank	1788	1323 (74.0)	465 (26.0)	**<0.001**
Senior Rank	378	310 (82.0)	68 (18.0)	
Officer	109	96 (88.1)	13 (11.9)	

* mean (SD)

4.2.1 Descriptive analysis

4.2.1.1 Socio-demographic and occupational characteristics

The mean age of the participants was around 29 years old, and there was no significant difference between males and females (Table 4.8). Majority of the participants were Malays, with at least secondary education, and married. There were higher proportions of female participants above 30 years old, Malays, had at least secondary education, and married. This is consistent with the socio-demographic characteristics in Phase 1, except that there were no significant gender differences in the above and below 30 years in Phase 1.

Additional data on the socio-economic background that were not available in Phase 1 were gathered in Phase 2. There were a significantly higher proportion of married females with working spouses and monthly household incomes of more than RM3000. A majority of the married personnel had at least one child.

The mean duration of service was around nine years, with no significant difference between males and females (Table 4.9). There were equal proportions of participants who had served less than 10 years and 10 years and above. Only small percentage of females had served 15 years and above.

Table 4.8: Socio-demographic characteristics of participants in Phase 2

	Total (n = 836)	Males (n = 645)	Females (n = 191)	p
		n (%)		
Age (years) *	29.2 (5.24)	29.1 (5.55)	29.6 (3.99)	0.215
Age				
<30 years	486	387 (79.6)	99 (20.4)	**0.044**
≥30 years	350	258 (73.7)	92 (26.1)	
Ethnicity				
Malays	727	550 (75.7)	177 (24.3)	**0.008**
Non-Malays	109	95 (87.2)	14 (12.8)	
Education Level				
Lower Secondary	143	141 (98.6)	2 (1.4)	**<0.001**
Secondary	622	443 (71.2)	179 (28.8)	
Tertiary	71	61 (85.9)	10 (14.1)	
Marital Status				
Married	602	451 (74.9)	151 (25.1)	**0.014**
Unmarried	234	194 (82.9)	40 (17.1)	
Spouse working §				
Yes	299	192 (64.2)	107 (35.8)	**<0.001**
No	146	143 (97.9)	3 (2.1)	
Number of children §				
None	78	65 (83.3)	13 (16.7)	**0.046**
1-3	330	247 (74.8)	83 (25.2)	
>3	37	23 (62.2)	14 (37.8)	
Household income #				
<RM3000	437	353 (80.8)	84 (19.2)	**0.003**
≥RM3000	187	131 (70.1)	56 (29.9)	

* mean (SD)
§ Among married personnel participated in dietary study (n = 445)
# Number of respondent in dietary study, n = 624

Table 4.9: Occupational characteristics of participants in Phase 2

	Total (n = 836)	Males (n = 645)	Females (n = 191)	p
		n (%)		
Duration of service (years) *	9.2 (5.32)	9.2 (5.64)	9.2 (4.06)	0.980
Duration of service				
<5 years	179	153 (85.5)	26 (14.5)	**<0.001**
5-9.9 years	245	183 (74.7)	62 (25.3)	
10-14.9 years	320	226 (70.6)	94 (29.4)	
≥15 years	932	83 (90.2)	9 (9.8)	
Rank				
Junior Rank	672	510 (75.9)	162 (24.1)	**0.030**
Senior Rank	140	119 (85.0)	21 (15.0)	
Officer	24	16 (66.7)	8 (33.3)	

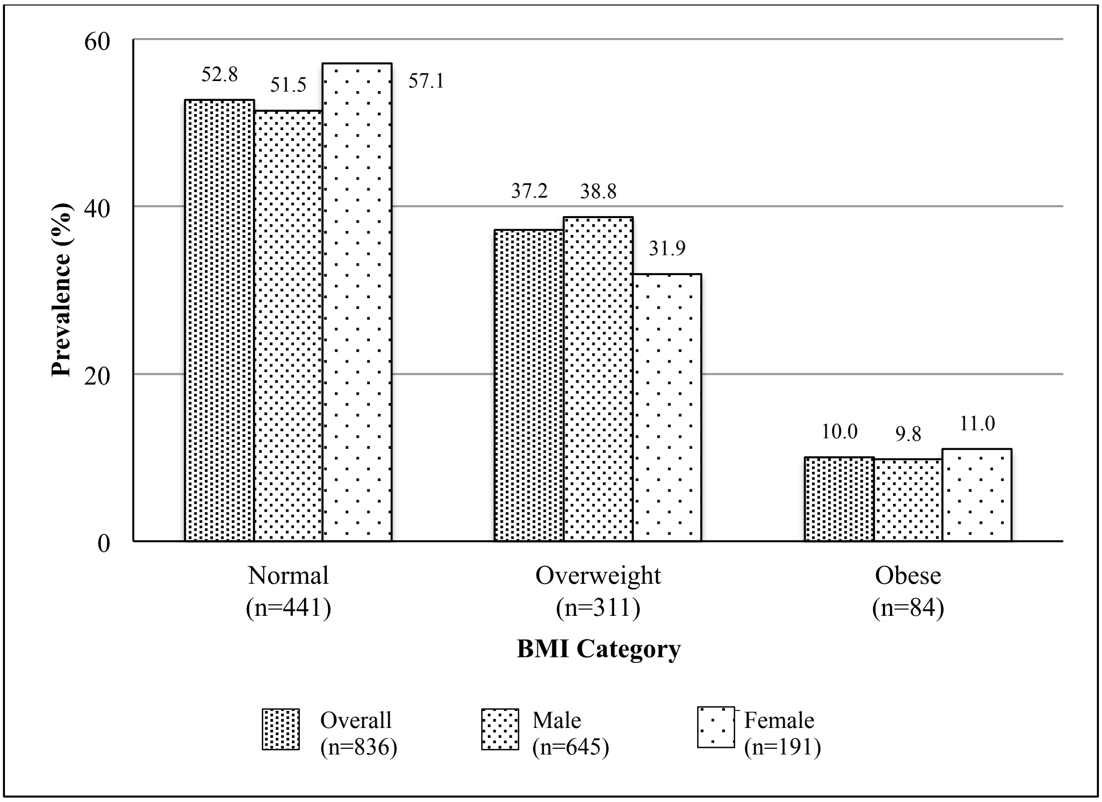
* mean (SD)

A comparison of Phase 1 and Phase 2 participants showed that there were higher proportions of females, Malays, those who had at least completed secondary education, junior rank, and senior rank among Phase 2 participants. However, there were no significant differences in mean age, mean duration of service, and the proportion of married and unmarried personnel. Results are attached in **Appendix N**.

4.2.1.2 Anthropometric measurements and body compositions

(a) Body Mass Index

The mean BMI (SD) was 24.9 (3.92) kg/m^2. There was no significant difference between males and females. The overall prevalence of overweight and obesity were 37.2% and 10.0% respectively (Figure 4.16). Among males, the prevalence of overweight and obesity were 38.8% and 9.8% respectively. Compared to males, females had a lower overweight prevalence of 31.9% but higher obesity prevalence of 11.0%. However, there was no significant difference in the proportion of overweight and obesity between males and females.



Underweight was combined with normal weight due to its small number (n=20)

Figure 4.16: Prevalence of normal, overweight and obesity in Phase 2

(b) Waist circumference

The mean (SD) WC was 80.7 (9.9) cm (Table 4.10). Both male and female WC means were within the recommended limits according to both the WHO and CPG classifications. The prevalence of both increased and substantial risks of developing obesity-related health problems according to the WHO classifications was 17.5%. The Malaysian CPG used a lower cut-off point for WC. Hence, the prevalence of obesity-related health problems was higher (24.4%) compared to WHO classifications. Although females had significantly lower mean WC compared to males, they had a higher proportion of the increased and substantial risk of developing obesity-related health problems in both the WHO and the Malaysian CPG classifications. For instance, among those with an increase and substantial risks, more than half were females.

Table 4.10: Prevalence of risk of obesity-related health problems according to WC classification

	Total (n = 836)	Males (n = 645)	Females (n = 191)	p
		n (%)		
WC - mean (SD)	80.7 (9.9)	81.7 (10.0)	77.3 (8.8)	**<0.001**
WC Category (WHO)				
Low risk [a]	690	573 (83.0)	117 (17.0)	**<0.001**
Increased risk [b]	98	49 (50.0)	49 (50.0)	
Substantial risk [c]	48	23 (47.9)	25 (52.1)	
WC Category (CPG)				
Low risk [d]	630	513 (81.4)	117 (18.6)	**<0.001**
Increased risk [e]	236	132 (64.1)	74 (35.9)	

WC (WHO)
[a] Male: <94 cm; Female <80 cm
[b] Male: 94-102 cm; Female: 80-88 cm
[c] Male: >102 cm; Female >88 cm

WC (CPG)
[d] Male: <90 cm; Female <80 cm
[e] Male: $\geq$90 cm; Female $\geq$80 cm

(c) Body compositions

According to BF% classification, the prevalence of obesity was 27.5% (Table 4.11). The mean BF% for males and females were within the recommended limit of <25% for males and <35% for females. There were significantly higher proportions of females in the obese group (31.7%) compared to the normal group (19.5%). Females also had a significantly higher mean BF% and fat mass, and lower mean muscle mass and muscle mass percentage compared to males.

Table 4.11: Body compositions and prevalence of obesity according to BF% classification

	Total (n = 836)	Males (n = 645)	Females (n = 191)	p
		n (%)		
BF% - n (%)				
Normal [a]	606	488 (80.5)	118 (19.5)	**<0.001**
Obese [b]	230	157 (68.3)	73 (31.7)	
		Mean (SD)		
BF%	23.8 (8.2)	20.8 (6.2)	33.6 (6.4)	**<0.001**
Fat Mass	16.9 (7.6)	15.4 (6.9)	21.8 (7.9)	**<0.001**
Muscle Mass%	72.0 (8.3)	74.9 (6.4)	62.3 (6.6)	**<0.001**
Muscle Mass	49.3 (8.0)	52.4 (5.9)	38.8 (4.2)	**<0.001**

[a] Male: <25%; Female <35%
[b] Male: ≥25%; Female ≥35%

(d) Correlation between BMI and BF%

Figure 4.17 shows a strong positive correlation between BF% and BMI for males and females.

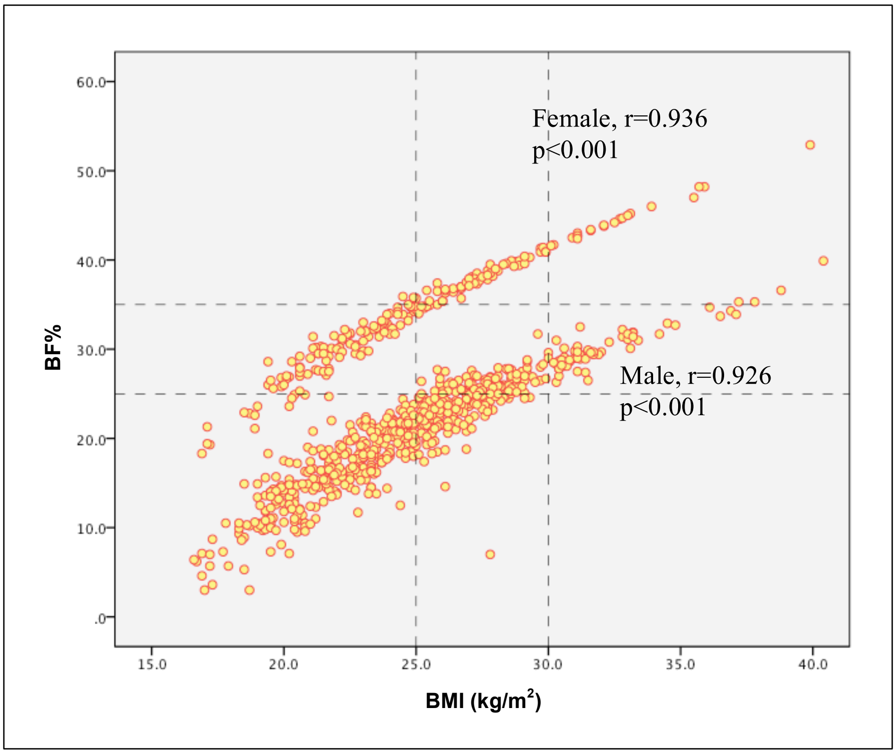


Figure 4.17: Classification of overweight and obesity and correlation between BMI and BF%

BMI and BF% had correctly classified almost all normal and obese participants (Table 4.12). However, 62.4% of overweight males had normal BF%, and 82% of overweight females had obese BF%.

Further sub-analyses of the overweight group (BMI 25-29.9 kg/m^2) showed that, the proportion of overweight males and females who had normal BF% were 62.4% and 18% respectively (Table 4.13). Among the overweight personnel with BMI <27 kg/m^2, 85.7% of males and 38.5% of females had normal BF%, and 14.3% of males and 61.5% of females had obese BF%.

Table 4.12: Proportions of overweight and obesity according to BMI and BF% classifications

Body Mass Index (BMI)	Body Fat Percentage (BF%)	
	Normal [d], n (%)	Obese [e], n (%)
Overall		
Normal [a] (n = 441)	439 (99.5)	2 (0.5)
Overweight [b] (n = 311)	167 (53.7)	144 (46.3)
Obese [c] (n = 84)	0 (0.0)	84 (100.0)
Male		
Normal (n = 332)	332 (100.0)	0 (0.0)
Overweight (n = 250)	156 (62.4)	94 (37.6)
Obese (n = 63)	0 (0.0)	63 (100.0)
Female		
Normal (n = 109)	107 (98.2)	2 (1.8)
Overweight (n = 61)	11 (18.0)	50 (82.0)
Obese (n = 21)	0 (0.0)	21 (100.0)

[a] BMI <25.0 kg/m^2
[b] BMI 25.0-29.9 kg/m^2
[c] BMI $\geq$30.0 kg/m^2
[d] BF%; <25% (Male), <35% (Female)
[e] BF%; $\geq$25% (Male), $\geq$35% (Female)

Table 4.13: Proportion of overweight group according to BMI and BF% classifications

BMI (n)	BF%	
	Normal [a], n (%)	Obese [b], n (%)
Male		
25-26.9 kg/m^2 (n = 133)	114 (85.7)	19 (14.3)
27-29.9 kg/m^2 (n = 117)	42 (35.9)	75 (64.1)
Female		
25-26.9 kg/m^2 (n = 26)	10 (38.5)	16 (61.5)
27-29.9 kg/m^2 (n = 35)	1 (2.9)	34 (97.1)

[a] BF%; <25% (Male), <35% (Female)
[b] BF%; $\geq$25% (Male), $\geq$35% (Female)

(e) Sensitivity and specificity of BMI and BF%

The sensitivity of BMI in defining overweight based on BF% was above 95% overall, male and female participants (Table 4.14). However, the specificity was lower with 72% in overall, 68% in males, and 91% in females. This value indicates that among males, 68% who were BMI-normal had normal BF%, and 32% were BF%-obese. The Positive Predictive Value (PPV) for overweight was greater than 50% overall and in males. The female's PPV was 82%. The PPV value means that among males, 37% of BMI-overweight was BF%-obese, while 63% had normal BF%. The Negative Predictive Value (NPV), which reflects the percentage of BMI-normal who had normal BF%, was all close to 100%.

Meanwhile, the sensitivity, specificity, PPV, and NPV overall, males and females for obesity were all around 100%. This indicates that the ability of BMI to classify obese personnel with excess BF% were accurate.

Table 4.14: Diagnostic compatibility between BMI and BF%

	Overall (n=836)	Male (n = 645)	Female (n = 191)
Overweight [a]			
Sensitivity	98.6%	100%	96.2%
Specificity	72.4%	68.0%	90.7%
Positive Predictive Value	46.3%	37.6%	82.0%
Negative Predictive Value	99.5%	100%	98.2%
Obesity [b]			
Sensitivity	97.7%	100%	91.3%
Specificity	100%	100%	100%
Positive Predictive Value	100%	100%	100%
Negative Predictive Value	99.5%	100%	98.2%

[a] BMI 25.0-29.9 kg/m^2
[b] BMI $\geq$30.0 kg/m^2

4.2.1.3 Smoking

The overall prevalence of smoking was 51.1% (Table 4.15). Almost all of the smokers and ex-smokers were males. Among the smokers and ex-smokers, around 60% were moderate smokers and had smoked for more than 10 years. Among ex-smokers, most of them (64.4%) had quit within the last 5 years.

Table 4.15: Smoking characteristics of personnel in Phase 2

	Total (n = 836)	Males (n = 645)	Females (n = 191)	p
		n (%)		
Smoking status				
Smoker	427	425 (99.5)	2 (0.5)	**<0.001**
Ex-Smoker	59	57 (96.6)	2 (13.4)	
Never Smoke	350	163 (46.6)	187 (53.4)	
Smoking amount [a]				
Light (<10 cpd)	179	177 (98.9)	2 (1.1)	0.831
Moderate (10-20 cpd)	294	292 (96.6)	2 (0.7)	
Heavy (>20 cpd)	13	13 (100.0)	0 (0.0)	
Duration of smoking [a]				
<5 years	49	47 (95.9)	2 (4.1)	**0.023**
5-10 years	132	132 (100.0)	0 (0.0)	
>10 years	305	303 (99.3)	2 (0.7)	
Smoking (pack-year) [a]				
<5 pack-years	220	218 (99.1)	2 (0.9)	0.849
≥5 pack-years	266	264 (99.2)	2 (0.8)	
Duration of quitting [b]				
<5 years	36	36 (100.0)	0 (0.0)	0.072
≥5 years	23	21 (91.3)	2 (8.7)	

cpd – cigarette per day
[a] Among smoker and ex-smoker, n = 486
[b] Among ex-smoker, n = 59

4.2.1.4 Physical activity

Overall, median total physical activity (95% CI) was 5511.7 (5230.2,5793.1) METs-minute/week (Table 4.16). Males had a significantly higher level of median total physical activity, vigorous intensity, and leisure time activity compared to females. Females, on the other hand, had a significantly higher level of activity in the domestic domain and average sitting time. There were no significant differences in the walking and moderate intensities and work domain between males and females.

Table 4.16: Level of physical activity – median

Physical Activity	Total (n = 836)	Males (n = 645)	Females (n = 191)
	Median (95% CI)		
Total Activity	5511.7 (5230.2,5793.1)	5770.0 (5449.6,6090.4)	4877.0 (4340.4,5413.6)
Intensity			
Walking	693.0 (639.9,746.1)	693.0 (632.6,753.4)	594.00 (486.5,701.5)
Moderate	1920.0 (1811.1,2028.9)	1920.0 (1795.9,2044)	1925.00 (1672.6,2177.3)
Vigorous	2160.53 (1976.8,2344.1)	2400.0 (2190.9,2609.1)	1440.00 (1157.8,1722.2)
Domain			
Work	2843.25 (2659.3,3027.3)	3000.0 (2800.8,3199.2)	2085.0 (1677.7,2492.3)
Transport	0.0 (-12.9,12.9)	0.0 (-16.8,16.8)	0.0 (-21.5,21.5)
Domestic	900.00 (834.6,965.4)	855.0 (787.5,922.5)	1050.0 (893,1206.9)
Leisure	712.50 (635.7,789.3)	792.0 (690.3,893.7)	396.0 (359.7,432.3)
Sitting†	300.00 (290.6,309.4)	291.4 (280.7,302.1)	334.3 (315.4,352.6)

† Average sitting (excluding transport) measured in minute/day

Overall, 75% of the participants were highly active (Table 4.17). Males were significantly more active (78%) than females (66%). There were also considerably more males who recorded high level of vigorous, work and leisure physical activity compared to females.

Table 4.17: Levels of physical activity – categorical

	Level of Physical Activity			
	Low [a]	Moderate [b]	High [c]	p [*]
	n (%)			
Total Activity				
Overall (n = 836)	12 (1.4)	197 (23.6)	627 (75.0)	**0.003**
Male (n = 645)	7 (1.1)	137 (21.2)	501 (77.7)	
Female (n = 191)	5 (2.6)	60 (31.4)	126 (66.0)	
Intensity				
Walking				
Overall	390 (46.7)	400 (47.8)	46 (5.5)	0.380
Male	293 (45.4)	317 (49.1)	35 (5.4)	
Female	97 (50.8)	83 (43.5)	11 (5.8)	
Moderate				
Overall	107 (12.8)	496 (59.3)	233 (27.9)	0.879
Male	83 (12.9)	385 (59.7)	177 (27.4)	
Female	24 (12.6)	111 (58.1)	56 (29.3)	
Vigorous				
Overall	169 (20.2)	376 (45.0)	291 (34.8)	**<0.001**
Male	104 (16.1)	286 (44.7)	253 (39.2)	
Female	65 (34.0)	88 (46.1)	38 (19.9)	
Domain				
Work				
Overall	113 (13.5)	331 (39.6)	392 (46.9)	**<0.001**
Male	73 911.3)	250 (38.8)	322 (49.9)	
Female	40 (20.9)	81 (42.4)	70 (36.6)	
Transport				
Overall	725 (86.7)	104 (12.4)	7 (0.8)	0.201
Male	552 (85.6)	87 (13.5)	6 (0.9)	
Female	173 (90.6)	6 (0.9)	1 (0.5)	

Table 4.17 (Continued)

	Level of Physical Activity			p [*]
	Low [a]	Moderate [b]	High [c]	
	n (%)			
Domain				
Domestic				
Overall	292 (34.9)	478 (57.2)	66 (7.9)	0.082
Male	238 (36.9)	359 (55.7)	48 (7.4)	
Female	54 (28.3)	119 (62.3)	18 (9.4)	
Leisure				
Overall	391 (46.8)	352 (42.1)	93 (11.1)	**<0.001**
Male	279 (43.3)	280 (43.4)	86 (13.3)	
Female	112 (58.6)	72 (37.7)	7 (3.7)	

[a] <600 METs-minute/week [b] 600-3000 METs-minute/week [c] >3000 METs-minute/week
[*] p-value for the difference in the proportion between males and females

Almost all (94%) participants had achieved the recommended level of physical activity of 150 minutes of moderate or 75 minutes of vigorous physical activity in a week, to maintain good health and prevent chronic diseases (Table 4.18) (WHO, 2017a). Majority of the participants (86%) were also able to achieve the amount twice as much, for additional health benefits. There were no significant differences in the proportion of males and females who were able to accomplish both of the proposed standards. However, more males were able to participate in both the 75 minutes and 150 minutes vigorous physical activity in a week compared to females.

Table 4.18: Level of physical activity – recommended by the WHO

	Total (n = 836)	Male (n = 645)	Female (n = 191)	p
		n (%)		
150 minutes of moderate physical activity/week				
Yes	732	561 (76.6)	171 (23.4)	0.348
No	104	84 (80.8)	20 (19.5)	
75 minutes of vigorous physical activity/week				
Yes	667	541 (81.1)	126 (18.9)	**<0.001**
No	169	106 (61.5)	65 (38.5)	
150 minutes of moderate physical activity/week OR 75 minutes of vigorous physical activity/week				
Yes	789	611 (77.4)	178 (22.6)	0.419
No	47	34 (72.3)	13 (27.7)	
300 minutes of moderate physical activity/week				
Yes	603	465 (77.1)	138 (22.9)	0.966
No	233	180 (77.3)	53 (22.7)	
150 minutes of vigorous physical activity/week				
Yes	578	470 (81.3)	108 (18.7)	**<0.001**
No	258	175 (67.8)	83 (32.2)	
300 minutes of moderate physical activity/week OR 150 minutes of vigorous physical activity/week				
Yes	721	565 (78.4)	156 (21.6)	**0.034**
No	115	80 (69.6)	35 (30.4)	

4.2.1.5 Dietary habits

Out of 836 personnel, 624 (74.6%) participated in the 24-hour dietary recall study. Characteristics of participants and non-participants are shown in **Appendix O**. Compared to the non-participants, the participants were significantly younger and had served shorter duration. Mean (SD) age and duration of service for the participants were 28.8 (4.90) and 8.9 (5.10) years compared to 30.2 (5.09) and 10.1 (5.84) years among non-participants. There were also significantly higher proportions of non-Malays and personnel with tertiary education among the participants. However, there were no significant differences in the proportions of gender, marital status, and rank among the participants and non-participants.

There were no significant differences in the mean age and duration of service between genders among the 624 participants (Table 4.19). However, there were higher proportions of females in the age group of 30 years and above. Females also had higher proportions of personnel with secondary education, married, and officer rank. Fewer females had served for 15 years and above.

Table 4.19: Characteristics of participants in the dietary study

	Total (n = 624)	Males (n = 484)	Females (n = 140)	p
		n (%)		
Age (years) *	28.8 (4.90)	28.7 (5.12)	29.4 (4.00)	0.111
Age				
<30 years	382	310 (81.2)	72 (18.8)	**0.007**
≥30 years	242	174 (71.9)	68 (28.1)	
Ethnicity				
Malays	530	404 (76.2)	126 (23.8)	0.057
Non-Malays	94	80 (85.1)	14 (14.9)	

Table 4.19 (Continued)

	Total (n = 624)	Males (n = 484)	Females (n = 140)	p
		n (%)		
Education Level				
Lower Secondary	101	99 (98.0)	2 (2.0)	**<0.001**
Secondary	456	325 (71.3)	131 (28.7)	
Tertiary	67	60 (89.6)	7 (10.4)	
Marital Status				
Married	445	335 (75.3)	110 (24.7)	**0.031**
Unmarried	179	149 (83.2)	30 (16.8)	
Duration of service (years) *	8.9 (5.10)	8.9 (5.35)	9.0 (4.08)	0.745
Duration of service				
<5 years	143	122 (85.3)	21 (14.7)	**0.002**
5-9.9 years	177	134 (75.7)	43 (24.3)	
10-14.9 years	246	176 (71.5)	70 (28.5)	
≥15 years	58	52 (89.7)	6 (10.3)	
Rank				
Junior Rank	500	378 (75.6)	122 (24.4)	**0.011**
Senior Rank	109	96 (88.1)	13 (11.9)	
Officer	15	10 (66.7)	5 (33.3)	

* mean (SD)

Participants' eating habits were assessed together with the 24-hour dietary recall. The questionnaires enquired on the food sources for the five main meals of the day, and the frequency of fast food consumption. A high proportion of the participants took their three main meals, i.e., breakfast, lunch, and especially dinner at home compared to other sources (Table 4.20). Most participants had their morning tea at the workplace and did not take evening tea. There were significantly higher proportions of females who took their breakfast and evening tea from outside sources or skipped their lunch and morning tea. Conversely, males had most of their meals at home or the workplace.

If all five meals for all the participants were accounted for, ‘home’ made up 40% and ‘outside’ represented 17% of the total food sources. There were higher proportions of males who took their meals at home and females who took their meals from outside sources.

The mean (SD) frequency of fast food consumption was 1.30 (1.13) times a month. Majority of the personnel (74.6%) had consumed fast food at least once a month. There were no significant differences in the fast food consumption between males and females.

Table 4.20: Dietary habits and fast food consumption

	Total (n = 624)	Males (n = 484)	Females (n = 140)	p
		n (%)		
Breakfast				
Home	216	185 (85.6)	31 (14.4)	**0.002**
Workplace	178	132 (74.2)	46 (25.8)	
Outsides	79	53 (67.1)	26 (32.9)	
Not taken	151	114 (75.5)	37 (24.5)	
Morning tea				
Home	82	70 (85.4)	12 (14.6)	**0.019**
Workplace	331	265 (80.1)	66 (19.9)	
Outsides	96	69 (71.9)	27 (28.1)	
Not taken	115	80 (69.6)	35 (30.4)	
Lunch				
Home	289	243 (84.1)	46 (15.9)	**<0.001**
Workplace	88	77 (87.5)	11 (12.5)	
Outsides	156	104 (66.7)	52 (33.3)	
Not taken	91	60 (65.9)	31 (34.1)	

Table 4.20 (Continued)

	Total (n = 624)	Males (n = 484)	Females (n = 140)	p
		n (%)		
Evening tea				
Home	150	123 (82.0)	27 (18.0)	**0.031**
Workplace	124	97 (78.2)	27 (21.8)	
Outsides	100	66 (66.0)	34 (34.0)	
Not taken	250	198 (79.2)	52 (20.8)	
Dinner				
Home	462	361 (78.1)	101 (21.9)	0.813
Workplace	13	11 (84.6)	2 (15.4)	
Outsides	109	82 (75.2)	27 (24.8)	
Not taken	40	30 (75.0)	10 (25.0)	
For all 5 meals #				
Home	1199	982 (81.9)	217 (18.1)	**0.037**
Workplace	734	582 (79.3)	152 (20.7)	
Outsides	540	374 (69.3)	166 (30.7)	
Not taken	647	482 (74.5)	165 (25.5)	
Fast Food consumptions				
Frequency *	1.3 (1.1)	1.3 (1.1)	1.5 (1.3)	0.082
Often (>1/month)	192	141 (73.4)	51 (26.6)	0.100
Sometimes (1/month)	276	214 (77.5)	62 (22.5)	
Rarely (<1/month)	159	132 (83.0)	27 (17.0)	

Total for 5 meals; 624 person x 5 meals/day = 3120 person-meals/day
* Frequency of consumption per month – mean (SD)

4.2.1.6 Dietary intake

Male participants had a significantly higher mean energy, carbohydrate, and protein intake compared to females (Table 4.21). There were no significant differences in mean total fat intake between male and female participants. In terms of percentage of nutrient intake, both male and female participants' had a slightly higher intake of carbohydrate and fat intake compared to the Recommended Nutrient Intake (RNI) for Malaysian adults (Noor et al., 2017). However, protein intake for both male and female participants was lower compared to the RNI. There were no significant differences in the percentage of nutrients intake between male and female participants.

Table 4.21: Dietary Intake

Nutrients	Total (n = 627)	Males (n = 487)	Females (n = 140)	p
	mean (SD)			
Energy (kcal)	2005.9 (731.2)	2044.4 (713.7)	1872.3 (777.0)	**0.014**
Carbohydrate (g)	266.7 (103.0)	271.8 (103.8)	249.2 (98.4)	**0.022**
Protein (g)	72.7 (29.3)	74.3 (28.8)	67.4 (30.5)	**0.014**
Total Fat (g)	71.7 (35.2)	73.1 (33.3)	67.0 (40.8)	0.072
Carbohydrate (%)	53.6 (9.5)	53.5 (9.5)	53.9 (9.6)	0.707
Protein (%)	14.7 (3.5)	14.7 (3.4)	14.8 (4.0)	0.827
Total Fat (%)	31.6 (8.4)	31.7 (8.3)	32.2 (8.4)	0.577

4.2.1.7 Physical fitness performances

Of 836 personnel, 634 (75.8%) participated in the BMFT. Characteristics of participants and non-participants in the physical fitness are shown in **Appendix P**. There were no significant differences in the socio-demographic and occupational characteristics, except for higher proportions of married personnel among participants compared to the non-participants. Although there seemed to be a higher proportion of personnel who served between 5 to 15 years, there were no significant differences in the mean duration of service between participants and non-participants of the BMFT.

Overall, 51.6% passed the BMFT (passed all the test) [Table 4.22 (a)]. Out of 307 personnel who failed the BFMT, around 58% failed one test, 32% failed two tests, and 10% failed all three tests. There were no significant gender differences in the proportion of test failed. When analysed according to each test, sit-up and 2.4km run recorded the highest failure rates of 35% and 30% respectively [Table 4.22 (b)]. On the contrary, only 10% failed the push-up test. There was a higher proportion of female participants who failed the sit-up test (30%), but there were no gender differences in the performance of the other two tests.

Table 4.22: Physical fitness test results

(a) Overall results

Results	Total (n = 634)	Males (n = 487)	Females (n = 147)	p
		n (%)		
Passed *	327	253 (77.4)	74 (22.6)	0.732
Failed #	307	234 (76.2)	72 (23.8)	
Failed one test	179	136 (76.0)	43 (24.0)	0.543
Failed two tests	97	72 (74.2)	25 (25.8)	
Failed all tests	31	26 (83.9)	5 (16.1)	

* Passed all tests

\# Failed at least one test

(b) According to each test

Results	Total (n = 634)	Males (n = 487)	Females (n = 147)	p
		n (%)		
Push-Up				
Passed	575	436 (75.8)	139 (24.2)	0.066
Failed	59	51 (86.4)	8 (13.6)	
Sit-Up				
Passed	412	330 (80.1)	82 (19.9)	**0.008**
Failed	222	157 (70.7)	65 (29.3)	
2.4km run				
Passed	449	337 (75.1)	112 (24.9)	0.102
Failed	185	150 (81.1)	35 (18.9)	

4.2.2 Factors associated with overweight and obesity - Univariate analysis

All the socio-demographic and occupational factors and lifestyle variables were analysed against BMI (normal, and overweight and obese) in the univariate analysis.

4.2.2.1 Socio-demographic factors

Overweight and obese personnel were significantly older compared to the normal weight personnel (Table 4.23). Among those aged 30 years and above, more than half were overweight or obese. There were also significantly higher proportions of married personnel with monthly household income of more than RM3000 among the overweight and obese participants. However, there were no significant differences in the proportion of gender, ethnicity, education level, whether the spouse is working, and the number of children between normal weight, and overweight and obese personnel.

Table 4.23: Association between socio-demographic factors and overweight and obesity

	Total (n = 824)	Normal (n = 435)	Overweight & Obese (n = 389)	p
		n (%)		
Age (years) *	29.2 (5.2)	28.1 (5.3)	30.6 (4.8)	**0.001**
Age				
<30 years	475	283 (59.6)	192 (40.4)	**<0.001**
≥30 years	349	152 (43.6)	197 (56.4)	
Gender				
Males	633	326 (51.5)	307 (48.5)	0.177
Females	191	109 (57.1)	82 (42.9)	
Ethnicity				
Malays	715	379 (53.0)	336 (47.0)	0.751
Non-Malays	109	56 (51.4)	53 (48.6)	

Table 4.23 (Continued)

	Total (n = 824)	Normal (n = 435)	Overweight & Obese (n = 389)	p
		n (%)		
Education Level				
Lower Secondary	142	68 (47.9)	74 (52.1)	0.417
Secondary	611	330 (54.0)	281 (46.0)	
Tertiary	71	37 (52.1)	34 (47.9)	
Marital Status				
Married	598	274 (45.8)	324 (54.2)	**<0.001**
Unmarried	226	161 (71.2)	65 (28.8)	
Spouse working [§]				
Yes	299	143 (47.8)	156 (52.2)	0.287
No	146	62 (42.5)	84 (57.5)	
Number of children [§]				
None	78	39 (50.0)	39 (50.0)	0.546
1-3	330	147 (44.5)	183 (55.5)	
>3	37	19 (51.4)	18 (48.6)	
Household income [#]				
<RM3000	437	252 (57.7)	185 (42.3)	**<0.001**
≥RM3000	187	79 (42.2)	108 (57.8)	

[*] mean (SD)
[§] Among married personnel participated in dietary study (n = 445)
[#] Number of respondent in dietary study, n = 624

4.2.2.2 Occupational factors

Overweight and obese personnel had served significantly longer compared to normal weight personnel (Table 4.24). The proportions of overweight and obesity increased as the duration of service increased. Among those who had served more than 10 years, more than half were either overweight or obese. As for the rank, 60% among the senior ranks was either overweight or obese compared to only 45% and 38% among the junior ranks and the officer respectively. Age, duration of service, and rank were time-related factors.

Table 4.24: Association between occupational factors an overweight and obesity

	Total (n = 824)	Normal (n = 435)	Overweight & Obese (n = 389)	p
		n (%)		
Duration of service (years) *	9.2 (5.3)	7.7 (5.3)	11.0 (4.7)	**<0.001**
Duration of service				
<5 years	172 (20.9)	142 (82.6)	30 (17.4)	**<0.011**
5-9.9 years	241 (29.2)	128 (53.1)	113 (46.9)	
10-14.9 years	319 (38.7)	130 (40.8)	189 (59.2)	
≥15 years	92 (11.2)	35 (38.0)	57 (62.0)	
Rank				
Junior Rank	660 (80.1)	365 (83.9)	295 (44.7)	**0.002**
Senior Rank	140 (17.0)	55 (12.6)	85 (60.7)	
Officer	24 (2.9)	15 (3.4)	9 (37.5)	

4.2.2.3 Smoking

There were no significant differences in the proportion of smoking status between normal and overweight and obese personnel (Table 4.25). Among the smokers and ex-smokers, heavier and chronic smoking habits were associated with overweight and obesity. There were higher proportions of overweight and obesity among those who smoked for more than 20 cigarettes per day (cpd), more than 10 years, and more than five pack-years. The proportion of overweight and obesity was also higher among the quitters who had quit for more than 5 years.

Table 4.25: Association between smoking and overweight and obesity

	Total	Normal	Overweight & Obese	p
		n (%)		
Smoking status (n = 824)				
Smoker	427	226 (52.9)	201 (47.1)	0.696
Ex-Smoker	59	28 (4754)	31 (52.5)	
Never Smoke	350	187 (53.4)	163 (46.7)	
Smoking amount [a]				
Light (<10 cpd)	179	114 (63.7)	65 (36.3)	**<0.001**
Moderate (10-20 cpd)	294	136 (46.3)	158 (53.7)	
Heavy (>20 cpd)	13	4 (30.8)	9 (69.2)	
Duration of smoking [a]				
<5 years	49	33 (67.3)	16 (32.7)	**<0.001**
5-10 years	132	87 (65.9)	45 (34.1)	
≥10 years	305	134 (43.9)	171 (56.1)	
Smoking (pack-year) [a]				
<5 pack-years	220	137 (62.3)	83 (37.7)	**<0.001**
≥5 pack-years	266	117 (44.0)	149 (56.0)	
Duration of quitting [b]				
<5 years	36	22 (61.1)	14 (38.9)	**0.013**
≥5 years	23	6 (26.1)	17 (73.9)	

cpd – cigarette per day
[a] Among smoker and ex-smoker, n = 486
[b] Among ex-smoker, n = 59

4.2.2.4 Physical activity

There were no significant differences in the median level of physical activity between normal, and overweight and obese groups in the overall, and among males and females as well [Table 4.26 (a)]. However, those who were overweight and obese had a significantly lower level of vigorous activity compared to the normal weight group. There were no significant associations between other intensities or domains of physical activity with overweight and obesity. Among males, there were no significant associations found at all [Table 4.26 (b)]. On the contrary, the overweight and obese females had a significantly lower level total physical activity, moderate-intensity activity and physical activity at workplace compared to the normal weight females [Table 4.26 (c)].

Table 4.26: Association between level of physical activity (median) and overweight and obesity

(a) Total

Physical Activity	Total (n = 836)	Normal (n = 441)	Overweight and Obese (n = 395)
		Median (95% CI)	
Total Activity	5481.0 (5206.5,5755.4)	5569.5 (5158.3,5980.7)	5364.0 (4996.5,5731.5)
Intensity			
Walking	693.0 (641.5,744.5)	660.0 (595.9,724.1)	693.0 (613.8,772.2)
Moderate	1920.0 (1809.5,2030.5)	1935.0 (1767.8,2102.2)	1880.0 (1734.1,2025.9)
Vigorous	2160.0 (1984.4,2335.6)	2280.0 (2032.6,2527.4)	1020.0 (773.6,1266.4)
Domain			
Work	2847.0 (2661,3032.9)	2895.0 (2637.5,3152.5)	2739.0 (2464.9,3013.1)
Transport	0.0 (-12.9,12.9)	0.0 (-16.6,16.6)	0.0 (-201,20.1)
Domestic	900.0 (834.2,965.8)	915.0 (813.6,1016.4)	900.0 (813.7,986.3)
Leisure	697.5 (617.8,777.2)	628.5 (518.3,738.7)	792.0 (672.2,911.8)
Sitting†	300.0 (290.2,309.8)	300.0 (287.1,312.9)	291.4 (277.1,305.7)

† Average sitting (excluding transport) measured in minute/day

Table 4.26 (Continued)

(b) Male

Physical Activity	Total (n = 645)	Normal (n = 332)	Overweight and Obese (n = 313)
	Median (95% CI)		
Total Activity	5742.0 (5453.2,6030.7)	5733.0 (5317.4,6148.6)	5742.0 (5362.9,6121.1)
Intensity			
Walking	693.0 (639.1,746.9)	693.0 (624.1,761.8)	792.0 (714.2,869.8)
Moderate	1920.0 (1810.3,2029.7)	1895.0 (1737.3,2052.7)	1950.0 (1799.8,2100.2)
Vigorous	2400.0 (2211.9,2588.1)	2400.0 (2147.5,2652.4)	2400.0 (2126.2,2673.9)
Domain			
Work	3060.0 (2876.6,3243.4)	3060.0 (2820.3,3299.7)	3022.0 (2748.2,3295.8)
Transport	0.0 (-15.5,15.5)	0.0 (-17.8,17.8)	33.0 (6.61,59.4)
Domestic	855.0 (796.1,913.9)	840.0 (745.1,934.9)	865.0 (789.7,940.3)
Leisure	792.0 (702.1,881.9)	702.0 (578.1,825.8)	918.0 (786.6,1049.4)
Sitting†	291.4 (281.5,301.3)	296.1 (283.1,309.1)	282.9 (268.8,297.1)

† Average sitting (excluding transport) measured in minute/day

Table 4.26 (Continued)

(c) Female

Physical Activity	Total (n = 191)	Normal (n = 109)	Overweight and Obese (n = 82)
		Median (95% CI)	
Total Activity	4877.0 (4618.6,5135.3)	5471.5 (5077.7,5865.2)	4550.1 (4252.5,4847.7)
Intensity			
Walking	594.0 (5423.0,645.7)	594.0 (522.8,665.2)	594.0 (526.2,661.7)
Moderate	1925.0 (1803.5,2046.5)	2340.0 (2151.2,2528.8)	1767.0 (1635.8,1898.2)
Vigorous	1440.0 (1304.1,1575.9)	1440.0 (1232.9,1647.1)	1440.0 (1275.7,1604.3)
Domain			
Work	2085.0 (1888.9,2281.1)	2457.0 (2155.6,2758.4)	1881.0 (1649.1,2112.9)
Transport	0.0 (-10.3,10.3)	0.0 (-8.9,8.9)	0.0 (-15.1,15.1)
Domestic	1050.0 (963.4,1136.6)	1050.0 (935.6,1164.3)	1037.5 (909.4,1165.6)
Leisure	396.0 (344.4,447.6)	396.0 (325.5,466.5)	396.0 (322.1,469.8)
Sitting†	334.3 (325.3,343.3)	334.3 (320.6,348.1)	338.6 (326.9,350.3)

† Average sitting (excluding transport) measured in minute/day

There was no significant association between categories of physical activity for all intensity and domains with overweight and obesity (Table 4.27).

Table 4.27: Association between physical activity (category) and overweight and obesity

	Total (n = 836)	Normal (n = 441)	Overweight & Obese (n = 395)	p *
		n (%)		
Total Activity				
Low	12	8 (66.7)	4 (33.3)	0.574
Moderate	197	106 (53.8)	91 (46.2)	
High	627	327 (52.2)	300 (47.8)	
Intensity				
Walking				
Low	390	209 (53.6)	181 (46.4)	0.570
Moderate	400	205 (51.2)	195 (48.8)	
High	46	27 (58.7)	19 (41.3)	
Moderate				
Low	107	62 (57.9)	45 (42.1)	0.063
Moderate	496	245 (49.4)	251 (50.6)	
High	233	134 (57.5)	99 (42.5)	
Vigorous				
Low	169	92 (54.4)	77 (45.6)	0.592
Moderate	376	191 (50.8)	185 (49.2)	
High	291	158 (54.3)	133 (45.7)	
Domain				
Work				
Low	113	60 (53.1)	53 (46.9)	0.801
Moderate	331	170 (51.4)	161 (48.6)	
High	392	211 (53.8)	181 (46.2)	
Transport				
Low	725	389 (53.7)	336 (46.3)	0.399
Moderate	104	49 (47.1)	55 (52.9)	
High	7	3 (42.9)	4 (57.1)	
Domestic				
Low	292	157 (53.8)	135 (46.2)	0.073
Moderate	478	241 (50.4)	237 (49.6)	
High	66	43 (65.2)	23 (34.8)	
Leisure				
Low	391	218 (55.8)	173 (44.2)	0.087
Moderate	352	170 (48.3)	182 (51.7)	
High	93	53 (57.0)	40 (43.0)	

* p-value for the difference in the proportion between normal and overweight and obese

In terms of the ability to achieve the WHO recommended standard of physical activity, there were no significant differences between normal and overweight and obese participants (Table 4.28). More than 80% of the normal and overweight and obese personnel were able to meet the proposed level of physical activity.

Table 4.28: Association between level of physical activity (WHO recommended) and overweight and obesity

	Total (n = 836)	Normal (n = 441)	Overweight and Obese (n = 395)	p
		n (%)		
150 minutes of moderate physical activity/week or 75 minutes of vigorous physical activity/week				
Yes	789	411 (52.1)	378 (47.9)	0.117
No	47	30 (63.8)	17 (36.2)	
300 minutes of moderate physical activity/week or 150 minutes of vigorous physical activity/week				
Yes	721	378 (52.4)	343 (47.6)	0.638
No	115	63 (54.8)	52 (45.2)	

4.2.2.5 Dietary habits and intake

Overall, almost 40% of the meals consumed were from home (Table 4.29). However, among the overweight and obese personnel, there were significantly lower proportions of them who had home-cooked meals, and a higher proportion skipped their meals. There were no significant differences in the mean frequency of fast food consumption between normal, and overweight and obese personnel.

Table 4.29: Association between dietary habits and overweight and obesity

	Total	Normal	Overweight and Obese	p
		n (%)		
Food Source (n=3120) *				
Home	1200	690 (57.5)	510 (42.5)	**0.009**
Workplace	733	388 (52.9)	345 (47.1)	
Outsides	539	275 (51.0)	264 (49.0)	
Not Having	648	302 (46.6)	346 (53.4)	
		Mean (SD)		
Fast Food consumption #	1.3 (1.1)	1.3 (1.2)	1.3 (1.1)	0.971

* Calculated based on; 624 participants x 5 meals/day = 3120 meals
# Mean fast food consumptions in a month

In terms of dietary intake, overweight and obese personnel had significantly lower mean energy and carbohydrate intake (Table 4.30). There were no significant differences in the mean and percentage of protein and total fat intake between normal weight, and overweight and obese personnel.

Table 4.30: Association between dietary intake and overweight and obesity

Nutrients	Total (n = 612)	Normal (n = 325)	Overweight and Obese (n = 287)	p
		mean (SD)		
Energy (kcal)	2003.5 (733.7)	2062.6 (766.2)	1936.7 (690.3)	**0.034**
Carbohydrate (g)	266.4 (103.4)	276.2 (107.0)	255. 5 (98.2)	**0.013**
Protein (g)	72.6 (29.2)	74.2 (29.0)	70.8 (29.4)	0.158
Total Fat (g)	71. 6 (35.3)	73.2 (37.2)	69.9 (32.9)	0.243
Carbohydrate (%)	53.6 (9.6)	54.0 (0.9)	53. (9.8)	0.306
Protein (%)	14.7 (3.6)	14.6 (3.3)	14.8 (3.9)	0.662
Total Fat (%)	31.6 (8.4)	31.2 (8.2)	31.9 (8.6)	0.294

4.2.3 Factors associated with overweight and obesity – Multivariate analysis

Only selected socio-demographic and occupational factors, dietary habits and intake were included in the multivariate analysis (Table 4.31). Physical activity and smoking habits were not included, due to their insignificant findings in the univariate association ($p > 0.25$). In the univariate logistic regression analysis, significant factors include increasing age [OR = 1.10 (95% CI: 1.07,1.13)] and duration of service, (OR between 4.18 (95% CI: 2.62,6.67) to 7.71 (4.33,13.72), being married [OR = 2.94 (95% CI: 2.15,4.13)], senior rank [OR = 1.91 (95% CI: 1.32,2.78)], household income more than RM3000 [OR = 1.88 (95%CI: 1.33,2.66)], and not taking food from home [OR = 1.37 (95% CI: 1.22,1.41)]. However, in multivariate analysis, only duration of service and taking food high in calories remained significant. Compared to those who had served less than 5 years, the odds of being overweight and obese among those who had served between 5 to 10 years, between ten to 15 years, and more than 15 years were 5.45 (95% CI: 1.71,8.30), 5.70 (95% CI: 1.44,12.64), and 9.87 (95% CI: 1.12,17.00) respectively. Although taking food high in calories increased the odds of being overweight and obese, the odds and CI were marginally significant and may not have practical or clinical importance.

Table 4.31: Univariate and multivariate logistic regression of factors associated with overweight and obesity

Variables	Univariate	Multivariate
	Crude OR (95% CI), p	Adjusted OR (95% CI), p
Age	1.1 (1.07,1.13), **<0.001**	0.96 (0.86,1.08), 0.517
Gender		
Males	Reference	Reference
Females	0.80 (0.58,1.11), 0.177	0.64 (0.35,1.12), 0.151
Marital status		
Married	Reference	Reference
Unmarried	0.34 (0.25,0.48), <**0.001**	0.86 (0.40,1.84), 0.692
Duration of service		
<5 years	Reference	Reference
5-9.9 years	4.18 (2.62,6.67), **<0.001**	5.45 (1.71,8.30), **0.004**
10-14.9 years	6.88 (4.38,10.82), **<0.001**	5.70 (1.44,12.64), **0.013**
≥15 years	7.71 (4.33,13.72), **<0.001**	9.87 (1.12,17.00), **0.039**
Rank		
Junior Rank	Reference	Reference
Senior Rank	1.91 (1.32,2.78), **0.001**	2.07 (0.87,4.92), 0.098
Officer	0.74 (0.32,1.72), 0.487	2.21 (0.23,20.94), 0.489
Household income		
<RM 3000	Reference	Reference
≥RM 3000	1.88 (1.33,2.66), **<0.001**	1.09 (0.59,2.02), 0.786
Food source *		
Home	0.73 (0.63,0.85), **<0.00**1	0.77 (0.55,1.09), 0.147
Workplace	0.97 (0.77,1.21), 0.757	Not Included #
Outsides	0.84 (0.65,1.08), **0.178**	0.83 (0.56,1.24), 0.359
Not taken	1.18 (0.88,1.59), 0.276	Not Included #
Dietary Intake		
Energy (kcal)	1.00 (1.00,1.00), **0.035**	1.00 (0.99,1.00), **0.039**
Total fat (%)	1.01 (0.99,1.03), 0.293	0.99 (0.96,1.03), 0.720

* Calculated based on food source for 5 main meals in a day
# p-value >0.25 in the univariate analysis

4.2.4 Association between overweight and obesity with physical fitness

4.2.4.1 Univariate analysis

Table 4.32 presents the results for the association between anthropometric measurements and body compositions with physical fitness performances overall (a), males (b), and females (c). BMI, BF%, FM, and muscle mass were significantly associated with physical fitness performance in overall and among males, but not among females. In the overall results, those who failed physical fitness tests had significantly higher mean BMI, BF%, FM, and muscle mass. Among the overweight and obese personnel, more than half (56%) failed the fitness test, compared to only 42% failed among the normal weight personnel. BF% also showed a similar association. WC was not associated with physical fitness performance. Results for males mimicked the overall results. However, among females, anthropometric measurements and body compositions were associated with physical fitness.

Table 4.32: Association between anthropometric measurements and body compositions with physical fitness

(a) Overall (n=622)

	Total (n = 622)	Passed (n = 321)	Failed (n = 301)	p
		mean (SD)		
BMI (kg/m^2)	24.69 (3.56)	24.22 (3.62)	25.20 (3.51)	**0.001**
WC (cm)	79.93 (9.10)	79.53 (9.19)	80.36 (8.99)	0.257
Body Fat (%)	23.51(7.91)	22.67 (8.12)	24.41 (7.58)	**0.006**
Fat mass (kg)	16.40 (6.96)	15.52 (7.13)	17.32 (6.66)	**0.001**
Muscle mass (%)	72.23 (8.16)	72.82 (8.84)	71.62 (7.32)	0.066
Muscle mass (kg)	48.97 (7.81)	48.19 (7.33)	49.82 (8.21)	**0.009**
		n (%)		
BMI (kg/m^2)				
Normal	338 (54.3)	195 (57.7)	143 (42.3)	**0.001**
Overweight & Obese	284 (45.7)	126 (44.4)	158 (55.6)	
WC (cm) – WHO				
Low risk [a]	532 (85.5)	274 (51.5)	258 (48.5)	0.526
Increased risk [b]	64 (10.3)	31 (48.4)	33 (51.6)	
Substantial risk [c]	26 (4.2)	16 (61.5)	10 (38.5)	
WC (cm) – CPG				
Low risk [d]	484 (77.8)	254 (52.5)	230 (47.5)	0.415
High risk [e]	138(22.2)	67 (48.6)	71 (51.4)	
Body Fat (%)				
Normal [f]	470 (75.6)	254 (54.0)	216 (46.0)	**0.033**
Obese [g]	152 (24.4)	67 (44.1)	85 (55.9)	

[a] Male: <94.0 cm; Female: <80.0 cm
[b] Male: 94.0 cm-102 cm; Female: 80.0 cm-88.0 cm
[c] Male: >102 cm; Female: >88.0 cm
[d] Male: <90 cm; Female: <80 cm
[e] Male: ≥90 cm; Female: ≥80 cm
[f] Male: <25%; Female <35%
[g] Male: ≥25%; Female ≥35%

Table 4.32 (Continued)

(b) Males (n = 475)

	Total (n = 475)	Passed (n = 247)	Failed (n = 228)	p
		mean (SD)		
BMI (kg/m^2)	24.74 (3.51)	24.17 (3.51)	25.35 (3.42)	**<0.001**
WC (cm)	80.94 (9.17)	80.37 (9.03)	81.56 (9.31)	0.155
Body Fat (%)	20.54 (5.71)	19.65 (5.83)	21.50 (5.42)	**<0.001**
Fat mass (kg)	14.93 (6.09)	13.88 (5.96)	16.06 (6.03)	**<0.001**
Muscle mass (%)	75.19 (6.06)	75.93 (6.67)	74.39 (5.21)	**0.005**
Muscle mass (kg)	52.16 (5.56)	50.99 (5.27)	53.43 (5.59)	**<0.001**
		n (%)		
BMI (kg/m^2)				
Normal	250 (52.6)	149 (59.6)	101 (40.4)	**<0.001**
Overweight & Obese	225 (47.4)	98 (43.6)	127 (56.4)	
WC (cm) – WHO				
Low risk [a]	436 (91.8)	228 (52.3)	208 (47.7)	0.908
Increased risk [b]	29 (6.1)	14 (48.3)	15 (51.7)	
Substantial risk [c]	10 (2.1)	5 (50.0)	5 (50.0)	
WC (cm) – CPG				
Low risk [d]	388 (81.7)	208 (53.6)	180 (46.4)	0.138
High risk [e]	87 (18.3)	39 (44.8)	48 (55.2)	
Body Fat (%)				
Normal [f]	371 (78.1)	202 (54.4)	169 (45.6)	**0.044**
Obese [g]	104 (21.9)	45 (43.3)	59 (56.7)	

[a] <94.0 cm
[b] 94.0 cm-102 cm
[c] >102 cm
[d] <90 cm
[e] ≥90 cm
[f] <25%
[g] ≥25%

Table 4.32 (Continued)

(c) Females (n = 147)

	Total (n = 147)	Passed (n = 74)	Failed (n = 73)	p
	mean (SD)			
BMI (kg/m^2)	24.55 (3.85)	24.38 (3.97)	24.72 (3.75)	0.600
WC (cm)	76.67 (8.06)	76.73 (9.24)	76.58 (6.71)	0. 914
Body Fat (%)	33.10 (6.21)	32.75 (6.39)	33.47 (6.04)	0.482
Fat mass (kg)	21.15 (7.49)	21.02 (7.97)	21.29 (7.03)	0.822
Muscle mass (%)	62.70 (6.61)	62.43 (7.12)	62.96 (6.08)	0.630
Muscle mass (kg)	38.67 (4.37)	38.81 (5.13)	38.53 (3.46)	0.697
	n (%)			
BMI (kg/m^2)				
Normal	88 (59.9)	46 (52.3)	42 (47.7)	0.567
Overweight & Obese	59 (40.1)	28 (47.5)	31 (52.5)	
WC (cm) – WHO				
Low risk [a]	96 (65.3)	46 (47.9)	50 (52.1)	0.908
Increased risk [b]	35 (23.8)	17 (48.6)	18 51.4)	
Substantial risk [c]	16 (10.9)	11 (68.8)	5 (31.3)	
WC (cm)– CPG				
Low risk [d]	96 (65.3)	46 (47.9)	50 (52.1)	0.420
High risk [e]	51 (34.7)	28 (54.9)	23 (45.1)	
Body Fat (%)				
Normal [f]	99 (67.3)	52 (52.5)	47 (47.5)	0.447
Obese [g]	48 (32.7)	22 (45.8)	26 (54.2)	

[a] <80.0 cm
[b] 80.0 cm-88.0 cm
[c] >88.0 cm
[d] <80 cm
[e] ≥80 cm
[f] <35%
[g] ≥35%

4.2.4.2 Multivariate analysis

BMI was used as a proxy of adiposity in the Multivariate Logistic Regression analysis (Table 4.33). Both overweight and obese personnel showed higher odds of failing the fitness test compare to the underweight and normal weight personnel, even after adjusting for multiple confounders. Crude OR (95% CI) was 1.57 (1.07,2.31) and 2.12 (1.04,4.33) for overweight and obesity respectively. The OR (95% CI) of overweight personnel failing the fitness test was 1.60 (1.07,2.39) and remained significant even after adjusting for socio-demographics (age, gender, marital status), occupational (rank), and lifestyle factors (physical activity, smoking, and diet). On the contrary, the odds of obese personnel failing the fitness were not significant after adjusting for socio-demographics and occupational factors. However, these odds became significant after addition of lifestyle factors into the model. Compared to the normal weight participants, the OR (95% CI) of failing the fitness test among the obese personnel was 2.11 (1.01,4.43).

Table 4.33: Crude and adjusted odd ratio (OR) of physical fitness

BMI	Crude OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)
Normal [a]	1.0	1.0	1.0
Overweight	1.57 (1.07, 2.31)*	1.59 (1.07, 2.37)*	1.60 (1.07, 2.39) *
Obese	2.12 (1.04, 4.33) *	2.05 (0.99, 4.27)	2.11 (1.01, 4.43) *
p value	**0.018**	0.065	**0.024**

* $p < 0.05$
[a] 'Underweight' was combined with 'Normal' weight due to its small number (n = 14)
Model 1: Adjusted for age, gender, marital status and rank
Model 2: Adjusted for age, gender, marital status, rank, physical activity, smoking and diet

4.3 Summary of Chapter 4

Phase 1 revealed that the trend and incidence of overweight and obesity were increasing steadily from 1990 to 2015. The increment was also observed as the duration of service increased. In 2015, the prevalence of overweight in the Malaysian Army had exceeded the national prevalence.

Younger personnel (<30 years old), who were still new in the service (<5 years), married and with secondary education had a significantly shorter median survival time to reach overweight and obesity compared to their counterparts. However, in the multivariate Cox Regression analysis, only marital status, duration of service, and rank remained the significant predictors of overweight and obesity. Overweight and obesity were both significantly associated with sickness absenteeism even after adjusting for multiple confounders.

In Phase 2, increasing duration of service was positively associated with overweight and obesity. None of the lifestyle factors was significantly associated with overweight and obesity. Overweight and obesity also had a negative implication on physical fitness among military personnel.

CHAPTER 5: DISCUSSIONS

In this chapter, the discussions are divided into two main sections. The first part discusses findings from the Phase 1 retrospective cohort study, focussing on the trend of overweight and obesity and its implication on sickness absenteeism. The second section discusses the findings from Phase 2 cross-sectional study, mainly on the prevalence and factors associated with overweight and obesity and the implication of overweight and obesity on physical fitness. Limitations and strengths of the study are also discussed.

5.1 Phase 1

Obesity in the Malaysian Army is a serious issue affecting all levels of personnel and the organisation as a whole. Measures taken to handle this issue include implementing a BMI cut-off point of 27.0 kg/m^2 for any administrative enforcement including promotion, attending career courses, overseas deployment, and extension of service. This 'screening and termination' processes are going on throughout their entire services. The effects are mostly felt towards the second half of their career when they need to apply for an extension of service. As a result, after 10 to 15 years of service, most of the personnel with BMI more than 27.0 kg/m^2 were terminated from the service, leaving behind those with 'normal' BMI. This process has somehow affected the trend of BMI and the proportion of overweight and obesity throughout the service.

5.1.1 Socio-demographic and occupational characteristics

Phase 1 employed universal sampling from the states of Malacca and Negeri Sembilan, with large sample size totalling up to 2275 personnel. The majority (82.7%) of the personnel were males, which is similar to the military organisations in other countries such as the US and the UK (Hruby et al., 2015; Stevelink & Fear, 2016). The overall mean age was around 30 years. Males had higher mean age because they tend to stay longer in the service until the compulsory retirement age of 45 to 55 years. On the contrary, females were more likely to choose earlier voluntary retirement after 15 or 18 years of service. However, there were no differences in the proportion of those aged below and above 30 years old between males and females.

Malays (84%) dominated this sample. This is consistent with the higher proportion of Malays in the general Malaysian population (IPH, 2015) and smaller intake of Non-Malays into the service (Berita Harian, 2015, 2017). There was a significantly higher proportion of non-Malay males, who were mostly from East Malaysia (Sabah and Sarawak). Females attained higher education level, with almost all having completed at least high school compared to only 70% of the males. The higher percentage of married females was mostly due to their tendency to settle down earlier once they had joined the service. Overall, the composition of ethnicity, age and education level were similar to another study conducted in the Malaysian Army (Nadiy, Razalee, Zalifah, & Zulkeffeli, 2013).

Mean duration of service was around 10 years. Since the duration of service is highly correlated with age, males had a higher mean duration of service compared to females for the same reason. Junior rank personnel dominated the study population, followed by the senior rank and officers. This was consistent with the pyramidal military workforce, with officers leading the organisation, while the senior ranks supervise the ground workforce of the junior rank personnel.

5.1.2 BMI Classification

The overall prevalence of overweight and obesity in Phase 1 was 36.3% and 8.0% respectively. Except for the United Kingdom Armed Forces (Fear et al., 2011), these figures were higher compared to the Armed Forces from other nations such as the US Army (Hruby et al., 2015), the Greek Army (Mazokopakis et al., 2004) and the Royal Thai Army (Napradit et al., 2007). Although not significant, the prevalence of overweight in males was higher, but their prevalence of obesity was lower compared to females in the Malaysian Army. Most other studies among military populations have shown that prevalence of both overweight and obesity was higher in males (Bae et al., 2011; Eilerman et al., 2014; Fajfrová et al., 2016; Sanderson et al., 2014; Smith et al., 2014). This could be due to higher lean muscle mass in males, acquired through their training and involvement in more physical work compared to females (Wroblewski, Amati, Smiley, Goodpaster, & Wright, 2011).

Compared to the general Malaysian population, the prevalence of overweight in the Malaysian Army was higher, but the prevalence of obesity was lower (IPH, 2015). This again could be explained by the Malaysian Armed Forces policy to accommodate personnel with BMI between 25 to 27 kg/m^2 in the service and terminate those beyond that. The higher prevalence of overweight could have also been contributed by higher muscle mass percentage, especially among males. Due to the nature and demands of military tasks, those with BMI between 25 to 27 kg/m^2 with a higher lean muscle mass may have strength and endurance advantages over normal and underweight counterparts (Friedl, 2012).

The proportion of normal weight was inversely related while the proportion of overweight was directly proportionate to the duration of service. More than half of those who had served for fifteen years and above were overweight. The proportion of obese personnel has doubled between those who had served between 5 to 10 years and between 10 to 15 years. However, it has dropped among those who had served for fifteen years and above. The reduction in the proportion of obesity might have been the result of the termination of personnel with BMI $\geq$27 kg/m^2 during their extension of service at fifteen years. Meanwhile, the high proportion of overweight in those who had served for fifteen years and above could have been due to the high number of personnel with BMI of 25 kg/m^2 to 27kg/m^2. It was also possible that those who had exceeded the BMI cut-off, but not obese, still in the service before their next extension of service at 18 or 21 years. These findings were consistent with a study in the US Army (Hruby et al., 2017) and the Czech Army (Fajfrová et al., 2016), although these studies used age as a time factors instead of the duration of service. The prevalence of overweight and obesity increased as age increased, peaking at 30 years and decreasing after that. If the personnel joined the military at the age of 18 to 20 years, they would have been 33 to 35 years after fifteen years in the service.

5.1.3 Trend in Overweight and obesity

5.1.3.1 Trend in mean BMI

Although there was a downward trend in the mean BMI between 1990 and 1995, it has increased steadily after that until 2015. The increment was faster in the last 10 years. It is possible that the increase in the mean BMI was related to the increase in duration of the service. However, the mean duration of service between 1990 and 2015 was below 10 years, which mean that the participants were still in the early years of their service. The mean BMI in the Malaysian Army was lower compared to other countries such as the Czech Army (Fajfrová et al., 2016), the Korean Army (Bae et al., 2011), the US Navy (Gregg & Jankosky, 2012), the UK Armed Forces (Fear et al., 2011; Sundin et al., 2011), and the Saudi Arabian Army (Horaib et al., 2013). However, the increase in mean BMI was higher compared to both the Czech Army and the Korean Army. Comparison with other countries in terms of the increment of mean BMI was not possible due to limited data.

5.1.3.2 Trend in prevalence of overweight and obesity

The trend in overweight and obesity increased steadily from the initial recruitment into the service, peaked at 10 to 15 years before decreasing after that. The patterns were similar overall, males and females. One possible explanation for this is that the nature of the job and the environment were different from the recruitment process and the actual placement after the training, especially for the non-combatant personnel. Tendencies to put on weight were higher after an intensive and short strenuous physical training, such as in the military recruitment. Although their daily routines still include physical exercise, the intensities were much less since now they are assigned to other tasks or duties in their unit. In the long run, the personnel could become complacent with the environment. The amount and intensity of their routine physical training were reduced to 'as needed' while other obligations take precedence.

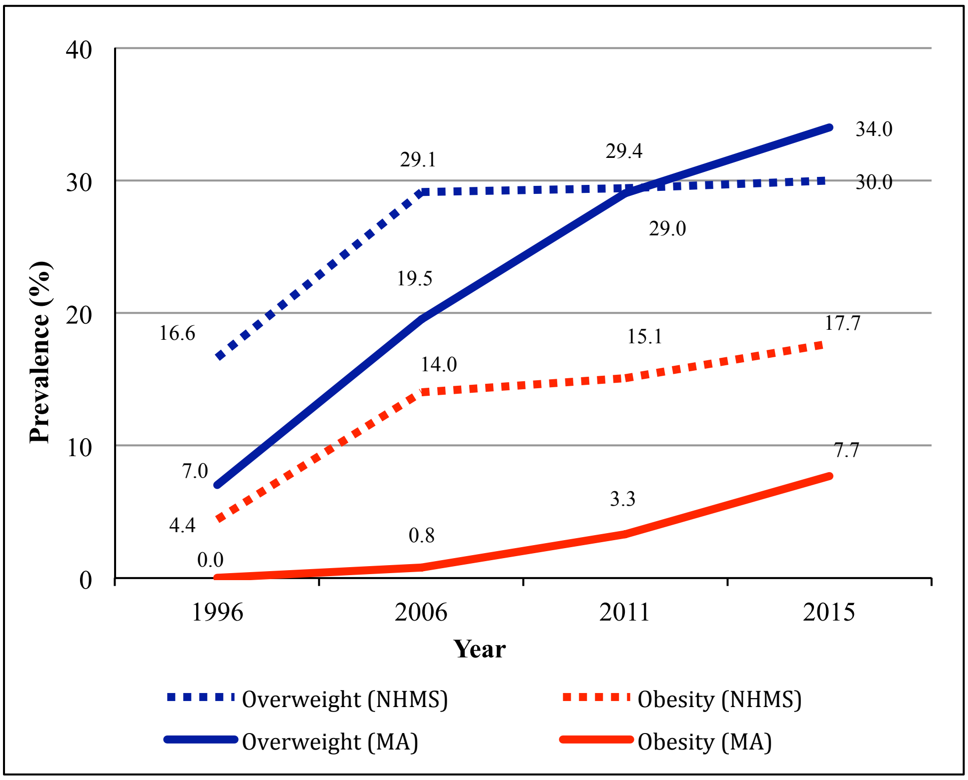
As the year goes by, the personnel will gain ranks and enjoy a more stable job and better income. However, the hectic working environment will take most of their time. These combinations will eventually lead them to a less healthy lifestyle such as neglecting their physical activities and resorting to more convenient fast food consumptions (Seibert, 2009). The military population, in general, are accustomed to strenuous physical activities. There are checked and measures throughout their service to ensure they are physically and mentally fit for the demanding task. Unfortunately, awareness of the proper dietary intake is almost non-existence let alone restriction or enforcement on it. The unhealthy dietary intake might have cancelled out the physical activity and contributed to the rise of overweight and obesity especially during the first 10 years of their career.

After 10 to 15 years of service, the proportion of overweight and obesity dropped significantly due to the 'screening and termination' processed that discontinued most of the personnel with BMI more than 27 kg/m^2. Another factor that could have contributed to this declining trend was the reduction in the lean muscle mass as age increased (Keller & Engelhardt, 2013; Siparsky, Kirkendall, & Garrett, 2014). The decline was more evidenced among the females, which decreased from 50.6% at 10 to 15 years to 8.3% after fifteen years of service. The downward trend may have been due to some of the female personnel choosing not to continue after completing their compulsory terms of service. Meanwhile, the decline among the males and overall was less from around 40% to 25%.

Although there was a decline in the proportion of overweight and obesity, the fact that one in every four personnel is either overweight or obese and remains in the service is alarming. Some personnel manipulated the system by working hard to achieve BMI of less than 27 kg/m^2 for the sake of continuation of service, just before the term of service expired. Unfortunately, some went back to the overweight and obese status soon after the approval. This phenomenon is also consistent with the Theory of Planned Behaviour where one's action and motivation for behavioural changes is influenced by attitude and anticipated rewards (Chung & Fong, 2015). Studies also have shown that weight regain after weight loss is common (Blomain, Dirhan, Valentino, Kim, & Waldman, 2013) and maintaining weight loss is difficult because of multiple factors can affect weight change (Evert & Franz, 2017). The duration of three years before the next service extension is long enough for some personnel to stay in the service without any administrative punishment enforced upon them even though they have exceeded the BMI cut-off limit.

Prevalence of overweight and obesity in the Malaysian Army has been rising since the mid-1990s. There has been more than fourfold increase in the prevalence of overweight over 20 years from 7% in 1996 to 34% in 2015 (Figure 5.1). This value has surpassed the Malaysian NHMS of 30% in 2015 (IPH, 2015). While the prevalence of overweight in the general population seemed to be plateaued at around 30%, the trends in the Malaysian Army show no signs of slowing down. A similar trend was observed in the trend of obesity prevalence, although the Malaysian Army is far from overtaking the general Malaysian population. The increase in the prevalence of overweight between 1996 and 2015 was much higher in the Malaysian Army compared to the general Malaysian population.

The higher prevalence of overweight in the Malaysian Army could be due to the higher proportion of personnel with high muscle mass especially the males, as shown in Table 4.12 earlier. Whereas, it is quite difficult to explain the higher increment in the prevalence of obesity in the Malaysia Army compared to the general population.



MA – Malaysian Army
NHMS – National Health and Morbidity Survey

Figure 5.1: Prevalence of overweight and obesity in the Malaysian Army and the general Malaysian population

Similarly, militaries from other parts of the world are facing the dilemma of increasing prevalence of overweight and obesity. These include the Korean Army and the US Armed Forces, which showed the highest increment of overweight and obesity respectively over their studied period (Bae et al., 2011; Reyes-Guzman et al., 2015). The increase in the prevalence of overweight and obesity in the Malaysian Army were comparable to those in the Korean Army (Bae et al., 2011). However, compared to the Czech Army and the US Armed Forces, the increases in the prevalence of overweight in the Malaysian Army were higher (Fajfrová et al., 2016; Reyes-Guzman et al., 2015). Published studies on overweight and obesity in the military population, especially from Asian countries, are still lacking. Thus limited data were available for comparison.

5.1.4 Predictors of overweight and obesity

Obesity is a multi-factorial phenomenon. Therefore, it is challenging to pinpoint to just a few factors or determine which one is more important than the others. This study focussed on the socio-demographic and occupational predictors of overweight and obesity in Phase 1. Phase 2 complimented this by adding on modifiable lifestyle factors such as physical activity, dietary habit and intake, and smoking.

Overall, more than half (55.8%) of the personnel were able to maintain their BMI within the normal range (<25 kg/m^2) throughout their service. Meanwhile, 36.3% and 8.0% have reached the overweight and obese status respectively at least once in their military career. This is considered as a high proportion as far as the military is concerned, and could be due to the 'interval' requirement (for promotion and extension of service) rather than 'persistent' enforcement yearly if not twice a year.

Median survival time for age, duration of service and rank were directly proportionate to time. The senior personnel with a longer duration of service must have gone through the 'elimination process' leaving behind those with BMI <27 kg/m^2. Thus, these groups, having maintained their BMI were unlikely to reach the overweight and obese status, therefore had a higher median survival time. The same principle applied to the senior ranks. They must have served at least 10 years and maintained their BMI to achieve the senior rank level. Another significant predictor was the education level and marital status. Those who had not completed their secondary school (lower secondary) had a higher median survival time. These groups were mostly from the junior rank, which again relates to lower age and duration of service. Married personnel had a shorter median survival time compared to the unmarried personnel. One plausible explanation for that could be the married personnel were allowed to stay outside the camp area, whether in military quarters or rental accommodation. This privilege gave them easy access to local eateries including fast food outlets, which operate until late hours. This indirectly exposed them to a higher risk of becoming overweight and obese (Burgoine, Forouhi, Griffin, Wareham, & Monsivais, 2014). Bachelors are required to stay in the barracks inside the camp with curfews enforced upon them. The meals are provided (although not controlled in terms of nutritional values) within a stipulated time. Strict SOP for getting in and out of the camp somewhat acts as a hindrance for them to leave the camp without any real purpose. Unfortunately, to the researcher's best knowledge, there have been no studies thus far comparing the dietary intake between these two groups as factors of overweight and obesity. Gender and ethnicity showed no differences in the median survival time.

Multivariate Cox regression analysis for the predictors of overweight and obesity concurred with the Kaplan-Meier survival analysis findings. Those who were older, served longer and in the senior rank groups had a lower hazard ratio of developing overweight and obesity due to their 'selected nature'. Most of those who still remained in the service had a BMI of $<27kg/m^2$. The significant predictors of overweight and obesity found in this study were time-related and affected by the 'screening and termination' process after 10 to 15 years of service.

5.1.5 Implication of overweight and obesity on sickness absenteeism and presenteeism

Sickness absenteeism and presenteeism affect productivity at the workplace (Schultz & Edington, 2007). In the military setting, teamwork, regular attendance, and being at their best physically and mentally are crucial in their daily routine. Sickness absenteeism and presenteeism, therefore, directly affects not just the personnel performance, but the productivity and efficiency of the whole troop (Kyrolainen et al., 2008).

This study evaluated the implication of overweight and obesity on sickness absenteeism and presenteeism in the Malaysian Army. Overweight and obese personnel were found to have higher median sickness absenteeism and presenteeism. Even after adjusting for gender, age, marital status, educational level, ethnicity and rank, overweight and obesity remained significantly associated with both sickness absenteeism and presenteeism. These findings were consistent with a couple of other studies in the military setting. Overweight and obese Finnish soldiers were more likely to take more and longer sick leaves compared to their normal weight counterpart (Kyrolainen et al., 2008). Among the US Active Duty personnel, it was estimated that more than USD100 million loss in productivity was attributed to sickness absenteeism and presenteeism linked to overweight and obesity (Dall et al., 2007).

In occupational groups other than military, such as the healthcare workers and the general employees, there is voluminous evidence supporting the association between BMI and sickness absenteeism and presenteeism (Bustillos et al., 2015; Christensen et al., 2015; Kleinman, Abouzaid, Andersen, Wang, & Powers, 2014).

With regards to the Malaysian Army in particulars, factors such as accessibility and availability of the military healthcare facilities could have contributed to the high number of sick reports. The Armed Forces hospitals and the Army sickbays are located in the close vicinity to the units and services are available 24 hours free of charge. These facilities were meant for the wellbeing of the personnel and their families and could have somehow been taken advantage of. The only gatekeeper for the sick report procedures was clearance from the unit's officer or the senior rank in-charge for the personnel to go and see the doctor. The nature of the sick report could also influence the number of sick leaves and excuses given to the personnel. Musculoskeletal injuries and follow-up for NCDs could have made up the majority of the sickness absenteeism and presenteeism (Owens et al., 2013; Prater & Smith, 2011).

5.2 Phase 2

5.2.1 Descriptive results

5.2.1.1 Socio-demographic and occupational characteristics

Due to the constraints from constant deployments, high turnover rate, and hectic working environment, convenient sampling was employed in Phase 2. There were higher proportions of younger (<30 years old) and female personnel who participated in Phase 2 compared to those who did not participate. These could be due to the lower rank or younger personnel with fewer job responsibilities are easily mobilised to participate in the study compared to the senior ranks or officers. Females were mostly stationed at desk jobs with less frequent deployment, thus easier for them to take part in the study. Other socio-demographic and occupational characteristics were comparable between the participants and non-participants in Phase 2.

Participants in Phase 2 showed similar socio-demographic and occupational characteristics with participants in Phase 1 with majority being males, Malays, had at least completed secondary education, married, and junior rank. However, there was a higher proportion of personnel aged less than 30 years, females, Malays, had completed secondary education, serving less than 10 years, junior ranks and senior ranks who participated in Phase 2. The use of convenient sampling in Phase 2 could have introduced selection bias in the study (Etikan, 2016). Studies have shown that females (Barber et al., 2009), educated, and younger individual (Paasche-Orlow, Parker, Gazmararian, Nielsen-Bohlman, & Rudd, 2005; Sorensen et al., 2015) scored higher in the health literacy index. Thus, they were more health conscious and informed, and more likely to participate in a study. Younger individuals were also more information technology (IT) savvy and hence have easier access to health information on the Internet, which could influence their interest in health matters (Gray, Klein, Noyce, Sesselberg, & Cantrill, 2005; Ishikawa, Nomura, Sato, & Yano, 2008). Although convenient sampling might introduce 'healthy worker effect', the results were analysed, adjusted for socio-demographic and occupational factors, and interpreted accordingly.

Phase 2 also acquired additional data on the socio-economic background. Around 30% of the participants lived on a single income, and 70% had a household income of less than RM3000. More than 80% of them had at least one child. These socio-economic profiles could have influenced their dietary habits and choice of food.

5.2.1.2 Anthropometric measurements and body compositions

(a) Body Mass Index

The combined overweight and obesity prevalence was 47.2%, of which 37.2% were overweight, and 10% were obese. Although these figures were slightly higher compared to Phase 1 with 36.3% (overweight) and 8% (obesity), the difference was not significant (p=0.116). The discrepancies may have been the result of convenient sampling used in Phase 2. Since this study was briefed as a study on obesity and health, individuals who were health conscious were more likely to participate, with a reward of free health screening. It may be that commanders had ordered personnel with excess body weight to participate in this study and gain benefit from it. As discussed earlier, the combined prevalence of overweight and obesity in the Malaysian Army was higher compared to the other countries such as the US Army, the Greek Army, and the Royal Thai Army (Hruby et al., 2016; Mazokopakis et al., 2004; Napradit et al., 2007).

Compared to the general Malaysian population (IPH, 2015), the prevalence of overweight in Phase 2 was higher, but the prevalence of obesity was lower. The BMI cut-off of 27 kg/m^2 policy in the Malaysian Armed Forces could have created an opportunity for personnel with BMI 25 to 27 kg/m^2 to stay in the service. Although the overall prevalence of overweight was higher, majority of the overweight male personnel had a normal BF%. Thus overweight in these groups could have been contributed by the higher lean muscle mass (Friedl, 2012). However, having 10% of obese personnel in the service is still considered a significant proportion of any military organisation. With all the obesity-related health problems, injuries and productivity issues (Guh et al., 2009; Kouvonen et al., 2013; Vignoli et al., 2016), obesity will reduce the efficiency of the total workforce and add burden to their colleagues (Gattis, 2011).

(b) Waist Circumference

The prevalence of central obesity was 5.7% and 24.6% according to the WHO and the Malaysian CPG classifications of WC measurement respectively. The prevalence was higher among females compared to males for both classifications. Compared to the general Malaysian population, the prevalence of central obesity overall, males and females in this study were four times lower according to the WHO classification and two times lower based on the Malaysian CPG guidelines (IPH, 2015). Studies in the UK Army and the US Active Duty personnel showed that the prevalence of central obesity in male soldiers was 10.4% and 51.4% respectively (Heinrich et al., 2008; Rona et al., 2011). This discrepancy could have been due to the different measurement protocols used in both studies (Freedman & Ford, 2015). Heinrich et al. also found that the prevalence of central obesity in males was higher compared to females. However, this study measured the WC at the umbilicus for men and the iliac crest for women as opposed to more commonly used protocol at the mid-way between the lowest rib and the iliac crest (WHO, 2011).

(c) Body compositions

The prevalence of obesity based on the BF% classification was higher in females (31.7%) compared to males (19.5%). There was no nationally representative data for comparison since the Malaysian NHMS did not include body composition analysis in the survey. Several studies have described the prevalence of obesity using BF% in sub-populations of Malaysian such as; high prevalence (72.8%) of obesity among the female older adult aged 40-60 years old (Johari et al., 2017; Su et al., 2015), lower BF% (15.7%) among the male athletes (Daud, Muda, & Abdullah, 2009), and significantly higher BF% among girls (31.7%) compared to boys (17.1%) (Teo, Nurul-Fadhilah, Aziz, Hills, & Foo, 2014). This highlighted the scarcity of research on obesity in Malaysia using BF% and none were in the Malaysian Army. The different population characteristics make these results non-comparable.

Likewise, comparison with studies in the military setting has to be interpreted cautiously because of the sample selection, different BF% cut-off and parameters used in each study. Sedek et al. presented the mean BF% in the male Malaysian Navy personnel, which was comparable to the mean BF% in current study (Sedek et al., 2010). Another study in the Malaysian Army reported a lower mean BF% (Yusuf, Noor, A.Karim, & Yahaya, 2012). However, their study only sampled fit and healthy male personnel who had passed the Military Fitness Test. Studies in the Belgian and Finnish Army also reported lower obesity prevalence since the sample was from their conscripts enrolling for military service (Mikkola, 2011; Mullie et al., 2008). The Belgian Army also used a lower BF% of 21% as the cut-off. A couple of other studies among the US Active Duty personnel and the US Navy revealed a higher prevalence of obesity due to the inclusion of only overweight and obese participants (Heinrich et al., 2008), and ex-service members aged more than 60 years (Gasier, Hughes, Young, & Richardson, 2015).

Overall, 50% of the participants had normal BMI and normal BF%. The disagreement between BMI and BF% mostly occurred in BMI-overweight participants. Around a quarter of males who were BMI-overweight had normal BF%, while a quarter of females who were BMI-overweight had excess BF%. Although the sensitivity of BMI in classifying overweight was good, its specificity and PPV were not, especially among male participants. Low specificity among males implied that there is a higher chance of BMI-normal participants to have excess BF%. Meanwhile, low PPV among males indicated that if a given participant were BMI-overweight, there is high chance that he may have normal BF%. On the other hand, females had a specificity and PPV above 80%. In terms of obesity, the sensitivity, specificity, PPV and NPV were above 90% overall, males and females.

Analyses among the overweight participants showed that 85% of males who were overweight with BMI between 25 and 26.9 kg/m2 had normal BF%. Meanwhile, 62% of females in the same BMI category had excess body fat. In other words, if BMI 27 kg/m^2 were to be used a cut-off point, 15% of the males and 62% of the females were obese by BF% classification. Thus, a gender-specific BMI limit, with a lower cut-off for the females is more appropriate to classify overweight and obesity especially in the military population (Friedl, 2012; Lennon et al., 2015).

The discrepancies between BMI and BF% in defining obesity were also described in other studies (Collins et al., 2017; Habib, 2013). Individual with normal BMI but excess body fat is also known as 'Thin-on-Outside Fat-on-Inside' or TOFI. They are at higher risk of metabolic diseases (Thomas, Frost, Taylor-Robinson, & Bell, 2012; Thomas, Parkinson, et al., 2012). However, the military is also concerned about the 'Fat-on-Outside Thin-on-Inside' or FOTI personnel. These individuals were not only at risk of cardiometabolic diseases (Chaldakov et al., 2012) but also more likely to be discriminated in their career based on their excess BMI (Friedl, 2004). Overweight personnel with higher lean muscle mass has an advantage in performing heavy physical work such as load carrying (Naghii, 2006). Thus, relying on BMI alone in defining obesity in the military population may be a disadvantage to otherwise a good soldier.

5.2.1.3 Smoking

The overall prevalence of smoking in this study was 51%. Compared to the military in other countries, the prevalence of smoking in the Malaysian Army was at par with the Royal Thai Army at 50% (Pantaewan et al., 2012). However, it is much higher compared to the US Army (Bray et al., 2010; Ornelas, Benne, & Rosenkranz, 2012) and the US Navy (Macera et al., 2011) as well as the militaries form the European countries such as the French Army (Marimoutou et al., 2010), the Greek Navy (Mazokopakis, Vlachonikolis, & Lionis, 2003), the Italian soldiers (Nicola et al., 2006), the Polish (Jedrzejko) and the UK Armed Forces (Fear et al., 2010). A study of Royal Malaysian Navy trainees revealed a higher prevalence at 68% (Sedek, Koon, & Noor, 2012). However, the comparison in the prevalence of smoking between studies has to take into account the unstandardized definition and methods in classifying smoking status (Jamal et al., 2015).

The prevalence of smoking in this study is more than doubled compared to the general Malaysian population (23%) (IPH, 2015; WHO, 2017d). Similarly, all the studies cited above reported higher prevalence of smoking compared to their respective general population, except for the UK Armed Forces. The smoking prevalence for the US population was obtained from the Centers for Disease Prevention and Control (CDC) report on smoking and tobacco use (CDC, 2017), while the prevalence for the European countries were extracted from a study on smoking in 27 European Union members (Bogdanovica, Godfrey, McNeill, & Britton, 2011). The prevalence of smoking in the UK Armed Forces and the general UK population were both around 30% (Bogdanovica et al., 2011; Fear et al., 2010). The higher prevalence of smoking in the military population could be contributed by the readily available and at a discounted rate for the military personnel (Fear et al., 2010). Besides, smoking in the military is used to a certain extent as a stress reliever from a hard day at work, or even during stressful tasks (Larson, Wooten, Adams, & Merrick, 2012; Smith et al., 2008). In the Malaysian Army, smoking ban was limited to mostly healthcare facilities and training institutes only but not in the workplace. Although smoking ban during training has been shown to deter smoking initiation or encourage quitting (Talcott et al., 2015), they only spent minimal amount of time throughout their career in training centre.

5.2.1.4 Physical activity

The total activity for the overall, males and females exceeded 3000 METs-minute/week, which were considered as ‘high’ level of physical activity. Overall, 75% of the total participants, 80% of males and 66% of females, had achieved high level of total physical activity. These were higher than the general Malaysian population with 67%, 71% and 62% for the total, males and females, respectively (IPH, 2015).

Compared to females, males had a higher level of physical activity at work, during leisure time as well as vigorous physical activity. The gender differences in the work-related and leisure time physical activity (LTPA) were consistent with another study conducted in six countries from the WHO Asia Pacific region, including Malaysia (Bauman et al., 2011). The level of occupational activity was higher in the Malaysian Army, but the level of LTPA was lower compared to the general Malaysian population. The proportion of personnel with high level of LTPA in the Malaysian Army was also lower compared to the US Active Duty Army and the Korean Army (Bae et al., 2011; Smith et al., 2013). In terms of intensity, around 30% of the participants had achieved high level of vigorous and moderate intensity. However, only 5% had attained this level in the walking category. This was much lower compared to the 33% of Belgian Armed Forces who had reached the high level of vigorous, moderate and walking category

(Collee et al., 2014). This indicates that the Malaysian Army preferred to use the motorised vehicle to move around, even for close distances.

Despite the lower level of LTPA, almost all of the participants in this study were able to meet the level of physical activity recommended by the WHO (WHO, 2017a). On the contrary, only 57% of the US Active Duty Army had achieved the recommendation by the American College of Sports Medicine (ACSM) and American Heart Association (AHA) (Haskell et al., 2007; Smith et al., 2013). Although the WHO recommendation of 150 minutes of moderate activity in a week is slightly difference from 30 minutes a day for five days used by the ACSM and AHA, study has shown that there were no differences in the outcome of physical activity between groups given this two different advice (Murtagha et al., 2016).

5.2.1.5 Dietary habits and intake

Participants who took part in the 24-hour dietary recall were younger, had a shorter duration of service, and had at least completed high school. Younger and educated individual were more health literate and informed through the Internet (Barber et al., 2009; Ishikawa et al., 2008), thus were more likely to participate in the study.

Males were more likely to have their breakfast and lunch at home, while females tended to skip or have these two meals from outside sources. These could be influenced by the fact that more males had a non-working spouse and fewer children compared to females. On the other hand, working females have to manage their time between career and taking care of the family, and thus have little time to prepare breakfast or lunch. Among the three main meals, breakfast was the most frequently skipped meal. Majority of both males and females did not have their breakfast at home. A study in the US Army also showed that more than 40% had their breakfast, lunch, and dinner at home, and a majority skipped breakfast too (Smith et al., 2013).

Around 75% of the participants consumed fast food at least once a month. Studies in the general Malaysian population showed that 68% of the urban Malaysian community (Abdullah, Mokhtar, Bakar, & Al-Kubaisy, 2015), and 84% of the Malaysian university students (Habib, Dardak, & Zakaria, 2011) consumed fast food at least once a month. Although the prevalence of monthly fast food consumption in the US Army was lower at 50%, one-third of them had fast food on a daily basis (Smith et al., 2013). Studies on fast food consumption among the military population are still limited. Hence, the comparison between countries and with the general population, and its implication in the military perspective are yet to be determined.

The dietary intake of the Malaysian Army from this study was comparable to the Recommended Nutrient Intake (RNI) for Malaysian adults (Noor et al., 2017), except for the lower energy intake among the males and the total fat percentage intake was slightly above the recommended limit (Table 5.1). This may be contributed to by the tendency to under-report food high in energy content (Subar et al., 2015). While the high total percentage fat intake could be due to the high level of oils and fat found in most of Malaysian food (Baker & Friel, 2014). Furthermore, the RNI was designed to prevent chronic diseases, ensure adequate nutritional intake and maintain the energy balance for an average Malaysian adult. Thus, the military should improvise on this recommendation to tailor their specific job, health and fitness requirements. The Malaysian Army should consider reducing the fat intake and increasing the protein intake to ensure lower BF% and higher muscle mass. Energy and carbohydrate intake should be customised accordingly to avoid excess energy intake that could lead to obesity.

Table 5.1: Dietary intake comparison between the Malaysian Army and the RNI for the Malaysian adults

	RNI	Malaysian Army
Energy (kcal)		
Male (18-59 years)	2190-2240	2044
Female (18-59 years)	1840-1900	1872
Carbohydrate (%)	50-65	53.6
Protein (%)	10-15	14.7
Fat (%)	25-30	31.6

5.2.1.6 Physical fitness performance

In the Malaysian Army, physical fitness is assessed twice a year using BMFT, which comprises of 2.4 km run, sit-up, and push-up. Overall, around 50% failed the BMFT, and there were no significant differences between male and female in their overall performance. However, there was a significantly higher proportion of females who failed the sit-up test. This could have been due to the higher prevalence of abdominal obesity among females, and possibly the females' physiological disadvantages in terms of physical fitness (Dagan et al., 2013; Hunter, 2014).

Absolute comparison with other nations was not possible given the different protocols and standards used in testing and classifying physical fitness performance. Even within the US, the protocols used are different between the military branches (Vanderburgh, 2008). Some studies have used comparable protocols used in this study. For example, the Belgian Army and the US Air Force adopted the similar tests, but the scoring system was different (Collee et al., 2014; Wilson, Markey, & Markey, 2012). Around 12% of the Belgian Army failed the fitness test. VO_2max is the most commonly used method to assess physical fitness in many studies. However, there is still no consensus on the cut-off value to define physical fitness. In the Brazilian Military

Firefighter, 47% were classified as unfit, defined as VO_2max of less than 12 METs (Nogueira et al., 2016). Several other studies used a more comprehensive fitness test that incorporates the elements of the BMFT and the VO_2max, as well other tests such as the Wingate aerobic cycling test and various protocol to assess muscular strength (Crawford et al., 2011; Kyrolainen et al., 2008; Yanovich et al., 2008).

Despite the high percentage of personnel failed the BMFT, fitness performance was taken rather lightly and was not considered in the overall evaluation of performance. If the personnel failed the fitness during their promotion evaluation, they might have lower marks for the fitness criteria. Conversely, personnel with BMI >27 kg/m^2 would not even be considered for promotion or any other career perks. Being physically unfit was not viewed as threatening as overweight and obese, especially among the non-combatant troops. Those who had served long enough and achieved a higher rank were less likely to take this test seriously, as it would not affect them as much.

5.2.2 Factors associated with overweight and obesity

Phase 2 incorporated additional modifiable lifestyle factors, i.e., smoking, physical activity and dietary habits and intake as well as socio-demographic and occupational factors to complement Phase 1.

5.2.2.1 Socio-demographic and occupational factors

This study found significant associations between older age (≥30 years), married, household income more than RM3000, longer duration of service and senior rank with being overweight and obese. These factors were consistent with other studies in the US Army (Smith et al., 2012) and the UK Army (Sundín et al., 2011) where advancing age and longer duration of service were also found to be associated with obesity. Being older and longer in the service, with higher rank placed these groups of personnel at a higher order of command in the Army. As they go up the ladder, they have less commitment to groundwork, and their obligations will be more towards administrative and supervisory tasks. Hence, there will be more sedentary work and less physical job for them. Studies have shown that those who work in the administrative line, with less physically demanding job and more sedentary and high sitting hours were more likely to become overweight and obese (Choi et al., 2010; Duncan et al., 2015; Singer et al., 2016). Thus, in the long run, the senior rank personnel will be exposed to a higher risk of becoming overweight and obese.

As mentioned earlier, some of the personnel in these groups have achieved their highest possible rank and BMI does not have any significant consequences for them. On the contrary, those in the lower rank, and mostly served less than 10 years were more involved in the physical tasks at work. As they are moving up their career path, they are more motivated to maintain their BMI to increase their chances for promotion and career courses. The young bachelor military personnel dine in the camp that typically offered more variety of food including fruits and vegetables. Combined with the high basal metabolic rate and energy expenditure, the younger personnel were more likely to maintain their BMI (McDowell & Hubbard, 2013).

Higher socio-economic status correlates with higher purchasing power and has been linked to obesity (Dinsa et al., 2012). Thus, being more affluent and living a hectic lifestyle, especially among married personnel, may push respondents to resort to ‘outside’ and processed food rather than the healthier home-cooked food (Devine et al., 2009; Malik et al., 2013).

5.2.2.2 Smoking

This study found no difference in the odds of being overweight and obese between smokers and non-smokers. The insignificant findings from this study may be caused by a higher prevalence of smoking and narrow spectrum of BMI among the participants. Several other studies among the general population also revealed no differences in the BMI between smokers and non-smokers (Gasperin et al., 2014; Kim et al., 2012).

On the contrary, many studies have shown that nicotine increases energy expenditure and reduces appetite, leading to lower BMI among the smokers (Audrain-McGovern & Benowitz, 2011; Chiole et al., 2008). Although most of these studies concentrated more on the general population, a study in the US Army concurred with these findings where smokers were found to have lower mean BMI compared to non-smokers (Macera et al., 2011). Similarly, the odds of overweight and obesity were lower among the current smokers in the Royal Thai Army compared to the non-smokers (Napradit et al., 2007).

Results from this study showed that smokers who smoked more than 20 cigarettes per day and had been smoking for more than 10 years, and quitters who had quitted for more than 5 years were associated with being overweight and obese. More than half of the heavy smokers and smokers who had smoked for more than 10 years were overweight and obese. Similarly, a study among the general Swiss population showed that heavy smokers had a higher BF% and WC (Clair et al., 2011). Chronic heavy smokers also tend to have unhealthy lifestyles, such as poor dietary intake, physically inactive, and high alcohol consumption, compared to the light to moderate casual smokers (Tuovinen et al., 2016). The occasional moderate smokers also used smoking as a stress reliever or 'rewards' in between heavy physical daily tasks. In light of several proven adverse health consequences of smoking, those chronic and heavy smokers should have their BMI and general health monitored closely.

5.2.2.3 Physical activity

Overall, there were no significant differences in the total level of physical activity between normal weight and overweight and obese personnel. These could be due to the high level of physical activity (more than 5000 METs-minute/week) in both the normal weight group and overweight and obese groups. The only significant finding was that the overweight and obese group had lower vigorous intensity activity compared to the normal weight group. Among males, there were no significant associations between physical activity and overweight and obesity. However, overweight and obese females were found to have a lower level of total physical activity, moderate intensity and physical activity at the workplace. The insignificant association between physical activity and overweight and obesity in the overall results, and among the males suggested that the personnel are physically active regardless of their BMI status. This could be due to the tendency to over-reporting of physical activity in the IPAQ, which is common in research using self-reported questionnaires (van de Mortel, 2008). Another possible reason was the inadequate sample size might not be able to establish any associations between physical activity and overweight and obesity.

However, findings from this study concurred with another study in the US Army which found no association between changes in physical activity and overweight (Lindquist & Bray, 2001). A study in the Korean Army showed that the amount and intensity of physical activity were inversely related to BMI (Bae et al., 2011). This study, however, used a single question to assess the level of physical activity as opposed to the more common IPAQ. Other studies in the Royal Thai Army and Singaporean Army also showed those who reported higher physical activity were less likely to be obese (Napradit et al., 2007; Shi et al., 2014).

More than 90% of the participants, regardless of their BMI status were able to achieve the level of physical activity recommended by the WHO (WHO, 2017a). However, these guidelines were meant for prevention of NCDs and improvement of the general health, but not for weight reduction or maintenance. Thus, overweight and obese personnel are expected to be involved in physical activity more than the suggested level to make an impact on their BMI.

Among the general Malaysian population, lower level of physical activity was found to be associated with overweight and obesity with marginal significance (Chan et al., 2017). Findings from other studies have supported the association between level of physical activity, especially the leisure activity and sitting time with overweight and obesity. Those who reported a lower level of leisure time activity and higher sitting time were more likely to be overweight and obese (Banks et al., 2011; Chau, van der Ploeg, Merom, Chey, & Bauman, 2012; Chu & Moy, 2013). One study has shown that standing burns more calories than sitting (Perry, 2012). In line with this, employees with a 'sitting job', and those who had more than four hours leisure-time sitting were more likely to be overweight and obese (Chau et al., 2012).

In this study, almost all the participants reported either high or moderate physical activity and the results showed no significant association with overweight and obesity. However, the benefits of physical activity in maintaining good overall health and fitness should not be disregarded.

5.2.2.4 Dietary habits and intake

Participants who skipped meals, especially breakfast, and consume more food from outside sources rather than home-cooked meal were more likely to be overweight and obese. This finding concurred with studies among the US Active Duty Army, which showed that those who skipped breakfast and regularly eating out were more likely to put on weight (McDowell & Hubbard, 2013; Smith et al., 2013). Home-cook meals have more variety including fruits and vegetables and less fat, sugar and lower in calories (Cohen & Bhatia, 2012; Wolfson & Bleich, 2015). Regular home-cook meals also reduced the tendency to consume fast food.

This study found no association between frequency of fast food consumption with overweight and obesity. Another study in the US Air Force also found no association between fast food consumption and increase in BMI (Seibert, 2009). The insignificant findings could have been the results of under-reporting given the average consumption was only once a month, or the military personnel were able to maintain their negative energy balance with a higher level of physical activity. However, several studies in the general population have shown that the frequency of fast food consumption was associated with overweight and obesity. (Prince et al., 2012; Rosenheck, 2008; Smith et al., 2009).

In terms of food intake, those who were overweight and obese were found to have a lower energy and carbohydrate intake. It is possible that those overweight and obese were trying to cut down on their calorie intake having a fear of being penalised due to high BMI. Again, it is also possible that these were the results of under-reporting from this group. Other studies also found that the problem of under-reporting in dietary survey has been the major obstacle in accurately measuring food intake (Gemming, Jiang, Swinburn, Utter, & Mhurchu, 2014). In this study, women, overweight and obese participants, and those of older age were more likely to under-report the intake of unhealthy food. Even study from the late 90s had acknowledged the issue of under-reporting in dietary research (Macdiarmid & Blundell, 1998). Since study on dietary intake is prone to under-reporting, results should be interpreted cautiously, and the conclusions drawn should be critically appraised. This study also found no differences in the total fat and total fat percentage intake between those with normal BMI and overweight and obese personnel. Again, this may be the result of cutting down the calories or contamination from under-reporting.

5.2.2.5 Summary of factors associated with overweight and obesity

In summary, increasing duration of service was the only factor significantly associated with overweight and obesity. There was no significant association found between lifestyle factors (smoking, physical activity, and dietary intake) with overweight and obesity. Although there was no association between smoking status with overweight and obesity, heavy and chronic smokers were more likely to be overweight and obese. Inadequate sample size in the association study might have contributed to these insignificant findings. The possibility of bias from over-reporting of physical activity and under-reporting of dietary intake cannot be ruled out.

5.2.3 Implication of overweight and obesity on physical fitness

This study found that BMI and BF% were significantly associated with physical fitness in overall and male participants. However, MM% and WC were not. Among females, all anthropometric measurements and body composition measures were not associated with physical fitness. This may be due to the small number of female participants (n = 147).

Those who failed the fitness test had a higher mean BMI and BF%. More than 50% of those who failed the fitness test were overweight and obese. Among the Belgian Armed Forces, personnel with BMI >25 kg/m^2 were more likely to fail the fitness test (Collee et al., 2014). US Army personnel with BF% above the recommended limit (>18%) performed poorer in both aerobic and anaerobic fitness tests even with similar FFM (Crawford et al., 2011; Zajdowicz & McKenzie, 2003). Similar associations were also observed in Brazilian firefighters, for whom obesity and high BF% were found to be significantly associated with reduced cardio-respiratory fitness (Nogueira et al., 2016).

In the multivariate regression model, overweight and obesity remained significantly associated with failing the fitness test after adjusted for socio-demographics, occupational and lifestyle factors. Around 34% of overweight and obese personnel failed the 2.4km run test, which assesses their aerobic fitness. On the contrary, there were no significant differences in the proportion of overweight and obese personnel who failed the sit-up and push-up tests. Similar findings were observed in the Royal Malaysian Navy trainees, as personnel with higher BMI and BF% were found to have slower cardiorespiratory fitness (Sedek et al., 2012).

5.2.4 Overview of results

This study has shown that trends in overweight and obesity increased from 1990 to 2015. Results from Phase 1 and Phase 2 also suggest that personnel who had served longer were more likely to be overweight and obese. Overweight and obesity were also associated with higher sickness absenteeism and poorer fitness performance in the Malaysian Army.

5.3 Research limitations and strengths

5.3.1 Limitations

5.3.1.1 Phase 1

In the Phase 1 retrospective cohort study, the data were extracted from the available personnel medical and service records, which dated back to the year 1990. These data were not intended for this research. Thus, Phase 1 depended highly on the quality of the data and very much restricted by its availability. Some of the information, such as sick reports, was either not recorded or missing. Although most of the information needed for this study was available, some were found to be incomplete and out-dated. Multiple efforts were made to go through the data and went back to the respective units to fill in the missing information and update the records. These exhaustive, diligent, and rigorous data extractions maximised the amount of data collected. For the records on sickness absenteeism, information was traced and confirmed by both the sick leaves or excuse given and cross-checked with the consultation history in the medical records.

Phase 1 depended on the data extracted from the Service and medical records, which do not contain data on lifestyle behaviours. These inadequacies were complimented in Phase 2 with the inclusion of smoking habits, physical activity, dietary habits and intake, and also physical fitness.

The quality of available data was not perfect, since they were manually documented and not digitalised. However, these data were recorded and updated at least annually if not more often, especially the medical records. These data were among the reference information in defining the military readiness. Thus, it is considered reliable to represent the general picture of the military health status. However, the existence of information bias cannot be ruled out, since excess BMI will affect their career advancement, continuation of service, and deployment opportunities.

5.3.1.2 Phase 2

Phase 2 was a cross-sectional study using the sub-sample from Phase 1 with additional recruitment to achieve the desired sample size. There were notable limitations in using this study design such as its inability to infer causality and establish temporality association, and also exposure to multiple confounders. These disadvantages were acknowledged, and the potential confounders were adjusted in the multivariate analysis.

The other limitation in the Phase 2 was the possibilities of over-reporting of physical activity using IPAQ (Dyrstad, Hansen, Holme, & Anderssen, 2014) and under-reporting of the 24-hour dietary recall (Schoch & Raynor, 2012). Overweight and obese personnel may manipulate the outcomes by reporting the socially desirable input, either under-reporting on the unhealthy eating or over-reporting their level of physical activity. A study found that women, older age group, and a specific ethnic group were more prone to under-report their dietary intake (Gemming et al., 2014). There were no easy ways to tackle these issues. The participants were briefed on confidentiality and ensured that the information would only be used for this research to gain their confidence and encourage them to provide transparent information. Individual information was not exposed to their commanders or any other parties. Most dietary studies face such problems and it is recommended that the results should be critically appraised before drawing any conclusions (Subar et al., 2015).

Dietary intake was assessed using 24-hour dietary recall. Although this was not reflective of the actual dietary intake, an assessment over a shorter period is more convenient to the participants (Rutishauser, 2007). Laboratory analyses of food contents, nutrient biomarkers, and estimation of energy intake are more accurate compared to the dietary recall. However, these methods are less favourable in a large-scale study due to their high cost of collecting and analysing the data (Thompson, Subar, Loria, Reedy, & Baranowski, 2010). There is no doubt that 24-hour dietary record is prone to information bias. Social desirability factor also may influence the participants to under-report on food with negative health image and over-report on food with positive health image (Schoch & Raynor, 2012; van de Mortel, 2008). However, the 24-hour dietary recall is more feasible, inexpensive and less prone to recall bias compared to the longer 7-days recall or Food Frequency Questionnaires (Thompson & Subar, 2013). Shorter duration of recall minimised the effort to remember what was taken the day before. Briefing and presentation on food types and samples and tools for portion estimation were used to guide the participants in filling in their food intake in the last 24 hours. The use of visual presentation and physical samples has facilitated the participants in estimating their food intake, and hence increase the accuracy (Ortega, Perez-Rodrigo, & Lopez-Sobaler, 2015).

Another limitation worth mentioning is the selection of IPAQ in measuring the level of physical activity. Although an accelerometer was the preferred choice of instrument to objectively measure the impact of physical activity on health (Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005), it is expensive and not practical for a large-scale study. Thus, due to limited resources, this study resorted to using long-form IPAQ as an alternative. Despite being prone to over-reporting, IPAQ has been widely used in many epidemiological studies due to its low cost and less time-consuming. The IPAQ used in this study was previously translated into the Malay language and validated among Malaysian adults (Chu & Moy, 2012).

Because of the hectic unit activity and highly mobile troops performing frequent out-of-unit tasks, not all of the personnel were able to participate in the dietary recall and perform the fitness test. After repeated attempts were made to ensure maximum participation in both of these variables, the data collection was stopped due to time constraint. However, all these shortcomings were addressed in the analyses. Participants and non-participants were compared, and the similarities and differences were acknowledged in the discussion.

5.3.2 Strengths

Despite the limitations mentioned above, this study has its strengths and advantages. Firstly, the retrospective cohort study design with over 2000 participants was able to demonstrate the trend of BMI over 25 years period and throughout their career. Although prospective cohort is more favourable, it is less practical and takes a more extended period to capture these changes (Euser, Zoccali, Jager, & Dekker, 2009). Universal sampling with the inclusion of large sample size was more representative of the population. Since the compositions of the Army Divisions were almost homogenous, the results of this study could be inferred to the Malaysian Army as a whole. The choice of cross-sectional study design gave the advantages of less time consuming, inexpensive and easier to carry out. Phase 2 incorporated the modifiable lifestyles factors such as smoking, physical activity, and dietary intake to give more comprehensive coverage on overweight and obesity issues in the Malaysian Army.

This study used standardised instruments for measurements, thus ensuring consistency and reproducible results for comparison and future research. Although BIA is not the gold standard for assessment of body compositions, when combined with BMI it is able to estimate body adiposity with acceptable accuracy. Most of the Army health centres were now equipped with BIA machines. Obesity, and hence body adiposity can now be measured with better accuracy in combination with much criticised and commonly used BMI. More technological advanced techniques such as DEXA, CT scan, and MRI are far more expensive and not practical for a large-scale study (Beechy et al., 2012).

The trends of overweight and obesity were compared with the general Malaysian population to highlight the similarities and differences in the emerging trend of overweight and obesity in the Malaysian Army. The results were also compared to the military from other countries to get a better perspective of these issues.

To the best of our knowledge, this is the first study highlighting the trend, factors, and consequences of overweight and obesity in the Malaysian Army over 25 years. This large-scale and multi-factorial study will set the precedence and reference for the future studies in the overweight and obesity-related field. It will put Malaysian Army in the 'obesity map' together with other countries, and enables comparison with Army from other nations in term of trend, prevalence, associated factors and consequences of overweight and obesity. It may also provide an opportunity to design interventions or even apply the interventions that have been used in other countries in managing obesity. This study was an attempt to not just highlight this critical issue with evidence-based facts. It will also generate more attention from the top officers and policymakers in the Malaysian Army and snowballing down to the implementers on the ground.

5.4 Summary of Chapter 5

The prevalence of overweight and obesity in the Malaysian Army has been steadily increasing over the last 25 years. Although the prevalence of obesity in the Malaysian Army is still lower than the general Malaysian population, the prevalence of overweight has exceeded the general population. At the univariate level, married personnel, senior rank, higher household income, frequent eating out, and chronic and heavier smoker were more likely to be overweight and obese. However, multivariate regression analysis showed that only longer duration of service was associated with higher odds of becoming overweight and obese. Overweight and obesity were found to significantly affect productivity and physical fitness performance in the Malaysian Army. Chapter 5 also discussed the limitations and strengths of both phases of the study.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

This chapter concludes the findings from this study and makes suggestions for future research as well as public health consequences and recommendations.

6.1 Conclusion

The conclusions are made based on the three main objectives of this study, the trend and prevalence, the factors and predictors, and lastly the consequences of overweight and obesity in the Malaysian Army.

6.1.1 Trend and prevalence of overweight and obesity

This study has demonstrated an increasing trend of overweight and obesity in the Malaysian Army in three different ways; the mean BMI and the prevalence of overweight and obesity over 25 years, the prevalence according to the duration of service and the comparison with the national trend.

Both the mean BMI and the prevalence of overweight and obesity have been increasing steadily over the last 25 years. The trend in overweight showed that the increment was around 1 kg/m^2 per year over the last 20 years, and the rise was faster in the last 10 years. Although the increase in the obesity prevalence was slower compared to overweight, most of the increment happened in the last 5 years.

In terms of the duration of service, the prevalence of obesity increased from the first year of joining the service and peaked at between 10 to 15 years and dropped after that. On the contrary, the prevalence of overweight continued to rise and was the highest among those who had served for 15 years and above, with more than half of them overweight. The drop in the prevalence of obesity could be attributed to the termination of personnel with BMI >27 kg/m^2 after 12 or 15 years of service.

In 2015, the prevalence of overweight had exceeded the national prevalence. However, the prevalence of obesity was lower compared to the general population (IPH, 2015). The prevalence of overweight in the general population remained at around 30% in the last 10 years. Meanwhile, there was a 14% increase in the prevalence of overweight in Malaysian Army during this period. The prevalence of obesity in the Malaysian Army seemed to be catching up to the general population. Over the last 10 years, there was a 3% increase in the prevalence of obesity in the general population compared to 7% in the Malaysian Army.

6.1.2 Factors and predictors of overweight and obesity

Another outcome of interest in this study was to determine the predictors and factors associated with overweight and obesity in the Malaysian Army. In view of the multi-factorial nature of overweight and obesity, this study has combined the retrospective cohort and cross-sectional findings to get a more holistic understanding. Increasing duration of service had been a consistently significant factor in both phases. The odds of overweight and obesity among those who served 15 years and above were ten times the odds of those served less than 5 years. Other factors that were significant at the univariate level only and worth highlighting include senior rank, married personnel, higher household income, chronic and heavy smokers, and those who took less home cooked food. Although this study found no association between smoking and physical activity with overweight and obesity, the potential adverse health effects of smoking and physical inactivity should not be disregarded.

6.1.3 Consequences of overweight and obesity

This study has shown that overweight and obesity were associated with reduced productivity in terms of higher sickness absenteeism and presenteeism, as well as lower fitness level in the Malaysian Army personnel. Overweight and obese personnel reported a significantly higher median sickness absenteeism and presenteeism after adjusting for socio-demographic and occupational factors. Being female and increasing age were also significantly associated with sickness absenteeism and presenteeism. Thus, overweight and obese, and older female personnel were more likely to cause loss of productivity by mean of sickness absenteeism and presenteeism.

Both BMI and BF% were associated with failing the fitness test among males, but not females. The odds of failing the fitness test was 60% higher among the overweight personnel and twice as high among the obese personnel compared to the normal weight personnel, after adjusting for the socio-demographic and occupational factors.

Sickness absenteeism, presenteeism, and physical fitness are important indicators of military readiness that are often overlooked. BMI should not only represent the image of the military personnel, used only during promotion and extension of service. Its consequences on military productivity and performance should be of more concern to the organisation.

6.2 Recommendations

The recommendations for future studies and public health implications are discussed with this study's strengths and limitations in mind.

6.2.1 Recommendation for future studies

Despite some convincing results produced from this study, its limitations open up an avenue for improvement in the future studies. A prospective cohort study with inclusion of larger scale military population, perhaps the Navy and the Air Force, would give a better indication of overweight and obesity problems in the Malaysian Armed Forces as a whole. This study only sampled the non-combatant personnel. Combatant personnel are expected to be physically better due to the more demanding nature of their training and daily routines. They are assumed to have higher lean muscle mass and lower body fat. Thus, their inclusion could have increased the prevalence of overweight and may be lowered the prevalence of obesity. Future studies to compare between these groups and the accuracy of BMI in classifying overweight and obesity in the combatant personnel would be beneficial to the Malaysian Army and the Malaysian Armed Forces in general.

The Malaysian Armed Forces Health Services has recently launched their Military Lifetime Health Record (MLHR) system, which records all the medical-related information from so-called 'womb-to-tomb' of the personnel. This includes laboratory results such as total cholesterol, low and high-density lipoproteins, fasting blood glucose as well as anthropometric measurements and body composition analysis. Future studies on overweight and obesity in the military population should make use of these large digitalised data sets. The use of bioinformatics system ensures more reliable, easily accessible and traceable data. The usage of electronic medical record could improve the diagnosis and documentation of overweight and obesity (Bode, Roberts, &

Johnson, 2013; Williamson et al., 2009)

Future studies should also invest in a more objective measurement to avoid information bias affecting the outcomes. The use of an accelerometer instead of IPAQ (Bonomi & Westerterp, 2011), and the inclusion of biomarkers for instances, although costly, may produce more convincing results and definitive conclusions. The use of dietary smartphone applications may be more favourable and can be considered as an assessment tools among the growing IT-savvy population. Although it has not been shown to eliminate the recall or record bias, it will probably increase the data accuracy and participation rates.

This study has included factors commonly associated with overweight and obesity, namely smoking, physical activity, and dietary intake. It has also looked at the consequences of overweight and obesity on military productivity in terms of sickness absenteeism and presenteeism, and physical fitness. Future studies should also include the psychosocial and occupational factors that could have been affected by overweight and obesity. Variables such as job satisfaction, workability index, mental status, and quality of life would give a complimentary overview to the biophysical consequences of overweight and obesity.

Although this study found no association between smoking and obesity, further analysis revealed significant differences in the mean WC. Smokers and ex-smokers had a higher mean WC compared to never smokers, suggestive of higher risk of central obesity from smoking. This finding concurred with several previous studies among the general population (Canoy et al., 2005; Clair et al., 2011). Given the high percentage of smokers among the Malaysian Army, especially among the men, and the known facts of adverse health effects from smoking, it is worth to further explore these associations.

Finally, in view of voluminous evidence on the association between overweight and obesity and NCDs, and increasing prevalence of overweight and obesity in the Malaysian Army that this study has found, future studies may want to explore the extent of these problems in the military population. The NCDs could have contributed to the peacetime workforce disabilities.

6.2.2 Public health implications and recommendation

This study illustrates the increasing trend of overweight and obesity in the Malaysian Army, as well as the associated factors and its consequences on military productivity. Given the limited studies on overweight and obesity in the Malaysian Army, this study could provide a platform and guidance to the policymakers on the projection of this growing problem. It is time to translate this evidence into practice with increased awareness, and addressing this issue in a more comprehensive approach involving all relevant parties; the decision-makers, the commanders, the medical personnel, and last but not the least, the soldiers themselves. Policies on weight management should be strengthened, and enforcement should be transparent covering all level of personnel and officers. Military nutritionist may help in improving health literacy in terms of healthy food choice and review the existing menu served to the soldiers (Carbone & Zoellner, 2012). Programs on health promotion towards healthy lifestyle should be part of the continuous development program and carried out regularly throughout the year.

Results from this study could be used to initiate public health measures to tackle overweight and obesity issues in the Malaysian Army. Those overweight and obese soldiers have been putting on weight mostly in the first 5 to 10 years of their service. Thus, intervention should set in even before this period. Soldiers at risk should be identified earlier, counselled and programmed intensively. In contrast to the current practice, recruiting overweight and obese personnel into BMI or weight reduction programs are rehabilitative rather than preventive.

The use of BMI alone as a measure of obesity, although cost-effective and practical, may have misclassified personnel with high lean muscle mass as overweight. Since the availability of BIA machines in most military healthcare centres, it is time to incorporate body composition analysis in addition to BMI as the overall measures of personnel's health status. The additional information on BF% and muscle mass percentage will help the Commanders to make a fairer decision. Alternatively, instead of measuring the body compositions for all personnel, which could be time-consuming, the BIA could be used as a second stage screening for those who were overweight.

The current BMI cut-off point of 27 kg/m^2 used in the Malaysian Army should be brought down. By using this standard, 36% of overweight males with normal BF% will be discriminated. On the contrary, 60% of females who were overweight but had not exceeded the cut-off BMI were obese by BF% standard. Given these findings, it is suggested that the BMI cut-off point should be gender-specific (Friedl, 2012; Lennon et al., 2015), and used in combination with BF% measurement. The BMI and BF% cut-off point should be brought lower than the general population to ensure an effective screening process to preserve only fit and healthy personnel. For example, the US Department of Defence is using BF% $\leq$18% for their male soldiers as opposed to 25% (Crawford et al., 2011).

Indirectly, BMI of 27 kg/m^2 could have been used as 'target BMI' by the personnel, which does not reflect on the overall health and fitness. It is too late for any effective corrective measures once their BMI has reached the pre-obese stage.

This study also revealed an alarming proportion of personnel failing the fitness test, considering their presumably active routines. Overweight and obesity was again one of the significant factors. Unlike BMI, fitness tests are never used as an administrative punishment in any way. Those who failed the fitness test were given a second chance to attempt until they make it. Hence, this test was not taken seriously and seen as a routine twice a year activity rather than something that they train hard to pass. The emphasis on physical fitness should not be just on passing the fitness test, but also to improve their overall health, gain respect form their colleagues, and more importantly be part of their culture (Wilson et al., 2012). It is therefore suggested that physical fitness is incorporated into the overall evaluation together with BMI and other administrative and disciplinary considerations. Some of Armed Forces in other countries have denied any deployment, and in some cases, dismissed from the services should personnel have failed the fitness test (Collee et al., 2014).

Emphasis on physical fitness not only improves their physical conditioning but also helps in weight reduction and maintenance, especially the overweight and obese personnel. Fitness should be a lifestyle rather than just a military requirement. Those who exercise out of their own will were more like to perform better in the fitness test compared to those who felt obligated to do it (Wilson et al., 2012). On the ground level, their routine physical training should be tailored according to the specific groups, either based on BMI, age or gender to ensure its effectiveness (Anderson et al., 2016). The focus should be more on creating an anti-obesogenic environment and developing a fitness culture rather than an obesity program.

6.3 Summary of Chapter 6

This study has set a precedence for future studies looking at overweight and obesity issues in the Malaysian Army. Overweight and obesity should be given serious attention in view of its increasing trend and its implication on productivity and fitness performance. Early identification of 'at risk' personnel and consistent intervention could have prevented them from reaching the danger zone. The BMI cut-off point for intervention measures should be revisited with the inclusion of BF% as another health indicators. The fitness test should be included in the overall evaluation of personnel performance.

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LIST OF PUBLICATIONS AND PAPERS PRESENTED

CONFERENCE PRESENTATION

Type	Title	Conference
Oral Presentation	Overweight and obesity are associated with physical fitness among military personnel	Scientific Conference on Obesity organised by the Malaysian Association for the Study of Obesity (MASO). 'Battling Obesity: Causes, Management, and Preventive Action'. Kuala Lumpur, Malaysia. 20-21 November 2017.
Oral Presentation	Overweight and obesity among military personnel and its implication on sickness absenteeism	Scientific Conference on Obesity organised by the Malaysian Association for the Study of Obesity (MASO) in conjunction with the World Obesity Day. 'Combating Obesity: Societal and Environmental Issues and Challenges'. Kuala Lumpur, Malaysia. 28-29 October 2015.
Poster Presentation	Physical fitness literacy in the Malaysian Army	The 4th AHLA International Health Literacy Conference. 'Health Literacy and Quality of Healthcare Services'. Haiphong, Vietnam. 7-9 November 2016.

PROPOSED PUBLICATIONS

Type	Title	Journal
Journal Article (Prepared for submission)	Overweight and obesity are associated with physical fitness among military personnel	Obesity
Short Communication (Prepared for submission)	Trend and prevalence of overweight and obesity in the Malaysian Army	International Journal of Obesity