Obesity in the Army: prevalence, correlates and predictors

By

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Abstract

The emergence of obesity as a distinct disease could have far reaching consequences for an organisation where optimum health and physical fitness are required for personnel to perform their occupational roles effectively. The aim of this thesis is to increase our understanding of the prevalence, correlates and predictors of obesity in the British Army.

Systematic review indicated a smaller body of knowledge in respect of the treatment and correlates of obesity in military populations. Successful treatment interventions incorporated exercise, healthy eating information, behavioural modification, self-monitoring, relapse prevention, structured follow-up and were supported by trained personnel. The major significant correlates of obesity were being enlisted personnel, male, ≥35 years of age, African-American / Hispanic ethnicity, and married (with spouse present). The review highlighted the deficit in knowledge concerning treatment, and correlates of obesity in military populations.

The trend of escalating obesity has prompted some armed forces to report obesity trends and prevalence, the findings of which suggest that obesity is a growing concern in the armed services. A study based on the secondary analysis of data covering 50,000 British Army soldiers indicated that according to BMI, 56.7% of the study population were overweight and of those individuals 12% were obese. When waist circumference data were added to the BMI data, the results indicate that females displayed a higher percentage of risk of obesity related ill-health (a combination of BMI and waist circumference) than males (30.4% and 24% respectively). Further analysis suggested that age, marital status, rank and military employment category were significant correlates of obesity. Additionally, obesity and increased risk of obesity related-ill-health were linked to higher failure and lower attendance on British Army physical tests. Data suggested older army personnel (>30) had a higher pass rate, but a lower attendance rate.

The final analysis of all available variables suggested physical test outcome, age, medical status and enlisted status were the most significant predictors of obesity.

A final study based on a different study population (n=1124) from the high readiness component of the UK based British Army sought to identify relationships between health behaviours that were not supportive of healthy weight and to understand the predictive influence of individual and collective behaviour in relation to obesity and the risk of obesity related ill-health in military personnel. The investigation used a health behaviour questionnaire to assess health behaviours that might influence weight status. Final analysis of this highly active population suggested, restrained eating, food preparation in the working week, injury status, age, sedentary behaviour, leisure-time physical activity engagement and type of motivation for exercise were the most significant factors.

This thesis highlights the lack of knowledge, and gives evidence to support the impact of obesity on individual health and collective occupational capability. Obesity is a complex multifaceted disease where no single causal route predominates. However, the identification of potential causal and predictive relationships will aid in the prevention and treatment of obesity in the British Army.

Acknowledgements

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For agreeing to supervise me through this long and not always straight forward process, my sincerest thanks go to Professor Stuart Biddle and Doctor Stacey Clemes. Stuart and Stacy you have my enduring gratitude.

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Chapter 1

Introduction

General Introduction

Although it would seem that obesity is a relatively new phenomenon, it has been referred to and depicted in ancient civilisations (Boriani, Taveggia and Cravero 2005). In their contextualised account of obesity research, Bray, Bouchard and James (2004) highlighted this fact in their reference to drawings of obese females, dating back thousands of years. In addition, the negative influence of obesity on health status was commented on by Hippocrates, who observed "sudden death is more common in those who are naturally fat than in the lean", and that obesity was a "harbinger of other diseases" (Bain 2006). Hippocrates further suggested that it was "injurious to health" to consume excessive food without undertaking exercise to "carry off the excess" (Haslam 2007).

It was not until 1660 that obesity was used in a medical context, by the English physician Tobias Venner (Haslam 2007). In more recent times, the lack of weight and height has been the cause of much attention due the relationship between health and nourishment. One paper that investigated height and weight data of the British population from 1820 to 1975 concluded that while obesity is a source of some concern in the United States (US) and other countries, it is likely at least for many years to be of less significance than the reduction in prevalence of malnutrition (Floud and Harris 1997). In 1971 Omran proposed the term "epidemiologic transition" to help explain the shifts in long-term disease patterns. Specifically for the western world there has been a shift from the high levels of poverty and malnutrition associated with Britain through the 18th and 19th century towards highly prevalent chronic diseases such as obesity (Omran 1971).

Obesity has been termed a multi-factorial disorder (Nammi et al 2004) with a causative pathway linked to a combination of physical inactivity, diet, metabolic factors influenced by genetic factors (Lindquist and Bray 2000). However, the transition from manual, through industrial to technical work have led to lower levels of occupational activity (Hill and Peters 1998), some researchers have suggested the pace of technological revolution has indeed surpassed human evolution (Farooqi and O'Rahilly 2007, Bloom 2007). While the human genome is genetically enabled to be highly active (Booth, Chakravarthy and Spangenburg 2002), human beings have evolved with an underlying propensity to accumulate and conserve energy due to genetic risk and survival (Farooqi and O'Rahilly 2007). While these two facts alone cannot explain the obesity phenomenon, the disparity between energy accumulation and energy expenditure is central to the debate, and indeed it has become progressively easier to consume more calories while expending fewer (Power and Schulkin 2009).

There is general acceptance across the scientific community to support relationships between obesity and premature mortality (Kivimaki et al 2008, Whitlock et al 2009), elevated rates of cardiovascular disease (CVD) risk (Nanchahal et al 2005, Logue et al 2011), increased type 2 diabetes risk (Wang et al 2011), selected cancers (Calle et al 2003, Batty et al 2005), disability (Ferraro et al 2002, Launer et al 1994), and depression (Vieweg et al 2006, Roberts et al 2002). When these facts are allied to a highly prevalent disease currently affecting almost two-thirds of adults in the United Kingdom (UK) (overweight or obese) (NHS 2011), it is clear that obesity is a major national health priority.

Future prevalence projections suggest that the UK will be mainly obese by 2050 (Kopelman, Jebb and Butland 2007). Since the population pool of the British Army is recruited primarily from the UK, the emergence of obesity as a major public health concern (Swinburn, Gill and Kumanyika 2005), could have far reaching consequences on an organisation where optimum health and physical fitness are required for soldiers to perform their peace and war time roles effectively (Dystad 2007). Due to the specific occupational requirements of military employment, the current and projected rise in obesity prevalence pose real dangers to recruitment (Niebuhr et al 2009), retention (McLaughlin and Wittert 2009) and productivity (Dall et al 2008). Obesity has also been reported to be detrimental to individual and collective military capability due to established relationships with depressive symptoms (Kress, Peterson and Hartzell 2006), post-traumatic stress syndrome (PTSD) (Vieweg et al 2006), cardio-respiratory (CRF) and neuromuscular fitness (Fogelholm 2006), heat stress (Yokota, Bathalon and Berglund 2008), sleep apnoea (Loube, Loube and Mitler 1994) and load-carriage (Lyons, Allsopp and Bilzon 2005, Charteris 2000).

Beyond the health and occupational implications, obesity has also been shown to have a profound effect on healthcare costs (Dall et al 2008). Whilst the UK Military do not have a cost mechanism in place to assess the economic burden of obesity, studies on the US Military estimated that the military health insurance program spends $1.1 billion annually treating obesity-related illness (Dall et al 2007). In comparison, the US Military spend less on treating illnesses related to tobacco ($564 million) and alcohol consumption ($425 million) combined (Dall et al 2007). Studies in both the UK and US have suggested that obesity and excess body fat are linked to musculoskeletal (MSK) injury causation (Ross et al 1994, Knapik et al 2004) and outcome (as a by-product of MSK injury) (Lohmander et al 2007). The current and potential impact of obesity has prompted the US Institute of Medicine to state that "obesity threaten(s) the long –term welfare and readiness of US Military forces" and therefore US National Security" (IOM 2004).

Military populations have long understood the need for vocational health and physical prowess, with aesthetics and physical robustness honed through exercise and sport being central to both Greek and Roman cultures (Mechikoff and Estes, 2006). However, body composition to support the occupational stresses of military life has, until recent times, focussed on eliminating the inadequately muscled, sickly or chronically malnourished individuals (Friedl 2004). For the British Army, medical examinations for soldiers were introduced widely in 1790, however, by the time of the South African War (1899-1901), 40% of British volunteers were unfit and in the First World War (1914-18) almost half the conscripted men were considered unsuitable (Cooter 1993). From 1860 until 1975 the British Army Medical Services recorded body height and body weight information on Army recruits, these results measured by the Quetelet Index (body mass index (BMI)) suggest a minor increase in body fat or muscle mass (21.7 kg/m^2 in 1860, 23.0 kg/m^2 in 1975) (Rosenbaum 1992). Similarly in the US Army, one study reported an average increase of over 13 kg of lean-mass in young US soldiers between 1864 and 2000 (Friedl 2004).

Information from the US Department of Defence (DoD) indicates there has been little change in the prevalence of overweight (BMI 25 – 29.99 kg/m^2) from 1998 through 2008 (48.8% and 48.6%), however, this level of stability is not replicated within the obese (BMI) ≥30.0 kg/m^2) military population, where the prevalence has more than doubled (6.4% - 13.2% 1998 and 2008 respectively) (Bray et al 2009). For the UK Military, earlier work by Durnin, McKay and Webster (1984) has observed mean BMI measurements of 23.4 kg/m² and 24.9 kg/m² for males aged 20-24 years and 35 to 39 years respectively. More recent work have sought to clarify the prevalence of obesity in the UK Armed Forces (Wood 2007). This work highlighted that the armed forces has an emerging obesity issue with 15% of Caucasian military males and 12.5% Caucasian military females categorised as obese (Body mass index (BMI) ≥ 30 kg/m²) (Wood 2007). Whilst these figures are lower than UK civilian population, the results indicate that obesity is a real and current problem in the UK Armed Forces.

Current evidence would suggest that obesity and poor physical performance capacity are incompatible with the demands of a military career and can degrade operational effectiveness (Kyrolainen and Nindl 2012). The threat obesity posed to the UK Military was recognised in 2007 when the Defence Health Strategy – Defence Health Agenda Framework (DHAF) identified the reduction of obesity as "one of" the eight main focus areas. This policy direction was supported by the Services Personnel Operating Board (SPOB) at its meeting in May 2008. The SPOB agreed that obesity was a significant problem for the Armed Forces and directed the development of a weight management policy (MoD 2007). The Defence Board endorsed the need to address the damaging trends in obesity. Failure to take decisive action to address obesity could be perceived as a failure by the MOD in its health and welfare responsibilities (MoD 2008). In addition the study of obesity in the British Army is in-keeping with Government initiatives (Department of Health 2004 and Department of Health 2008).

<u>Aim</u>

The aim of the research reported in this thesis is to increase our understanding of the prevalence, correlates and predictors of obesity in the British Army. In order to achieve this, the thesis has the following objectives:

- To assess the current knowledge in respect of the correlates and treatment of obesity in military populations.

- To establish the current prevalence of obesity in the British Army in relation to age, gender, marital status and occupationally defined employment.
- To understand the impact of weight status on occupational fitness.
- To clarify using a large sample, the predictors of obesity in the British Army.
- To gain a broader understanding of the health behaviours, physical characteristics and motivations linked to BMI and the risk of obesity related ill-health.

Overview of Thesis

The structure of each chapter presented in the thesis is briefly described below:

Chapter 2 uses systematic review methods to identify the current knowledge in respect of treatment and correlates of obesity in military populations. The systematic review utilized the National Institute of Clinical Excellence (NICE) and the National Health Service (NHS) Centre for Reviews and Dissemination (CRD) guidance. The completed review is published in *Obesity Facts (2011)*.

Chapter 3 seeks to establish the scale (prevalence) of obesity in the British Army. The study is based on the secondary analysis of a large data set (n=50,000+) of serving British Army officers and soldiers. The study reports prevalence by socio-demographic and other variables. The completed prevalence paper is published in the *Annals of Human Biology (2014).*

Chapter 4 presents the results of an investigation into weight status and fitness test outcomes. This chapter also used the extensive information available in Chapter 3 for secondary analysis and reports the outcome of two British Army fitness tests. The outcomes of pass, fail and failure to attempt the tests are reported by gender and age group in relation to weight status.

Chapter 5 describes the results of a study into the predictors of obesity in the British Army. This secondary analysis reports the predictive ability of variables in relation to age, gender, employment, marital status, physical test outcome, medical status, years employed in the Army and geographical location of unit. Results are presented for obesity as defined by BMI and the risk of obesity related ill-health (BMI and waist circumference combined).

Chapter 6 gives an insight into the health behaviours of British soldiers. This study outlines the results of a questionnaire based study that captured the responses of over 1000 serving soldiers in the UK 3rd Division. Data capture sought to highlight the relationships between obesity and mandatory physical training, leisure-time physical training, motivation towards exercise, dietary behaviour, sedentary behaviour and restrictive eating. Correlations and logistic regressions are reported and discussed.

Chapter 7 presents a discussion of the findings. These findings are presented in the context of the thesis aims. The importance of the findings and evidence based recommendations are contextualised within this chapter.

About the Author

By way of context, I thought it prudent to explain a little of my experience with the British Army. In 1982 I joined the British Army as a 'boy soldier' in the Royal Engineers where I undertook my first course in physical training instruction (1987). After an arduous transfer course in 1992 I became a Sergeant Instructor in the Royal Army Physical Training Corps (RAPTC) (the physical training element of the British Army). After various gymnasium and fitness programme management jobs, I secured employment at the Defence Medical Rehabilitation Centre (DMRC). Whilst at the DMRC as a physical therapist I completed a BSc (Hons) in Sports Rehabilitation and Sports Science. On commission to Captain (from the ranks) I undertook an MSc in Physical Activity and Health at Loughborough University. In the last five years as a Major I have being studying towards my PhD. During this time I have enjoyed employment influencing and creating policy at headquarters RAPTC, the Directorate of Defence Rehabilitation and HQ 3rd Division as the Director of Physical Development.

About the British Army

The British Army consists of the General Staff and the deployable Field Army and the Regional Forces that support them, as well as the joint elements that work with the Royal Navy and Royal Air Force. The Army carries out the tasks given to it by the democratically elected Government of the United Kingdom (UK). Its primary task is to defend the interests of the UK, which consists of England, Wales, Scotland and Northern Ireland. This may involve service overseas as part of a North Atlantic Treaty Organisation (NATO) force or any other multi-national deployment. Soldiers may also be deployed on United Nations (UN) operations and used to help in other emergencies.

Initial soldier training occurs at various UK training centres and training regiments. Junior soldier entry (aged between 16 and 17.5 years) takes place in the south of England at Winchester. Adult soldier training is undertaken at Pirbright (Standard Entry) and Catterick (Infantry soldier).

The command structure is hierarchical with divisions and brigades responsible for administering groupings of smaller units (major and minor units). Major Units are typically commanded by a Lieutenant Colonel and consists of between 300-800 officers and soldiers. Minor units are commanded by a Major and consist of between 20 – 300 officers and soldiers.

The units within Divisions and Brigades undertake certain functions that reflect the nature of the employment within each unit. Infantry, armoured and aviation units are part of the Combat Arms, these “teeth arms” are the units which engage in close action. Combat Support Arms provide direct support to the Combat Arms and include artillery, engineer and signals (communications). The Combat Services Support Arms provide sustainment and support for the Combat and Combat Support Arms (logistics, medical and mechanical support).

Chapter 2

The Correlates and Treatment of Obesity in Military Populations: A Systematic Review

Chapter 2 Systematic Review

Chapter 2 uses systematic review methods to identify the current knowledge in respect of treatment and correlates of obesity in military populations. The systematic review utilized the National Institute of Clinical Excellence (NICE) and the National Health Service (NHS) Centre for Reviews and Dissemination (CRD) guidance. The completed review is published in *Obesity Facts (2011)*.

The Correlates and Treatment of Obesity in Military Populations: A Systematic Review

Introduction

With the global epidemic of obesity (Ezzati et al 2003), some nations have identified a trend towards escalating levels of overweight and obesity within their military populations (IOM 2004, USMSMR 2009). It would appear that despite body fat standards being imposed on military personnel, the armed forces population are experiencing similar patterns of increasing levels of overweight and obesity as observed in civilian society (USMSMR 2009, McLaughlin and Wittert 2009). A recent study from the US Department of Defence (DoD) (*n* = 16,146) indicates that 61% of men and 39% of women employed in the active component of the US Military are overweight and collectively 12% are obese (USMSMR 2009). Evidence from the UK shows lower collective values of 38% overweight and 14% obesity (*n*=4,500) (Wood 2007), but still suggestive of a problem.

Several studies have investigated the associated costs of obesity to the military (Dall et al 2007, Bradham et al 2001, Kyrolainen et al 2008). Dall et al (2007), for example, estimated that the financial cost of excess weight and obesity to the US DoD was $1.1 billion. Such findings were corroborated by data from the US Medical Surveillance Monthly Report for January 2009 (USMSMR 2009), indicating that 23% and 16% of US Service members diagnosed with overweight and obesity respectively in 2008 had at least one medical encounter for a joint and back pain disorder, and that these conditions were among the leading causes of health care costs and lost duty time.

Whilst the financial connotations of obesity are clearly important, the psychological and physiological impact to service personnel may have wider occupational implications due to the association between obesity and depressive symptoms (Kress, Peterson and Hartzell 2006), post-traumatic stress syndrome (PTSD) (Vieweg et al 2006), cardio-respiratory (CRF) and neuromuscular fitness (Fogelholm et al 2006), heat stress (Yokota, Bathalon and Berglund 2008), sleep apnoea (Loube, Loube and Mitler 1994) and load-carriage (Lyons, Allsop and Bilzon 2005, Charteris 2000). Several investigations into load-carriage within military populations have observed that ‘load-carriage’ ability was reduced in ‘over-fat’ military personnel (Lyons, Allsop and Bilzon 2005, Charteris 2000). Fogelholm et al (2006) concluded that individuals with higher levels of body fat had not only impaired CRF, but also reduced muscular and motor function, reducing the over-fat individual’s ability to complete physically challenging military tasks.

Studies attempting to explore trends between physical activity (PA) and overweight (Weinsier et al 1998), and the correlates of obesity (Martinez et al 1999) have, to date been conducted on the general population and may not reflect a sub-population with relatively high levels of PA, such as the military (Lindquist and Bray 2001). Therefore, a greater understanding of the correlates of obesity could offer a means to mediate the effect on the military, allowing for specific prevention and treatment interventions. Given the established links between obesity and the major causes of morbidity and mortality (Sharma 2007), and impact on personal and collective ‘operational effectiveness’ (Bray et al 2006), the aim of this chapter was to systematically review the current evidence in respect of the correlates and treatment of obesity in the armed forces.

Methods

This study followed the procedures for systematic reviews outlined by the National Health Service (NHS) Centre for Reviews and Dissemination (NHS 2001), and the National Institute for Health and Clinical Excellence (NICE) ‘Methods for the development of NICE public health guidance’ (NICE 2009).

Search Strategy

The following electronic databases were searched, CINAHL, MedLine (Pub med), OCLC First Search, CSA Illumina, Sports Discus and Cochrane electronic databases using the search terms 'Military' or ‘Army’ or ‘Air Force’ or ‘Navy’ or ‘Marines’ AND 'weight', 'overweight', 'obesity', 'weight maintenance', 'weight loss' or 'weight control'. Due to the restricted nature of some material concerning the military, an additional search of all military sponsored literature was conducted. This search strategy included numerous e-mails to several worldwide military departments (US DoD, Australian Defence Force, New Zealand Army and Canadian Army, etc), and a focussed search of the North Atlantic Treaty Organisation (NATO) medical research publications.

Inclusion and Exclusion Criteria / Identification of Relevant Studies

For inclusion, studies were required to (i) refer to a regular (as opposed to reservist) military population, (ii) have an outcome that was weight, health or PA related, (iii) be written in the English Language and published between 1990 to May 2009. Studies were excluded if (i) the focus was surgical or pharmaceutical, (ii) the intervention did not include obesity as a primary condition. The first author identified relevant papers through the search strategy by reading their titles and abstracts. If abstracts were not available or yielded insufficient data, the whole article was screened for suitability for inclusion. Data from papers meeting the inclusion criteria were extracted by the first author on a standardised form developed for this review (Appendix 1)

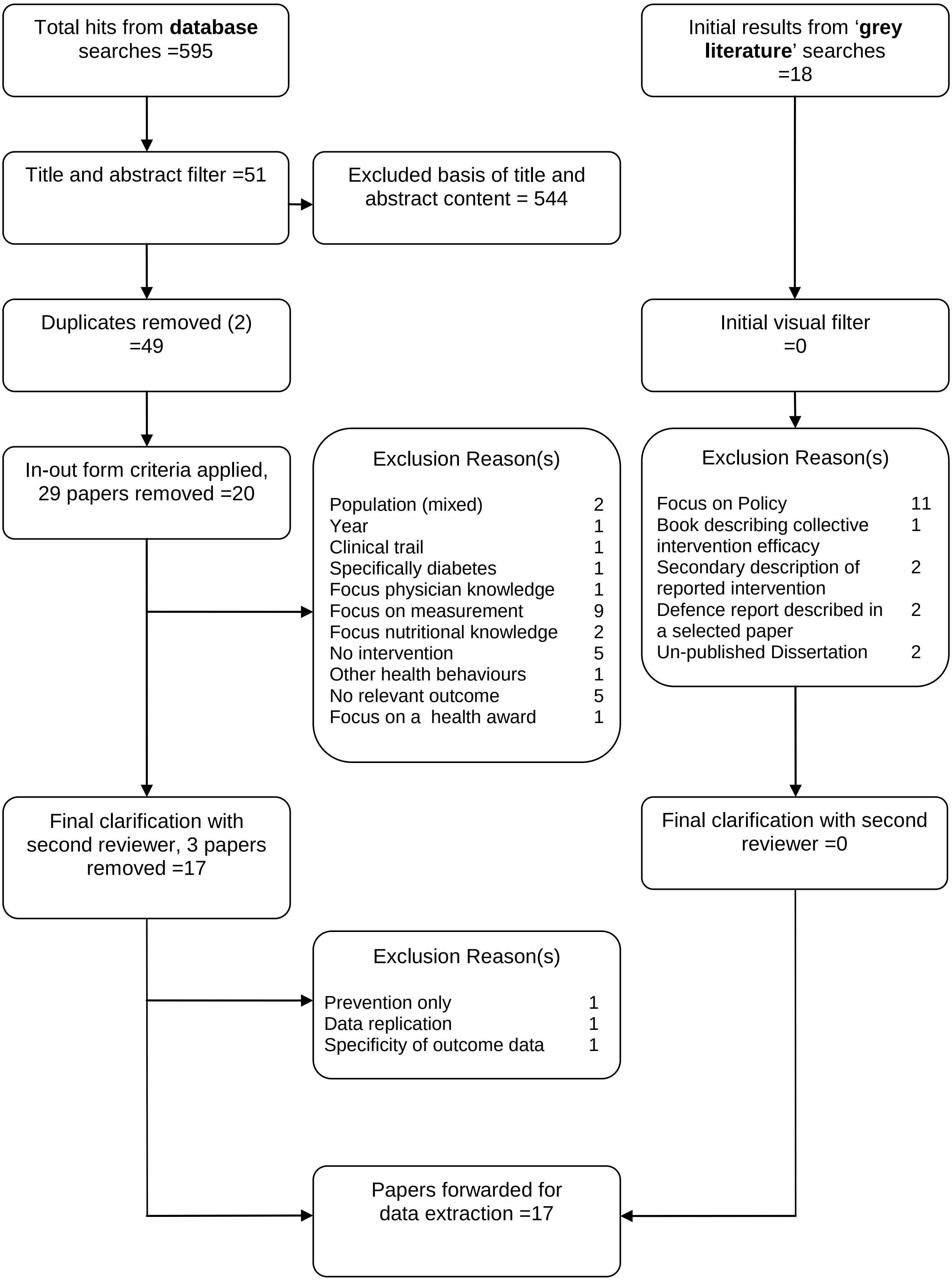
Study type and quality appraisal

Studies were categorised by study design as described in the NICE 'Methods for development of NICE public health guidance' Annex D & E (NICE 2009). Quality appraisal was reflective of: *Population* – source, recruitment and representation; *Method of allocation* – randomization, concealment and exposure; *Outcomes* – measurement, reliability and follow-up; *Analyses* – methods, intention to treat and calculable effect sizes; *Summary* – validity and generalisability of findings.

Results

The literature searches yielded 595 potentially relevant articles. Based on the title and abstract 544 papers were removed from the review. Duplications accounted for 2 papers; a further 29 papers did not withstand the criteria for the review (see Figure 2.1). A final confirmatory filter with a second reviewer (SJHB) reduced the remaining 20 papers to 17. Of the papers included in the review only one paper was from outside the USA (Israel). The 'grey literature' search returned 18 potential papers, none of which could be included in the review. In the main, these papers focussed on 'military policy' regarding obesity classification and associated regulations (see Figure 2.1).

Figure 2.1 Systematic review flow diagram of study selection



Papers were filtered into the sub-categories of treatment (*n*=13) and correlates (*n*=4). The quality appraisal by sub category is shown in Table 2.1. A quality assessment of '++' was allocated to the two Randomized Controlled Trials (RCTs) and the one Cluster Randomized Controlled Trail (CRCT); the Non-Randomized Controlled Trial (NRCT) was assessed as '+'. The remaining papers were cross-sectional (CS) (*n*=4) and non-experimental pre-post (NEPP) (*n*=9), and were assessed as '-'.

Table 2.1: Systematic review quality assessment by sub category

	Quality Assessment		
	-	**+**	**++**
Treatment	9	1	3
Correlates	4	0	0

Treatment

Thirteen studies (RCT = 2, CRCT = 1, NRCT = 1, NEPP = 9) examining the treatment of obesity in military populations were reviewed (Table 2.2). The period of intervention ranged from 3 weeks to 12 months, with an associated follow-up of 3 to 18 months. The average sample size was 134 (range: 31 - 624), and the reported average age was 31.5 years (range: 19 – 50 years). In general terms the sampling reflected both genders (*n*=10), however, three studies reflected a single sex sample (2 male, 1 female). The majority of papers (*n*=9) reported an intervention based on Cognitive Behavioural Theory (CBT *n*=8), or the Transtheoretical Model (TTM *n*=1). All interventions included PA as part of the treatment process, diet modification was offered by nine of the interventions (James, Folen and Earles 2001, Davis 1996, Earles et al 2007, Simpson et al 2004, James et al 1999, Bowles et al 2006, James et al 1997, James, Folen and Davis 1997, Trent and Stevens 1995), with diet education incorporated into all but one (Woodruff, Linenger and Conway 1992).

With the exception of three interventions (Simpson et al 2004, Woodruff, Linenger and Conway 1992, Veverka et al 2003), self monitoring techniques were generally included. Behavioural / lifestyle change was a central theme in all but one of the interventions (Woodruff, Linenger and Conway 1992), whilst creating a supportive environment was only partially referred to in eight of the interventions (James, Folen and Earles 2001, Davis 1996, Earles et al 2007, Simpson et al 2004, James et al 1999, Bowles et al 2006, James et al 1997, James, Folen and Davis 1997), each of which followed a 'cognitive-behavioural' approach. Significantly the intervention that used PA in isolation (Woodruff, Linenger and Conway 1992) was the least effective, achieving <1% weight loss. Where comparison allowed (Trent and Stevens 1995, Veverka et al 2003, Dennis et al 1999), a reduction in reported body fat (Cohen's d = 0.42 – 0.66) as opposed to bodyweight (d = 0.14 – 0.38) or BMI (d = 0.03 – 0.53) was observed to be more significant.

Several of the interventions (Simpson et al 2004, James et al 1999, Bowles et al 2006, James et al 1997, James, Folen and Davis 1997, Dennis et al 1999) could be defined as successful as they produced reductions in bodyweight beyond that required by the US Institute of Medicine (1995) (≥5% of initial bodyweight). Whilst the most successful (>10% weight loss) interventions (James et al 1997, James, Folen and Davis 1997) all followed the 'Healthy Lifestyles, Exercise and Emotions, Attitudes and Nutrition' (LEAN) programme, these interventions reflected individuals that were heaviest at baseline in comparison with the participants taking part in the other studies reviewed.

Correlates

Four cross-sectional studies concerning the correlates of obesity were included in this review. Table 2.3 follows a similar approach advocated by previous reviews, (Martinez et al 1999, Sallis and Owen 1999, Trost et al 2002) and classifies correlates as demographic and biological, psychological, cognitive and emotional, behavioural attributes and skills, social and cultural, physical environment, and PA characteristics. The study populations ranged from 27 - 46,213 and reflected both genders (male = 78% (n=36,021); female = 22% (n=10,192)), age range 18 – 55 years.

A total of 19 correlates were identified from the four papers, with all of the evidence being based on one of the studies, or two studies with conflicting evidence; and therefore the quality of the evidence is classified as weak or mixed. These 19 correlates consisted of eight demographic and behavioural, five psychological, cognitive and emotional, and three environment factors. One correlate was identified for behavioural attributes and skill. Social and cultural factors were represented by a single correlate, as was physical activity characteristics.

The information offered by Bray et al (2006) represents the strongest evidence as data is derived from large-scale probability samples, from three separate surveys (1995, 1998 and 2002). This study concluded that age, education, gender, pay group, marital status and ethnicity were all significant ($p<0.05$) correlates of obesity. Based on a large mixed Israeli sample (n=22,671), Grotto et al (2008), reported that education (both participant and parents), smoking status and PA level was linked to obesity status ($p\leq0.035$). Sigrist, Anderson and Auld (2005), focussed on a small sample of senior officers (n=52), the primarily male (93%) sample indicated that 'not liking cooking' and 'lack of time' and 'low priority' were barriers to eating healthily and undertaking PA. Additionally, this study concluded that 'limited access' to fitness facilities, healthy food choices and mixed media messages were all factors related to obesity. The final reviewed study (Croteau 2001), concentrated on a small Navy sample (n=27) and offered one significant correlation ($p<0.05$) in reference to the 'perceptions of exercise leadership'.

Table 2.2: Systematic review summary of studies for the treatment of obesity in military populations

Author Year Sample	Study Design.	Intervention	Duration & Follow-up	Main Findings (Effect sizes (ES) - Cohen's *d* values of 0.2, 0.5 and 0.8 represent small, medium and large effects respectfully)
Veverka et al. (2003) 39	Randomized Controlled Trial	Treatment group access to web-site, stage-matched health information. Control group had no access to web site.	6 Months	The percentage of bodyweight reduction was significant, as was BMI ($p < 0.002$) and body-fat ($p < 0.0004$).Data offered the following effect sizes (ES) - bodyweight (0.38 (S)), BMI - (0.53 (M)) and body-fat (0.42 (S)). Increases in PA were un-significant. The sample was small and reflected one American Air-base.
Dennis et al. (1999) 31	Randomized Controlled Trial	One hour per week. Treatment consisted of: diet, behavioural modification, cognitive and emotional factors and exercise (same as control).	16 Weeks	Reductions to bodyweight ($p = 0.05$), BMI ($p = 0.05$) and body-fat ($p < 0.05$) were all significant. ES data indicated that only body –fat (0.63 (M)) had a graded ES. Sample was small, on board ship and did not reflect females or officers. PA was not part of the intervention.
Hunter et al. (2007) 446	Cluster Randomized Controlled Trial	Treatment = internet based behavioural, dietary and exercise information. Control = see primary care provider once annually for a preventative health risk.	6 Months	Reductions to bodyweight, BMI and body-fat were all significant ($p<0.001$) for the BIT (treatment) as opposed to the UC (control). ES were all un-graded. The intervention aimed to prevent weight gain and promote weight loss, there were a broad spectrum of associated outcomes. PA measured by IPAQ was not significant.
James et al. (2001) 48	Non Randomised Controlled Trial	Treatment = interactive-video link for individuals on deployable ships, Control = weekly sessions (nutritional guidance and behavioural modification).	1 Year Follow-up 3 months	Reductions to bodyweight and BMI ($p = 0.005$) were both significant. BMI was reduced in the NIATV as opposed to the IATV ($p = 0.05$). All results include the former treatment (LE3AN) which all study participants undertook. No real reference as to the efficacy of the telehealth intervention was offered in isolation.

Author Year Sample	**Study Design.**	**Intervention**	**Duration & Follow-up**	**Main Findings (Effect sizes (ES) - Cohen's *d* values of 0.2, 0.5 and 0.8 represent small, medium and large effects respectfully)**
Davis (1996) 46	Non Experimental Pre / Post	Report on the weight loss programme for Soldiers using the FLEX programme 3 phases inc PA, diet, behavioural and relapse.	3 Weeks Follow-up 6 months	Reductions to bodyweight and body-fat were both significant ($p < 0.001$) at end of the intervention (3 weeks). Most values returned to pre-intervention status at follow-up (apart from HDL - $p > 0.01$). BMI and PA were not reported.
Earles et al (2007) 167	Non Experimental Pre / Post	Multi-disciplinary in-patient intervention, involving exercise, attitudes, emotions and nutrition.	1-3 Weeks Follow-up 1 Year	Only significant outcome reported was BMI ($p < 0.001$). Many un-significant outcomes and although PA was central to the intervention it was not reported
Trent and Stevens (1995) 624	Non Experimental Pre / Post	Evaluation of the Navy obesity treatment programme Level 1 = conditioning, Level 2 = counselling, Level 3 = In-patient	6 Weeks Follow-up 6 & 12 Months	Reductions to Bodyweight (m = $p < 0.001$, f = $p < 0.01$), BMI (m + f = $p < 0.01$) and body-fat (m + f = $p < 0.001$) were all significant. Bodyweight and BMI reflected small ES (0.22 & 0.34), body-fat medium ES (0.66). PA was not reported.
Simpson et al (2004) 111	Non Experimental Pre / Post	1 x Week multi-disciplinary in-patient coupled with a 1 year out-patient weekly follow-up. Involving exercise, attitudes, emotions and nutrition	1 Year	Reductions to bodyweight were significant for both ethnic groups ($p = 0.001$), with an associated ES of (0.56 (M)). Treatment was more effective for the European-American sample as opposed to the African-American sample ($p < 0.05$). The final small sample of 65 did not include minor ethnic groups. Body-fat, BMI and PA were not reported.
James et al (1999) 40	Non Experimental Pre / Post	3 x Week multi-disciplinary in-patient coupled with a 1 year out-patient follow-up. Involving exercise, attitudes, emotions and nutrition	3 weeks Follow-up 6, 12, 18 months	Data only expressed in crude form reporting a (calculated) reduction in male bodyweight- post intervention (6%) and at follow-up (6 month – 8.5%, 12 month – 6.7% 18 month – 6,8%). The results for the female cohort were – post intervention – 3.4%, follow-up (6 – 12.7%, 12 – 12.3%, 18 – 15.3%).

Author Year Sample	Study Design.	Intervention	Duration & Follow-up	Main Findings (Effect sizes (ES) - Cohen's *d* values of 0.2, 0.5 and 0.8 represent small, medium and large effects respectfully)
Bowles et al (2006) 53	Non Experimental Pre / Post	Report on the LIFE weight loss programme. 2 Phases inc PA, nutritional education and stress management.	1 Month Follow-up 6 & 12 Months	Reductions to bodyweight and BMI were significant (p < 0.001) body-fat was not reported. ES were stated for bodyweight (m = 0.42 (S), f = 0.48 (S)). Most weight was reported to be lost in the initial 6 months (follow-up 6 / 12 months). PA was not reported.
James et al (1997) 40	Non Experimental Pre / Post	3 x Week multi-disciplinary in-patient coupled with a 1 year out-patient follow-up. Involving exercise, attitudes, emotions and nutrition	3 weeks Follow-up 6 months	Data expressed in basic form reporting a (calculated) m = 6.3%, f = 4.5% decrease in bodyweight at the end of the programme, m = 9.3%, f = 12.3% reduction at follow-up. The study suffered from, reduced sample at follow-up (m = 10, f = 2), lack of available data at follow up for fitness, and lack of stratification for gender (fitness).
Woodruff et al (1992) 110	Non Experimental Pre / Post	Sub Base: 3 x per week 1.5 hrs – physical exercise. Air base: 3 x (min) per week; 6 offered, 40–45 mins physical exercise.	24 weeks	All participants significantly improved their general fitness (sub base – p = 0 008 and Air base p = 0.04), body weight and body fat were un-significant. Body-fat was reduced in over-fat individuals at the Sub base (p= 0.026), and the obese individuals at the Air-base (p = 0.005).
James et al (1997) 64	Non Experimental Pre / Post	3 x Week multi-disciplinary in-patient coupled with a 1 year out-patient follow-up. Involving exercise, attitudes, emotions and nutrition.	3 Weeks Follow-up 6 Months	Reduction in bodyweight was offered at the post intervention and the 6 month follow-up. The male sample had a reduction of 4.2%, at follow-up this figure rose to 10.8%. At post intervention the female sample reduction was 5.9% and 15.6% at follow-up. The study did not report PA, BMI or body-fat.

Table 2.3: Systematic Review factors associated with becoming overweight / obese		
Determinant	**Review**	**Reference(s)**
Demographic and biological factors		
Age (≥35)	+	(Bray et al 2006)
Subjects Education	0	(Bray et al 2006) (Grotto et al 2008)
Parents Education (Father's schooling ≤12 yrs)	+	(Grotto et al 2008)
Gender (male)	+	(Bray et al 2006)
Pay Group (enlisted)	+	(Bray et al 2006)
Marital Status (married spouse present)	+	(Bray et al 2006)
Race/ethnicity (non-white)	+	(Bray et al 2006)
Oral Contraceptives (females not taking)	+	(Grotto et al 2008)
Psychological, cognitive and emotional factors		
Lack of time (to eat healthily / undertake PA)	+	(Sigrist et at 2005)
Low priority (to eat healthily / undertake PA)	+	(Sigrist et at 2005)
Do not like to cook	+	(Sigrist et at 2005)
Perceptions of exercise leadership	+	(Croteau 2001)
Behavioural attributes and skills		
Smoking status (ex smokers)	+	(Grotto et al 2008)
Social and cultural factors		
Armed service (Navy)	+	(Bray et al 2006)
Physical environmental factors		
Reduced access to Fitness facilities	+	(Sigrist et at 2005)
Healthful food choices (not available)	+	(Sigrist et at 2005)
Confusion from the media	+	(Sigrist et at 2005)
Physical activity characteristics		
Physical activity level (low)	+	(Grotto et al 2008)
Notes: ++ repeatedly documented positive association with obesity, + weak evidence of a positive association with obesity, 0 mixed evidence as to the positive / negative association with obesity, -- Repeated documented negative association with obesity, - weak or mixed evidence of negative association with obesity. N/R not reported / no data available.		

Discussion

The purpose of this review was to evaluate the available literature on the treatment and correlates of obesity in the Armed Forces. This paper is the first of its kind to systematically review these areas. The main findings of the review will be discussed in terms of these two areas below:

Treatment

Of the 13 reported studies, six (James, Folen and Earles 2001, Earles et al 2007, Simpson et al 2004, James et al 1999, James et al 1997, James, Folen and Davis 1997) referred to the LEAN intervention programme. However, each study reported on either a specific population or an evolution of the original framework, based on CBT. A similar 'cognitive behavioural' approach was also followed in the 'Lifestyle change, Individual readiness, Fitness excellence and Eating healthy' (LIFE) (Bowles et al 2006) and 'Fat Loss and Exercise' (FLEX) (Davis 1996) programmes. The TTM was applied in one study (Veverka et al 2003) with the remaining four studies having no reported theoretical framework. Universally the interventions that were supported by theoretical methodologies displayed greater efficacy in respect of weight loss. Previous reviews have highlighted the value of using behavioural theory to clarify individual component effectiveness (Sharma 2007), and the influence of mediating variables (Baranowski, Anderson and Carmack 1998).

Most interventions incorporating PA were poorly described, with little reference made to the prescriptive elements. All of the LEAN programmes (James, Folen and Earles 2001, Earles et al 2007, Simpson et al 2004, James et al 1999, James et al 1997, James, Folen and Davis 1997) advocated low intensity PA (a target pulse rate of 60% - 70% of maximum heart rate) for 40 minutes (Mon-Fri = 200 min/week) (James et al 1999). Current recommendations suggest that 45-60 mins/day of moderate intensity activity is required to prevent the transition to overweight or obesity and that 60-90 mins/day is required for the prevention of weight regain in formerly obese individuals (Saris et al 2003). The advocacy of low-intensity PA in the LEAN programmes was based on one study using a civilian female sample (Jakicic et al 1995), and may not adequately reflect a sub-population that is predominantly male who regularly engage in vigorous PA. The existence of dietary modification and diet education was another central theme of most of the interventions and is reflective of recent literature (Sharma 2007, Lang and Froelicher 2006). Two studies (Davis 1996, James et al 1999) reported the dietary modification applied (male – 1500 - 2000 kcal/day, female – 1400 - 1600 kcal/day), and these values are broadly in keeping with civilian recommendations (Nammi et al 2004). Whilst both studies were successful in reducing bodyweight, the 'multi-component' nature of the interventions precludes comment as to the efficacy of the individual component.

With the exception of five studies (Trent and Stevens 1995, Woodruff, Linenger and Conway 1992, Veverka et al 2003, Dennis et al 1999, Hunter et al 2008), general reference was made to the multi-disciplinary nature of the interventions and requirement for suitably trained professionals to support the intervention process. Health psychologists, dieticians, physical therapists and other paraprofessionals supported all of the LEAN programmes (James, Folen and Earles 2001, Earles et al 2007, Simpson et al 2004, James et al 1999, Bowles et al 2006, James et al 1997, James, Folen and Davis 1997), with similar support evident for the FLEX (Davis 1996) and LIFE (Bowles et al 2006) programmes. A self monitoring process was employed in the majority of interventions. The LEAN programmes incorporated specific self-monitoring techniques, based on evidence gained from 'binge eating' (James et al 1997) which attempted to highlight food relationships (family and social-environmental), and extended beyond food-journals utilized in most other interventions (Davis 1996, Dennis et al 1999, Hunter et al 2008). The keeping of detailed records in regards to nutrition and PA are often considered one of the key features of behavioural therapy (Berkel et al 2005), and have been associated with quick reductions in food intake and associated weight-loss (Blundell 2000). Collectively the programmes that employed self-monitoring techniques were the more successful (in terms of % of bodyweight lost) than those who did not (Woodruff, Linenger and Conway 1992, Veverka et al 2003).

The most successful interventions (Simpson et al 2004, James et al 1999, James et al 1997, James, Folen and Davis 1997) lasted twelve months, however, in the one study where data, were presented beyond 12 months (James et al 1997), the majority of weight loss occurred in the first 6 months. These findings were corroborated in an evaluation of the US Navy's obesity treatment programme (Trent and Stevens 1995) in that individual weight loss at 6 months remained in a virtual plateau until 12 months. One paper (Davis 1996) indicated that out-patient follow-up was hampered by changes in assignments, field exercises and mission requirements. The lack of genuine follow-up in most cases prevents any informed conclusion as to the long-term efficacy of the separate interventions. This fact remains problematic as most weight loss programmes can achieve satisfactory initial weight loss (Lang and Froelicher 2006), however, maintenance of weight loss is rarely retained (Wing 1997).

The majority of the interventions (Davis 1996, Earles et al 2007, James et al 1999, Bowles et al 2006, James et al 1997, James, Folen and Davis 1997, Trent and Stevens 1995, Dennis et al 1999) delivered the intervention through a combination of group and individual therapy, four programmes relied on individual / one to one treatment; group therapy alone was utilized by one intervention (Woodruff, Linenger and Conway 1992). In general the interventions that used a combined approach were more successful. Two of the interventions that used individual treatment were web-based (Veverka et al 2003, Hunter et al 2008), both interventions were statistically successful at reducing bodyweight, BMI and body fat, although the effect sizes (ES) were not clinically meaningful for one intervention (Hunter et al 2008). Internet-based programmes may present a platform for a widespread approach to weight management (Winet et al 2005) and offers a possible treatment option for those working in isolated areas.

All of the interventions reviewed were undertaken within armed forces real-estate, with all personnel subject to military rules therefore, attendance may not have been purely voluntary. The LEAN programmes all had a period of in-patient care at an Army medical centre. Three other interventions (Davis 1996, Bowles et al 2006, Trent and Stevens 1995) utilized an initial in-patient process for some or all of the tiered interventions. The remaining four interventions (Woodruff, Linenger and Conway 1992, Veverka et al 2003, Dennis et al 1999, Hunter et al 2008) were based in the workplace. Of the remaining two programmes, one (Woodruff, Linenger and Conway 1992) compared the efficacy of two conditioning programmes for land-based naval personnel. Both programmes utilized exercise as a singular intervention component. Whilst trends towards fitness improvement were reported (Woodruff, Linenger and Conway 1992), poor compliance and lack of a multidisciplinary approach, were suggested as reasons for the failure to elicit significant changes in weight status. Such findings are supportive of previous studies suggesting that interventions utilizing a multidisciplinary approach may be more effective (Lang and Froelicher 2006, Jakicic and Otto 2005).

Correlates

Demographic and Biological Factors: Bray et al (2006) concluded that a higher educational level was correlated with obesity prevalence in US Armed Forces personnel. Yet in a study based on the Israeli military (Grotto et al 2008), lower and not higher educational level (for study subject and male parent) was correlated to obesity. Current opinion concurs with the findings of Grotto et al (2008) and is supportive of a relationship between lower educational attainment and higher levels of obesity (Martinez et al 1999). Bray et al (2006) suggested that 'pay group' status of military personnel was correlated with obesity, in that those on lower pay displayed higher levels of obesity. There is a direct correlation between the hierarchical system of rank employed within the military and 'pay-group', with higher rank commanding higher wages. Several studies have highlighted the relationship between SES, obesity relevant health behaviours (Molarius 2003) and income inequality (Picket et al 2005). In one obesity review (Ulijaszek 2007), it was proposed that there may be psychosocial consequences of living in a 'more hierarchical society'. Therefore, it is not surprising that obesity was more common in the lower paid 'enlisted ranks' as opposed to the higher paid 'officer class' (Bray et al 2006). Obesity was found to be more prevalent in males aged ≥35 years (Bray et al 2006), which has also been observed in civilian samples (Martinez et al 1999). Being 'married' was linked to a higher level of obesity (Bray et al 2006). Specifically, married individuals who were accompanied by their wife / partner at their place of work had a higher propensity of obesity. This suggests that future obesity treatment interventions should also include spouses and partners (IOM 2004). Within the review stratification by injury status was not alluded to; military populations have high levels of musculoskeletal injury (Knapik et al 2004), and obesity is one outcome associated with long-term injury (Lohmander et al 2007). A recent study involving the British Navy (Kilminster, Roiz de sa and Bridger 2008) stated that those individuals deemed medically unfit (21.8%) as opposed to fit (12.1%) were almost twice as likely to be obese and, therefore, injury status should be investigated further.

Psychological, Cognitive and Emotional Factors: Lack of time, low priority and not liking cooking were offered as barriers to healthy living (Sigrist, Anderson and Auld 2005), with lack of time and low priority largely attributed as barriers towards PA and healthy eating. Within the correlates of PA 'lack of time' as a negative association attracted repeated support (Trost et al 2002, Dishman, Sallis and Orenstein 1985). Although based on a small specific sample, the allocation of time for PA and healthy eating deserves further investigation. Sigrist, Anderson and Auld (2005) further concluded that enjoyment of cooking may influence obesity status. Lack of cooking confidence, ability and enjoyment may impact on the ability to prepare healthy and inexpensive meals (Hyland et al 2006) and could enforce a reliance on convenience foods, many of which are high in fat (WHO

2003). However, this knowledge should reflect the institutional nature of the military services in regards to habitation and access to cooking facilities. The reviewed papers do not attempt to gain an understanding as to the food choices military personnel make or why they participate in PA. Due to the prospective impact of dietary habits and PA, the psychological factors that inform these decisions should be further investigated. Perceptions of exercise leadership displayed a negative association with reductions in body fat. Paradoxically those individuals less approving of the exercise leader displayed greater reductions in body fat (Croteau 2001). The authors postulated that the greater levels of self-motivation displayed by the participants showing the most significant weight loss could offer a possible explanation for this outcome (Croteau 2001), and this suggested explanation has been supported in a further study (Williams et al 2006). For countries such as the UK with dedicated military physical training instructors, additional investigations are required to understand the positive or negative influence of fitness instructors.

Behavioural Attributes and Skills: One behavioural attribute was identified from the four studies; Grotto et al (2008) concluded that smoking status (none smoker) was associated with lower BMI, and is a generally accepted relationship (Martinez et al 1999). The military is an institution with a high habitual alcohol intake (Kilminster, Roiz de sa and Bridger 2008), and long-term alcohol intake has been observed to increase BMI (Breslow and Smothers 2004). This is an area worthy of investigation within the military.

Social and Cultural Factors: Bray et al (2006) concluded that Navy personnel, as opposed to individuals serving in the Army, Air-force and Marine Corps, displayed a higher prevalence of obesity. One paper has suggested that snacking, and a lack of fresh food, which may be specific to ship-bound personnel may offer an explanation for this finding [34]. Social support was not reported to be a significant factor for weight and fat loss (Croteau 2001); however, this conclusion is not generally supported (Cohen et al 2005). One study (Berkman and Syme 1979) offered that those individuals with less social ties were more likely to be obese. Due to the social support network modifications linked to the regular location changes associated with military service, the perceived level of individual social support / isolation should be assessed.

Physical Environmental Factors: Reduced access to fitness facilities was offered as a correlate of obesity (Sigrist, Anderson and Auld 2005), while the restriction was not clarified as actual or perceived, similar findings have been suggested in the area of PA correlates (Trost et al 2002). Within most military units fitness facilities are freely available; however, within the operational environment access to fitness facilities could be markedly reduced. Thus the actual and perceived availability of suitable facilities warrants further investigation. Sigrist, Anderson and Auld (2005) concluded that the lack of healthy food choices and mixed media 'nutrition' based messages could influence the prevalence of obesity. Within work-site interventions, pricing has been observed to increase the consumption of healthy snacks (French et al 1997). Alternatively, increasing the availability of low-cost convenience foods may contribute to obesity (Cohen et al 2006). The issue of food availability and price is however, a multi-level issue for the military due to the centralised feeding associated with single personnel and the influence of the marital home, and should be further instigated within the environmental constraints.

Physical Activity Characteristics: Grotto et al (2008) concluded that high levels of PA (≥4 aerobic sessions p/week) were negatively associated with an increase in BMI, and that low levels of PA (<1 aerobic session p/week) were positively associated with overweight in females. Bray et al (2006) postulated that an increase in the prevalence of obesity in military personnel from 1995 – 2002 measured by BMI was associated with an increase in strenuous exercise across the same time period. However, definition of weight status, by the use of BMI in isolation could be misleading in a military population as the BMI may simply reflect greater muscle mass (McLaughlin and Wittert 2009). In a review of the variables independently associated with obesity in the European Union, Martinez et al (1999) concluded that low participation in leisure-time PA was associated with higher levels of obesity. Further clarity is required as to the association between PA and obesity. However, to fully appreciate the multiple factors associated with PA, allied to the impact of increasing sedentary behaviours, a wider ranging epidemiological investigation may be required (Martinez et al 1999).

Conclusions and Recommendations

This review has highlighted the lack of information available as to the probable correlates of obesity in military personnel. The information that is available on treatment is reflective of an American population and therefore raises significant issues of generalisability for other military populations. For the treatment of obesity the reviewed papers suggest that a multi-component approach to obesity within the military offers the most effective method. Whilst insufficient follow-up prohibits conclusions on the long-term efficacy of interventions, the application of behavioural theory to the intervention process was in the main supportive of significant weight-loss. However, if theory is to be applied, measurement of the mediating variables should be undertaken, as this will indicate the efficacy of the supporting theoretical framework and the mediating effect of the theoretical constructs (Sharma 2007, Baranowski, Anderson and Carmack 1998).

Although seldom mentioned in the reviewed papers, the institutional nature of the armed services may significantly impact on many aspects of an individual's immediate social and environmental surroundings, it follows, therefore, that interventions will need to account for the individual behaviour and the environment in which they interact with. Ecological models (Sallis and Owen 2002) may offer a theoretical process that can fully reflect the physical, economic, socio-cultural, environmental, and policy influences of obesity (Baranowski et al 2003). Significantly, all the correlate studies included in the review were of a cross-sectional nature and, therefore, causal relationships cannot be implied. Furthermore, in each instance the evidence was based on a single paper and was focused on a US or Israeli sample, presenting significant generalisability issues for other military populations. It is recommended that future correlates studies on the military should attempt to reflect the multi-factorial nature of obesity (Nammi et al 2004), the interaction with civilian society and the immediate institutional environment.

Chapter 3

Prevalence of Obesity in the British Army

Chapter 3 Prevalence of Obesity

Chapter 3 seeks to establish the scale (prevalence) of obesity in the British Army. The study is based on the secondary analysis of a large data set (n=50,000+) of serving British Army officers and soldiers. The study reports prevalence by socio-demographic and other variables. The completed prevalence paper is published in the *Annals of Human Biology (2014).*

Prevalence and Socio-Demographic Correlates of Obesity in the British Army

Introduction

Obesity is a multi-factorial disorder (Nammi et al 2004) linked to a higher likelihood of many chronic illnesses, including cardiovascular disease, diabetes and certain types of cancer (Ezzati et al 2002). Obesity has reached epidemic proportions globally and is rated the fifth most important risk factor contributing to the total worldwide disease burden (WHO 2009). The prevalence of obesity in the United States (US) continues to be high, exceeding 30% in most sex and age groups (Flegal et al 2010). The World Health Organisation (WHO) stated that approximately 1.6 billion adults (≥15 years of age) were overweight and at least 400 million adults were obese (WHO 2006). Whilst some surveys have indicated that the increase in obesity prevalence does not appear to be continuing at the same rate as seen over the last 10 years (Flegal et al 2010), United Kingdom (UK) estimates indicate that almost two-thirds of adults and a third of children are either overweight or obese (NHS 2011).

Many countries are monitored by comprehensive national health surveys that report obesity prevalence and emerging trends (Rennie and Jebb 2005). The worrying trend of escalating obesity has prompted some armed forces to replicate these surveys for military personnel, the findings of which have indicated that obesity is also a cause for concern in these specific populations (Napredit et al 2005, Mullie et al 2008, Helmhout 2009, Bray et al 2009). Where trend data are available, they suggest there has been little change in the level of overweight from 1998 through 2008 (48.8% and 48.6%), however, this level of stability is not replicated within the obese (Body Mass Index (BMI) ≥30.0 kg/m^2) military population, where the prevalence has more than doubled (6.4% - 13.2% 1998 and 2008 respectively) (Bray et al 2009). Current information indicates that obesity affects recruitment (Niebuhr et al 2009) and retention (McLaughlin and Wittert 2009) and has significant financial implications (Dall et al 2008). Furthermore, Kress et al (2005) concluded that US military retirees have a higher prevalence of obesity compared to their civilian counterparts, suggesting that a career in the military does not protect against obesity or associated co-morbidities. Given the current level of operational deployments and the associated fitness requirements for combat (McGraw et al 2008) and the threat to health and morbidity that obesity poses (Ezzati et al 2002), the aim of this chapter is to provide an appraisal of obesity prevalence and risk to obesity related diseases in the British Army in relation to age, gender, military rank and employment category.

Methods

Data presented are based on secondary analyses undertaken by the lead investigator on an existing data set produced for the British Army by the Defence Analytical Services and Advice (DASA), from information captured through the Army Fitness Information Statistical Software (FISS) system (DASA 2011). This information was electronically collected from units that had centralised information technology (IT) support within the Field Army and therefore did not account for individuals serving outside of centralised IT support and within training establishments. Furthermore, those serving in isolated areas or areas of heightened security were not accessible. From the original study population (N=54,854), 4219 individuals were removed as they did not meet the pre-set study cohort criteria of being regular army personnel with complete anthropometric information. Personnel were removed for the following reasons: 2562 due to Reservist status, 1109 for being in initial training and 245 for being cadets or university officer training corps personnel. Measurement error withdrew a further 233 individuals, and 70 were removed from the data set due to incomplete BMI information). The eventual observational cohort reflected 49.5% (*n*=50,635) of the British Army (*n*=102,202). Males accounted for 93% (*n*=47,173) and 7% were female (*n*=3,462), which is representative of the current army population of 92% and 8% respectively. The cross sectional data are in support of the Armed Forces Weight Management Policy (WMP), which stipulates that all personnel are required to provide bi-annual BMI and Waist Circumference measurements.

Anthropometric Assessment

Body mass and height were measured by medical staff (nurse) or by the unit Physical Training Instructor (PTI), who were trained to undertake these procedures.

Body Mass: Individuals were weighed to the nearest 0.1 kg using digital scales (Seca, Hamburg, Germany) wearing t-shirt and shorts.

Height: Height was measured to the nearest 0.1 cm. Individuals removed their footwear before standing on the stadiometer (Invicta, Leicestershire, England). Feet, buttocks and scapulae were in contact with the back of the stadiometer, and the individual was instructed to look directly ahead.

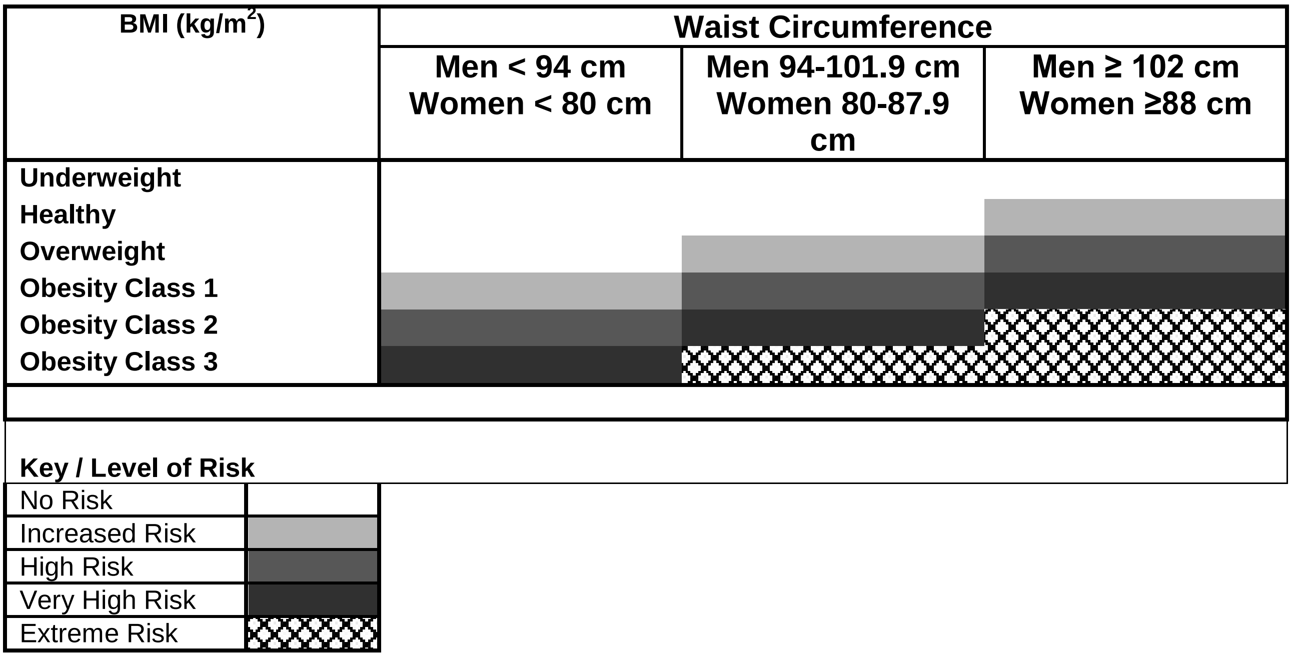
Body Mass Index (BMI): BMI was calculated from the equation of body mass divided by the square of height (kg/m^2).

Waist Circumference: This was measured at the level of the naval (usually the smallest diameter between the costal margin and the iliac crest) to the nearest 0.1 cm.

Classifications

Weight status was clarified by BMI and waist circumference using the current National Institute of Health & Clinical Excellence (NICE) guidelines (NICE 2006) based on the WHO recommendations (WHO 2000). These guidelines indicate that overweight is a BMI 25.0 – 29.9 kg/m^2, and obesity is characterised by a BMI 30.0 kg/m^2 and above. Obesity is further classified as class 1 (30 – 34.9 kg/m^2), class 2 (35.0 – 39.9 kg/m^2) and class 3 (≥40.0 kg/m^2). NICE guidelines suggest that waist circumference(s) of <94 cm for men and <80 cm for women is a healthy weight status, 94 cm -101.9 cm for men and 80 cm - 87.9 cm for women is overweight and >102 cm and >88 cm for men and women would be indicative of obesity. The NICE guidelines attribute a level of risk to obesity-related ill-health (particularly type 2 diabetes and coronary heart disease) using a combination of BMI and waist circumference measurements (NICE 2006), this risk matrix (Figure 3.1) is referred to in the text as 'level of risk'.

Figure 3.1: BMI and waist circumference (risk of obesity related ill-health matrix) – based on NICE (2006) guidelines.



Statistical Plan

Participants were categorised into groups according to age, gender, rank and operationally defined employment category. Age in years was reflected by the following groups (17-24, 25-34, 35-44, ≥45); with gender being either male or female. The terms Direct Entry (DE) Officer, Late Entry (LE) Officer and Soldier (all enlisted ranks) were utilized in the study. It was felt that the officer class required a further sub classification due to the potentially confounding nature of the LE Officer's age in relation to the DE Officer. LE Officers commission from the ranks and are typically 37+ years at the rank of Captain (43+ years = Major, 50+ years = Lieutenant Colonel). DE Officers commission direct from the civilian population and are typically 27+ years at the rank of Captain (30+ years = major, 35+ years = Lieutenant Colonel).

The operationally defined employment categories of Combat, Combat Service Support, Combat Support Services and Other were employed. Military personnel were categorised as Combat if they generally had direct contact with enemy forces. Combat Service Support were those personnel who offered direct support to combat elements, while Combat Support Services provided indirect support to combat elements and Others were supportive to all personnel (primarily through training).

Through further analysis, skewed distributions were identified through the calculation of z-scores, with a score of 3.29 constituting an outlier; these scores were then replaced with a value of the mean + 3 x the SD (Field 2005). The reported values were expressed as the proportion of individuals within each category. For categorical data, Chi-squared tests were used to compare the prevalence of obesity and risk to obesity-related ill-health in the demographic sub-groups.

Multiple logistic regression was used to identify independent predictors of obesity (BMI ≥30.0 kg/m^2) and increased risk to obesity related ill-health (including those categorised as increased, high, very high and extreme risk). Significant predictors were used to calculate the odds of being obese and the odds of having an increased risk towards obesity-related ill-health. Statistical significance was assessed with 95% confidence intervals (CI). The analyses were conducted separately by gender due to differences in both the prevalence of obesity and risk to obesity-related ill-health. Referent values were assigned within each predictor group (age - 17-24, marital status - married, rank - officer and employment group - combat). Model 1 incorporated the categories identified above (age, marital status, rank, and employment group) this least adjusted model represented the outcome of univariant analyses. Model 2 used multivariant analyses through multiple logistic regression to enable the identification of significant demographic predictors, while potential confounders were controlled. Analyses were performed using PASW version 18, and statistical significance was set at an alpha level of 0.05.

Results

BMI and Waist Circumference

Table 3.1 illustrates the sociodemographic characteristics of the British Army cohort. The study population, whilst primarily male, single and soldier (as opposed to officer), remains typical of the demographic of the British Army. Gross result by gender for BMI and obesity-related ill-health are presented in Table 3.2. According to BMI, 56.7% of the study population were overweight and of those individuals 12% were obese. Males were more overweight and obese than females, with 45.8% of males being overweight and 12.2% obese, compared to females who were 30% and 8.6% respectively. There were significant associations between gender and obesity χ^2 (1) = 42.1, $p < .001$ and based on odds ratios 'ORs' males were 1.49 (95% CI = 1.32–1.69) times more likely to be obese (than females). When waist circumference data were added to the BMI data, the results indicate that 24.5% of the study population was at increase risk of obesity-related ill-health, with females displaying higher levels of risk than males (30.4% and 24% respectively). This significant association (χ^2 (1) = 81.73, $p < .001$) suggested that (based on ORs) female study participants were 1.41 (95% CI = 1.31–1.52) times more likely to be at an increase risk of obesity-related ill-health than male study participants.

Table 3.1: Sociodemographic Characteristics for British Army total study cohort and by gender - (DASA 2011).

Variable	Sub Group	All = 50,635		Male = 47,173		Female = 3,462	
		n (%)		n (%)		n (%)	
Age Group	17 - 24	17,707	(35.0)	16,448	(35.0)	1,259	(36.4)
	25 – 34	20,949	(41.4)	19,343	(41.0)	1,606	(46.4)
	35 – 44	10,448	(20.6)	9,915	(21.0)	533	(15.4)
	45+	1,531	(3.0)	1,467	(3.0)	64	(1.8)
Military Status	Officer	3683	(7.3)	3,232	(6.9)	451	(13.0)
	LE Officer	780	(1.6)	739	(1.6)	41	(1.2)
	Soldier	46,172	(91.1)	43,202	(91.5)	2,970	(85.8)
Employment Group	Combat	15,663	(31.0)	15,594	(33.1)	69	(2.0)
	Com Services Support	14,738	(29.1)	14,043	(29.7)	695	(20.1)
	Com Support Services	15,269	(30.1)	13,817	(29.3)	1452	(42.0)
	Other	4,818	(9.5)	3,576	(7.6)	1242	(35.9)
	Missing	147	(0.3)	143	(0.3)	4	(0.0)

Table 3.2: Results for BMI and Risk to obesity related ill-health, (based on NICE 2006 guidelines) for total study cohort and by gender.

Category	All (50,635)	Male (47,173)	Female (3,462)
BMI kg/m^2	**n (%)**	**n (%)**	**n (%)**
<18.5	146 (0.3)	116 (0.3)	30 (0.9)
18.5 – 24.99	21787 (43.0)	19,693 (41.7)	2,094 (60.5)
25.0 – 29.99	22628 (44.7)	21,590 (45.8)	1,038 (30.0)
30.0+	6074 (12.0)	5,774 (12.2)	300 (8.6)
Risk (BMI & WC) WC)	**n (%)**	**n (%)**	**n (%)**
Underweight	146 (0.3)	116 (0.3)	30 (0.9)
No Risk	38084 (75.2)	35,705 (75.7)	2,379 (68.7)
Increased Risk+	12405 (24.5)	11,352 (24.0)	1,053 (30.4)

Univariate and Multivariate Analyses

The results of the multiple logistic regression analyses are shown for male study participants in, Table 3.3 (BMI) and Table 3.4 (risk of obesity-related ill-health). For female study participants, Table 3.5 shows the results for BMI and Table 3.6 displays the results in regards to risk of obesity-related ill-health. Multivariate analyses suggest male and female personnel classified as older and enlisted had greater odds of being obese. In addition those male personnel, who were married and employed in a non-combat role, were more likely to be obese. For female personnel, marital status and employment category were not significantly linked to BMI status. When WC measurements were added to BMI data and the risk of obesity-related ill-health were assessed; older, enlisted and married male and female soldiers had greater odds of increased risk. In addition and for male soldiers, those employed within a combat category had the least risk of obesity-related ill-health.

Male – BMI: For male study participants univariate analyses indicated that age, marital status, rank and employment group were all significant predictors of obesity (Table 3.3). When each predictor is controlled for each other, the multivariant analyses produced a final model χ^2 (9) = 4252.78, the R^2 0.156, suggest that the variables included in the model explain 16% of the variance. Of note, each interaction within age group remained significant p<.001, with those male army personnel of >45 years displaying the highest odds (14.43, 95% CI = 11.61–17.03). Being married remained significant p<.001, the eventual OR (1.74, 95% CI = 1.61–1.87) suggests that married male personnel were nearly 2 times more likely to be obese. For rank, being a soldier significantly (p<.001) increase the odds (3.35, 95% CI = 2.87–3.90) of being obese (when assessed against those who were DE Officers). While LE Officers were still 1.5 times more likely to be obese than DE Officers, the level of significance reduced to p<.05. For employment category, the only significant interaction was between the referent category (combat) and those male soldiers employed within Combat Services Support p<.05.

Table 3.3: Male BMI – Odds ratio of being obese, univariate and multiple logistic regression controlling for age, marital status, rank and employment group.

Variable	Group	Least Adjusted - Univariate				Multiple Logistic Regression			
		Sig[1]	OR	95% CI		Sig[1]	OR	95% CI	
				H	L			H	L
Age Group	17-24		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	25-34	***	**4.12**	3.78	4.85	***	**3.46**	3.16	3.80
	35-44	***	**13.01**	11.85	14.28	***	**10.51**	9.45	11.70
	45+	***	**12.12**	10.21	14.40	***	**14.43**	11.61	17.93
Marital Status	Single		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Married	***	**3.87**	3.64	4.12	***	**1.74**	1.61	1.87
General Rank	Officer		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	LE Officer	***	**3.58**	2.72	4.70	*	**1.54**	1.14	2.09
	Soldier	***	**1.46**	1.27	1.68	***	**3.35**	2.87	3.90
Employment Group	Combat		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Com Support Services	***	**1.15**	1.07	1.24		**1.03**	0.95	1.12
	Com Services Support	***	**1.47**	1.36	1.58	*	**1.12**	1.03	1.22
	Other	***	**2.14**	1.91	2.39		**0.95**	0.84	1.08

Note:

1. Significance level: * p<0.05, ** p<0.01, ***p<0.001.

Male Risk (BMI and WC combined): Univariate analyses of each predictor group suggested that age, marital status, rank and employment category were all significant predictors of increased risk of obesity-related ill-health (Table 3.4). Multiple logistic regression produced a final model ($\chi^2(9)$= 4292.20) and a R^2 = .083, suggesting that the predictors included in the model accounted for 8% of the variance. When controlling for each predictor variable, age still retained significant interactions between the referent and each age sub-group (p<.001), with the ≥ 45 year olds being over 7 times more likely to be at increase risk of obesity-related ill-health than the referent group (17-24). Odds ratios (1.4, 95% CI = 1.33–1.47) suggest that being married significantly (p<.001) increases the risk of obesity-related ill-health. While both rank interactions with the referent category (DE

Officer) remained significant, the LE Officer's significance of interaction was reduced to (p<.05). However, ORs indicate that soldiers are over 3 times more likely to be at an increased risk than officers (DE). For employment category all interactions with the referent 'combat' category were significant and although the ORs suggest a reduced size of effect (all between 1.12 and 1.26). Moreover, the direction of effect by the ORs indicated that male personnel employed in the combat category compared to personnel in the remaining 3 employment groups were least likely to be at risk of obesity-related diseases.

Table 3.4: Male Risk – Odds ratio for being at increased risk of obesity related ill-health, based on NICE (2006) guidelines: univariate and multiple logistic regression controlling for age, marital status, rank and employment group.

Variable	Group	Least Adjusted - Univariate				Multiple Logistic Regression			
		Sig[1]	OR	95% CI		Sig[1]	OR	95% CI	
				H	L			H	L
Age Group	**17-24**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	25-34	***	**2.60**	2.45	2.76	***	**2.32**	2.18	2.47
	35-44	***	**6.07**	5.70	6.47	***	**5.14**	4.78	5.53
	45+	***	**6.96**	6.21	7.79	***	**7.40**	6.41	8.54
Marital Status	**Single**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Married	***	**2.55**	2.45	2.67	***	**1.40**	1.33	1.47
General Rank	**Officer**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	LE Officer	***	**2.49**	2.10	2.95	*	**1.24**	1.03	1.50
	Soldier	*	**1.14**	1.05	1.25	***	**1.93**	1.76	2.12
Employment Group	**Combat**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Com Support Services	***	**1.19**	1.12	1.26	***	**1.12**	1.06	1.19
	Com Services Support	***	**1.50**	1.42	1.58	***	**1.26**	1.19	1.33
	Other	***	**2.02**	1.87	2.19	**	**1.16**	1.07	1.27

Note:
1. Significance level: * p<0.05, ** p<0.01, ***p<0.001.

Female BMI: For female military personnel the univariate analyses indicate that age, marital status and rank are all significant predictors of obesity. When predictors are controlled for each other a final multiple regression model χ^2 (9) = 98.03 produced a R^2 = .06. This model ceases to recognise the interaction between the female DE officer (referent) and LE officer as significant, however, odds ratios suggest that female soldiers are more likely to be obese than DE officers (ORs 4.1, 95% CI = 2.45–6.75, p<.001). Age retained high levels of significance (p<.001) for each interaction compared to the referent, with the ≥45 years age group being over 10 times more likely to be obese than the referent 17-24 years age group. For female study participants, multivariate analyses indicate that marital status is not a significant predictor of obesity. The final R^2 = .06, suggests a reduced fit compared to the male final model (female 6% and male 16% of variance explained respectively).

Table 3.5: Female BMI – Odds ratio of being obese, univariate and multiple logistic regression controlling for age, marital status, rank and employment group.

Variable	Group	Least Adjusted - Univariate				Multiple Logistic Regression			
		Sig[1]	OR	95% CI		Sig[1]	OR	95% CI	
				H	L			H	L
Age Group	**17-24**		**1.00**	**-**	**-**		**1.00**	**NA**	**NA**
	25-34	***	**2.47**	1.80	3.40	***	**2.36**	1.63	3.42
	35-44	***	**4.40**	3.03	6.39	***	**3.84**	2.48	5.94
	45+	***	**9.15**	4.66	17.95	***	**10.48**	4.68	23.50
Marital Status	**Single**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Married	***	**1.69**	1.30	2.19		**1.06**	0.80	1.41
General Rank	**Officer**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	LE Officer	*	**4.70**	1.71	12.95		**2.27**	0.75	6.80
	Soldier	***	**2.54**	1.59	4.06	***	**4.06**	2.45	6.75
Employment Group	**Combat**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Com Support Services		**0.70**	0.26	1.87		**0.58**	0.21	1.61
	Com Services Support		**1.16**	0.45	2.99		**0.96**	0.35	2.58
	Other		**1.29**	0.50	3.34		**0.81**	0 .30	2.20

Note:
1. Significance level: * p<0.05, ** p<0.01, ***p<0.001.

Female Risk (BMI and WC combined): An investigation of the female univariate output for risk of obesity-related ill-health reveals very similar outcomes to BMI univariate data, with age, marital status and rank all significant in their ability to predict increased levels of risk. When all predictors are controlled for each other, significant interactions between the referent and each age group are evident (p<.001), ORs indicate that older female personnel are at higher risk of obesity-related ill-health than younger female personnel. While ORs peak at the ≥45 years age group (3.99, 95% CI = 2.22–6.75), the 35-44 age group odds ratio (3.21, 95% CI = 2.53–4.06) suggests a levelling out of the effect. While marital status significance is retained in the final model the significance level and effect is reduced (ORs 1.22, 95% CI = 1.02–1.44, p<.05). Final multiple logistic regression supports the DE officer and soldier interaction (p<.001); however, the interaction between officer groups (DE and LE) was insignificant. ORs suggest the female soldiers are 4 times more likely to be at risk of obesity-related ill-health than female officers (DE). Multivariate analyses show that when female BMI and WC data are combined, and risk to obesity-related ill-health is assessed, that no significant difference exists between employment groups. The final multiple logistic regression model (χ^2 (9) = 98.03, R^2 = .04) is suggestive of a reduction of fit in comparison to the male final model (female 4% and male 8% of variance explained respectively).

Table 3.6: Female Risk – Odds ratio for being at increased risk of obesity related ill-health, based on NICE (2006) guidelines: univariate and multiple logistic regression controlling for age, marital status, rank and employment group.

Variable	Group	Least Adjusted - Univariate				Multiple Logistic Regression			
		Sig[1]	OR	95% CI		Sig[1]	OR	95% CI	
				H	L			H	L
Age Group	**17-24**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	25-34	***	**1.58**	1.34	1.88	***	**1.78**	1.49	2.13
	35-44	***	**2.69**	2.16	3.34	***	**3.21**	2.53	4.06
	45+	***	**2.67**	1.60	4.45	***	**3.99**	2.22	7.16
Marital Status	**Single**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Married	***	**1.50**	1.27	1.76	*	**1.22**	1.02	1.44
General Rank	**Officer**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	LE Officer	*	**2.92**	1.49	5.72		**1.82**	0.89	3.71
	Soldier	***	**2.17**	1.69	2.80	***	**2.88**	2.21	3.75
Employment Group	**Combat**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Com Support Services		**0.62**	0.37	1.04		**0.63**	0.37	1.08
	Com Services Support		**0.84**	0.51	1.39		**0.79**	0.47	1.32
	Other		**0.77**	0.46	1.27		**0.61**	0.36	1.03

Note:
1. Significance level: * p<0.05, ** p<0.01, ***p<0.001.

<u>Discussion</u>

The aim of this study was to report the prevalence of obesity and risk to obesity-related ill-health in a representative sample of individuals from the British Army. The large sample size supported an assessment of obesity prevalence across gender, rank, age group and operationally defined employment categories and represents the first study to investigate this specific population.

Across both genders, age represented a clear relationship with obesity and risk to obesity related diseases. This relationship is generally supported in other studies on the military population (Napredit et al 2005; Mullie et al 2008; Helmhout 2009; Bray et al 2009; Shaw, et al 2013). Similarly a significant association χ^2 (3)=41.86 ($p<0.05$) was found between age group and BMI classification of UK Royal Navy personnel, whereby participants in the 35-44 and ≥45 year age group were more likely to be obese in comparison to the younger age groups (Shaw et al 2013). Due to compressed age demographics in the current study, comparisons with civilian studies are problematic; however, several studies involving large samples have reported a relationship between age and weight status (Flegal et al 2010, Health Survey for England 2007). In respect of risk of obesity related diseases, the results of the present study (24% male and 30% female soldiers at increased risk) are comparable with recent data on the UK Royal Navy in which 30% of males and females are at increased risk (Shaw et al 2013), however, both are lower than the UK civilian population in which 57% of males and 56% of females are at increased risk (Health Survey for England 2010).

A study by Gallagher et al (1996) suggested that declining stature could account for a minor portion of the age-related increase in BMI, indicating that the advent of skeletal muscle decline in the third decade is related to an associated increase in fat mass (Dutta and Hadley 1995). A recent study on UK Royal Navy personnel concluded that study participants between 35 and 44 years old were significantly (χ^2 (9)=16.96, $p<0.05$) more likely to be inactive or moderately inactive in comparison with younger study participants (Shaw et al 2013). Helmhout (2009) suggested that the transition from active operational roles to more sedentary managerial employment may reduce occupational physical activity (OPA) levels and could induce changes to body composition. Therefore, the combination of advancing age and a requirement to undertake sedentary managerial tasks, may contribute to the substantial increase in obesity in the third and fourth decades. Since OPA has been cited as affording independent and significant risk reduction to all-cause and cardiovascular mortality (Hu, Eriksson and Barengo 2004), future studies should attempt to clarify the weight status and occupational fitness relationship, and therefore the potential impact on health and operational capability.

Due to the stratification of the officer cohort to reflect the DE and LE officer, the information regarding the British Army may offer greater sensitivity. However, the higher levels of obesity that were observed in the LE cohort either became insignificant (female) or reduced in significance (male) and effect size, when the predictor variables were controlled for each other. Two studies on military populations have reported elevated levels of obesity in the soldier populations as opposed to the officer populations (Mullie et al 2008, Bray et al 2009). One recent study indicated that a correlation might exist between the hierarchical system of rank employed within the military and 'pay-group', with higher rank commanding higher pay (Sanderson, Clemes and Biddle 2011). This would suggest that rank within the military is a proxy for socioeconomic (SES) status. This assertion would reflect two of the three measures often used collectively or in isolation to indicate SES, as income and occupational status are linked to military rank (Krieger, Williams and Moss 1997). Civilian studies have often described a relationship between low SES and higher levels of obesity, with the pattern being more clearly defined in women (Krieger, Williams and Moss 1997, Wardle, Waller and Jarvis 2002). Therefore, it may not be surprising that obesity was more common in the lower paid 'enlisted ranks' as opposed to the higher paid 'officer class' (Bray et al 2006). However, this simple statement does not fully represent the data; whilst both officer cohorts share commonality in occupational status and income, the LE Officer cohort displayed significantly higher levels of obesity and higher levels of risk to obesity related diseases. Although educational level was not assessed, it is clear that the LE Officer cohort was older (47.2% of the LE Officers were between 45-49 years, DE Officer = 6.1%). Civilian studies have shown that when adjusted for age, the impact of SES is diminished (Wardle, Waller and Jarvis 2002), and this could offer a possible explanation for the results of the British Army.

In the British Army male individuals serving in combat elements displayed the lowest levels of risk (of obesity related ill-health). These findings were supported by Napradit et al (2005), who concluded that the inability of BMI to distinguish between fat and fat free mass as a probable explanation for the findings. This highlights the limitations of BMI when applied to athletic (Ode et al 2007, Nevill et al 2005) and military populations (McLaughlin and Wittert 2009, Prentice and Jebb 2001). Several studies on the armed services have argued in favour of an elevation of BMI classification to reflect the occupational requirements and associated higher levels of muscle mass (Friedl 2004, Harman and Fryman 1992) postulating that, if set too low, current BMI levels could encourage disordered eating habits, impairing physical and medical readiness (Friedl and Leu 2002).

Data were not available to offer a contrast to the female findings in relation to employment category; however, comparison of risk data indicates that the risk reduction evident in the male combat element was not manifest in the female combat population. Where it has been suggested that BMI may be relatively homogeneous in populations with high levels of physical activity (Rose 1991); the results from the British Army sample indicate that this homogeneity may be somewhat questionable across the male and female operationally defined sub populations with a broad spectrum of occupationally enforced physical activity and sedentary behaviour levels.

Limitations

There were some limitations to this study; numerous persons collected the BMI data used to establish weight status in the British Army study at a variety of locations. Although many individuals were involved in the measurement process, all the individuals were given training by medical staff. Whereas the use of a cross-sectional study precludes causal inferences, the large sample size offer a representative sample of military personnel, increasing the power and generalizability of the findings.

Conclusion

British Army is experiencing high levels of obesity; specifically data suggests that, older, (35+ years) enlisted, married males in non-combat roles have an increased likelihood of being obese. Whilst older and enlisted female personnel are more likely to be obese, employment and marital category are not significant predictors of obesity. When waist circumference measurement is considered along with BMI, a greater percentage of female military personnel are at risk of obesity related ill-health than male military personnel, and that this risk increases with age. These findings suggest that age is the most significant factor in the prevalence of obesity in the British Army. Whilst in comparison British Army personnel have a lower prevalence of obesity and reduced risk to obesity related diseases than the civilian population, it is recommended that Armed Service personnel should be made aware of the implications of obesity in regards to health, occupation and operational effectiveness. Specific focus should be given to those older officers and soldiers employed in managerial positions undertaking low levels of OPA.

Chapter 4

The Relationship between Weight Status and Fitness Test Result in British Army Personnel

Chapter 4 Impact of Obesity on Military Fitness

Chapter 4 presents the results of an investigation into weight status and fitness test outcomes. This chapter also used the extensive information available in Chapter 3 for secondary analysis and reports the outcome of two British Army fitness tests. The outcomes of pass, fail and failure to attempt the tests are reported by gender and age group in relation to weight status.

The Relationship between Weight Status and Fitness Test Result in British Army Personnel.

Introduction

The protective effect of physical activity (PA) on all cause mortality and general health is robust (Powell et al 1987, Pate et al 1995). Regular physical activity, healthy nutrition and weight management provide extensive health, occupational and performance benefits, including physical and cognitive performance, and resistance to disease (Fogelholm et al 2006, Friedl 2012). Additionally physically active men display a lower risk of all-cause mortality than their in-active counterparts (Kampert et al 1996). Individuals in the armed forces are required to be physically fit to successfully engage in vocational activities that require high levels of occupational fitness (Fogelholm et al 2006) and operational fitness. In the military, obesity has been linked to a reduced cardiovascular and neuromuscular fitness (Fogelholm et al 2006, McLaughlin and Wittert 2009) and enhanced levels of musculoskeletal disorders and injury (Anandacoomarasamy et al 2008). Furthermore load carriage ability (Haisman 1988) and functional strength (Fogelholm et al 2006) are also diminished by excessive levels of body fat.

While body composition, body mass index and anatomical distribution of fat belong to the morphological components of health related fitness (Fogelholm et al 2006), health related fitness also consists of cardiorespiratory (CRF), metabolic and muscular components (Bouchard and Shephard 1994). Strong evidence exists identifying a positive association between poor CRF and cardiovascular disease, type-2 diabetes and colon cancer (Wei et al 1999, Evenson et al 2003). In addition, high levels CRF and neuromuscular fitness are central to occupational (Fogelholm et al 2006) and operational fitness (Bilzon, Allsop and Tipton 2001). Previous studies on the military have linked physical performance with weight status, suggesting that obese personnel present high levels of risk for recruitment (Niebuhr et al 2009), retention (McLaughlin and Wittert 2009), and public perception (Naghii 2006). Moreover, a recent study concluded that BMI was the single most important factor in predicting poor physical fitness test outcome (Gantt et al 2008). Currently no information exists within the British military on the relationship between weight status and occupational physical fitness. It is therefore of central importance for the military that the relationship between weight status and occupational physical fitness is investigated.

Aim

The aim of this chapter is to examine the influence of weight status on fitness test results within a sample of British military personnel.

Methods

Secondary analyses were undertaken on data produced for the British Army by the Defence Analytical Services and Advice (DASA) from information captured through the Army Fitness Information Statistical Software (FISS) system (DASA 2011). Data were collected on 49.5% (*n*=50,635) of the British Army (*n*=102,202). Males accounted for 93% (*n*=47,173) of the sample, which is representative of the current army population of 92% male and 8% female. From the original 54,854 study population, 2562 individuals were removed due to Reservist status, 1109 for being in initial training and 245 for being cadets or university officer training corps personnel. Measurement error withdrew a further 233 individuals, and 70 were removed from the data set due to incomplete information (height or waist measurement missing). The measurements are taken in support of the Armed Forces Weight Management Policy (WMP) which stipulates that all personnel are required to provide bi-annual Body Mass Index (BMI) and Waist Circumference measurements.

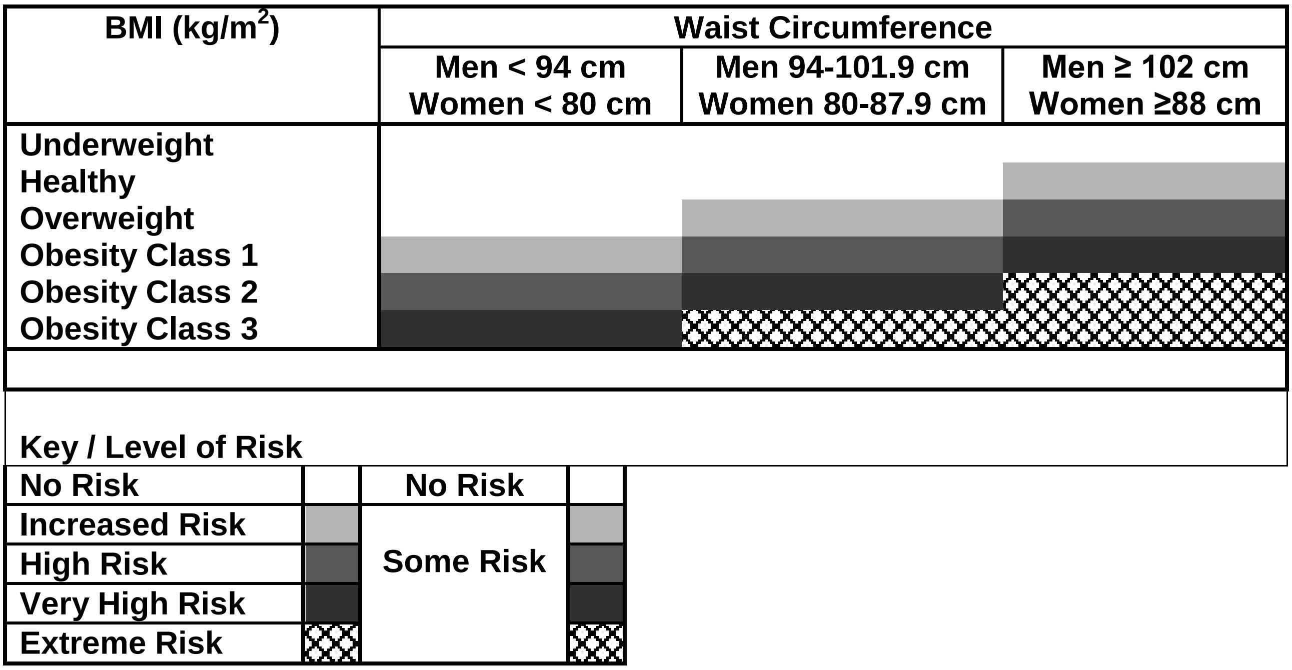
Anthropometric Assessment

Individuals were weighed to the nearest 0.1 kg using digital scales (Seca, Hamburg, Germany) wearing t-shirt and shorts, whilst height was measured to the nearest 0.1 cm, with shoes removed, using a stadiometer (Invicta, Leicestershire, England). Waist circumference was measured at the level of the navel (usually the smallest diameter between the costal margin and the iliac crest), using anthropometry tape.

Classifications

Weight status was classified by BMI and waist circumference using the current National Institute of Health & Clinical Excellence (NICE) guidelines (NICE 2006) based on the WHO recommendations (WHO 2003). These guidelines indicate that overweight is a BMI 25.0 – 29.9 kg/m^2, and obesity is characterised by a BMI 30.0 kg/m^2 and above. NICE guidelines suggest that waist circumference(s) of <94 cm for men and <80 cm for women indicate a healthy weight status, while circumferences between 94 -101.9 cm for men and 80 - 87.9 cm for women indicate overweight and circumferences >102 cm and >88 cm for men and women would be indicative of obesity. The NICE guidelines recommend a level of risk to obesity-related ill-health (particularly type 2 diabetes and coronary heart disease) using a combination of BMI and waist circumference measurements (NICE 2006). This risk matrix is referred to in the text as 'level of risk' (a high BMI and a large waist circumference would increase risk to obesity related ill-health). Figure 4.1 depicts the risk matrix.

Figure 4.1: BMI and waist circumference (risk of obesity related ill-health matrix) – based on NICE (2006) guidelines, with collated some risk group identified.



Physical Tests (Army – Mandatory Annual Training and Testing) (MATT 2012)

Annual Fitness Test (AFT)

The AFT represents the minimum maintenance standard of individual basic vocational fitness required by Army personnel. This load carriage activity required participants to complete a 12.8km loaded march (at least 4.8km to be off tarmac/metalled roads) in a maximum time of 2 hours, carrying a load that directly reflected the requirements of their specific combat employment groups (CEG's) within the army (load range 15-25 kg).

The Personal Fitness Assessment (PFA)

The PFA is an assessment of cardiovascular fitness and muscle endurance, designed to encourage improved physical performance and the maintenance of good health. The test is split into three areas of press-ups (expressed as the number completed in 2 minutes), sit-ups (the number completed in 2 minutes)), and a 1.5 mile (2.4 km) run (to measure aerobic capacity).

Press-ups: The test was started from the lowest face-down position. The hands were kept at shoulder width position. Fingers were directly forward, and legs were kept parallel to each other. During the movement, arms were fully extended and the torso was tensioned straight. Then the body was lowered to an elbow angle of 90̊. The result of this test was expressed as the number of press-ups during 2 minutes.

Sit-ups: In the starting position the participants were lying on the floor keeping the hands to the side of the head and directing the elbows forward. The knees were flexed at an angle of 90̊, legs were slightly abducted and the assistant supported the ankles. During the movement the participants lifted their upper body and touched their knees with the elbows. The result of the test was expressed as the number of sit-ups during 2 minutes.

The Aerobic Test (2.4 km run): This comprises two parts. Part 1 of the test is a warm up consisting of a walk/jog over a measured 800m course which is to be completed in a minimum time of 4mins 50secs and a maximum time of 5mins. Part 2 of the test is a best effort run over a measured 2.4km (ideally flat) course and follows on immediately after Part 1.

Statistical analysis

Participants were categorised according to sex and then by age (18 – 29, ≥ 30 years), further categories were allocated in reaction to test outcome (pass, fail and not-taken). To aid analyses for BMI data, those study participants deemed obese (≥30 kg/m^2) were assessed against those deemed not obese (<30 kg/m^2). Using the NICE guidelines to establish risk to obesity related ill-health, information regarding BMI and waist circumference were combined. All study participants deemed at 'some risk' (increased, high, very high and extreme risk) were collectively assessed against those classified as 'no risk'.

Through further analysis, outliers were identified through the calculation of z-scores for each variable, with a score of 3.29 constituting an outlier; these scores were then replaced with a value of the mean plus 3 x the SD (Field 2005). The reported values were expressed as the proportion of individuals within each category. Loglinear analysis was used for categorical data, where the outcome of more than two variables was required. Specific interactions between age and BMI group, age and risk group, AFT result and BMI group, AFT result and risk group, age and AFT result, PFA result and BMI group, PFA result and risk group, age and PFA result were interrogated with Chi-squared and odds ratios used to interpret the effect sizes. These analyses were conducted separately for male and female study participants. Statistical significance was assessed with 95% confidence intervals. Analyses were performed using SPSS version 18, and statistical significance was set at an alpha level of 0.05.

Results

Annual Fitness Test (AFT)

Data were available for 50,635 personnel, with 25,754 male and 1434 female personnel undertaking the fitness test (Table 4.1); these figures represent 54.6% and 41.4% of the male and female respective study populations. A total of 21,419 did not attempt the test. Of those that attempted the test, 98.6% of male soldiers (n= 25399) and 92% of female soldiers passed (n=1319). While the number of male soldiers who failed the test is relatively small, obese male soldiers failed more than non-obese soldiers; this relationship is underlined to a greater extent within the female population. When the waist circumference measurement is viewed alongside BMI, and risk to obesity related ill-health is assessed, those categorised as having ‘extreme risk’ displayed the highest levels of test failure. Data also suggest that those individuals deemed to have ‘no risk’ were more likely to attempt the test than those deemed at ‘some risk’ to obesity related ill-health.

The three-way log-linear analysis produced a final model that retained AFT result x BMI group x gender interactions. The likelihood ratio of the model was χ^2 (4) = 12.409, $p < .05$. This interaction indicates that the AFT results were different across the distinct BMI groupings (obese and non-obese) and between male and female study participants. Specifically, the interaction between AFT result and BMI was significant (χ^2 (4) = 1068.95, $p < .001$). The odds ratios (Table 4.2) indicate that non-obese male soldiers were nearly 5 times less likely to fail the test and twice as likely to attempt the test. For females, the non-obese were nearly 4 times less likely to fail and nearly 3 times more likely to attempt the test. When BMI and waist circumference data are combined and risk to obesity related ill-health is assessed, the final two-way analysis retained AFT Result and Risk Group (no risk and some risk), the likelihood ratio of the model was χ^2 (4) = 1314.71, $p < .001$. The OR suggest that those with some risk are less likely to pass and less likely to attempt the test than those deemed to have no risk (Table 4.2).

Table 4.1: AFT result by % of BMI / risk of obesity related ill-health (NICE 2006) groups.

BMI / Risk	Group	Pass n (%)	Fail n (%)	Taken Total (Pass + Fail) n (%)	Not Taken n (%)	BMI Totals (Taken + Not Taken) n (%)
Male BMI	<18.5	55 (47.4)	0 (0)	55 (0.2)	61 (52.6)	116 (0.3)
	18.5 – 24.99	11800 (60)	96 (0.5)	11896 (46.2)	7797 (39.6)	19693 (41.7)
	25.00 – 29.99	11471 (53.1)	156 (0.7)	11627 (45.1)	9963 (46.1)	21590 (45.8)
	>30.00	2073 (35.9)	103 (1.8)	2176 (8.4)	3598 (62.3)	5774 (12.2)
Female BMI	<18.5	10 (33.3)	0 (0)	10 (0.7)	20 (66.7)	30 (0.9)
	18.5 – 24.99	906 (43.3)	67 (3.2)	973 (67.9)	1121 (53.5)	2094 (60.5)
	25.00 – 29.99	351 (33.8)	35 (3.4)	386 (26.9)	652 (62.8)	1038 (30)
	>30.00	52 (17.3)	13 (4.3)	65 (4.5)	235 (78.3)	300 (8.7)
Male Risk	Underweight	55 (47.4)	0 (0)	55 (0.2)	61 (52.6)	116 (0.2)
	No Risk	20794 (58.2)	198 (0.6)	20992 (81.5)	14713 (41.2)	35705 (75.7)
	Increased Risk	2606 (46)	51 (0.9)	2657 (10.3)	3004 (53.1)	5661 (12)
	High Risk	1133 (41.1)	41 (1.5)	1174 (4.6)	1580 (57.4)	2754 (5.8)
	Very High Risk	717 (31.2)	43 (1.9)	760 (3)	1535 (66.9)	2295 (4.9)
	Extreme Risk	94 (14.6)	22 (3.4)	116 (0.5)	526 (82)	642 (1.3)
Female Risk	Underweight	10 (33.3)	0 (0)	10 (0.7)	20 (66.7)	30 (0.9)
	No Risk	1043 (43.8)	69 (2.9)	1112 (77.5)	1267 (47.3)	2379 (68.7)
	Increased Risk	140 (29.2)	17 (3.5)	157 (10.9)	323 (67.3)	480 (13.9)
	High Risk	90 (27.3)	16 (4.8)	106 (7.4)	224 (67.9)	330 (9.5)
	Very High Risk	34 (16.3)	9 (4.3)	43 (3)	165 (79.3)	208 (6)
	Extreme Risk	2 (5.7)	4 (11.4)	6 (0.4)	29 (82.9)	35 (1)

Table 4.2: AFT Odds ratio for failure and attendance by BMI (obese and not-obese) and risk of obesity related ill-health (some-risk and no-risk) (NICE 2006) groups.

	AFT			
	Male		Female	
BMI or Risk Group	Fail Less Likely to OR (95% CI)	Attend More Likely to OR (95% CI)	Fail Less Likely to OR (95% CI)	Attend More Likely to OR (95% CI)
BMI ≥30	1.00	1.00	1.00	1.00
BMI <30	4.60 (4.37-4.83)	2.19 (2.13-2.25)	2.84 (2.20-3.48)	2.78 (2.50-3.06)
Some Risk	1.00	1.00	1.00	1.00
No Risk	3.64 (3.43-3.85)	2.01 (1.97-2.05)	2.86 (2.46-3.26)	4.89 (4.75-5.03)

Table 4.3: AFT result by % of obese and non-obese and no-risk and some-risk of obesity related ill-health (NICE 2006) by age.

Gender	Age Group	BMI / Risk Group	Pass	Fail	Taken Total (Pass + Fail)	Not Taken	BMI Totals (Taken + Not Taken)
			n(%)	n(%)	n(%)	n(%)	n(%)
Male	<30 years	Not Obese	15651 (60.8)	166 (0.6)	15817 (61.4)	9924 (38.6)	25741 (54.6)
		Obese	878 (44.9)	49 (2.5)	927 (3.6)	1027 (52.6)	1954 (4.2)
	>30 years	Not Obese	7675 (49)	86 (0.5)	7761 (30.1)	7897 (50.5)	15658 (33.2)
		Obese	1195 (31.3)	54 (1.4)	1249 (4.8)	2571 (67.3)	3820 (8)
Female	<30 years	Not Obese	924 (44.3)	81 (3.9)	1005 (70.1)	1080 (51.8)	2085 (60.2)
		Obese	27 (22.9)	7 (5.9)	34 (2.4)	84 (71.2)	118 (3.4)
	>30 years	Not Obese	343 (31.8)	21 (2)	364 (25.4)	713 (66.2)	1077 (31.1)
		Obese	25 (13.7)	6 (3.3)	31 (2.2)	151 (83)	182 (5.3)
Male	<30 years	No Risk	14519 (61.6)	144 (0.6)	14663 (56.9)	8910 (37.8)	23573 (50)
		Some Risk	2010 (48.8)	71 (1.7)	2081 (8.1)	2041 (49.5)	4122 (8.7)
	>30 years	No Risk	6330 (51.7)	54 (0.4)	6384 (24.8)	5864 (47.9)	12248 (26)
		Some Risk	2540 (35.1)	86 (1.2)	2626 (10.2)	4604 (63.7)	7230 (15.3)
Female	<30 years	No Risk	781 (47)	55 (3.3)	836 (58.3)	826 (49.7)	1662 (48)
		Some Risk	170 (31.4)	33 (6.1)	203 (14.2)	338 (62.5)	541 (15.6)
	>30 years	No Risk	272 (36.4)	14 (1.9)	286 (19.9)	461 (61.7)	747 (21.6)
		Some Risk	96 (18.8)	13 (2.5)	109 (7.6)	403 (78.7)	512 (14.8)

Table 4.4: AFT Odds ratio for failure and attendance by BMI (obese and not-obese) and risk of obesity related ill-health (some-risk and no-risk) (NICE 2006) groups by age.

	AFT			
	Male		Female	
Age BMI or Risk Group	**Fail Less Likely to OR (95% CI)**	**Attend More Likely to OR (95% CI)**	**Fail Less Likely to OR (95% CI)**	**Attend More Likely to OR (95% CI)**
>30 Years BMI ≥30	**1.00**	**1.00**	**1.00**	**1.00**
<30 Years BMI ≥30	**0.80** (0.40-1.20)	**1.86** (1.74-1.98)	**0.92** (-0.29-1.92)	**1.97** (1.42-2.52)
<30 Years BMI <30	**4.09** (3.78-4.39)	**3.27** (3.20-3.34)	**2.73** (1.81-3.65)	**4.55** (4.15-4.95)
>30 Years BMI <30	**4.09** (3.74-4.44)	**2.02** (1.94-2.10)	**3.93** (2.94-4.92)	**2.48** (2.07-2.89)
>30 Years Some Risk	**1.00**	**1.00**	**1.00**	**1.00**
<30 Years Some Risk	**0.97** (0.65-1.29)	**1.79** (1.71-1.87)	**0.42** (-0.18-1.02)	**2.21** (1.93-2.49)
<30 Years No Risk	**3.43** (3.16-3.70)	**2.87** (2.82-2.92)	**2.16** (1.56-2.76)	**3.73** (3.50-3.96)
>30 Years No Risk	**4.0** (2.91-4.35)	**1.9** (1.84-1.96)	**1.25** (0.61-1.89)	**2.29** (2.03-2.55)

Results indicate that within each age grouping (<30 and ≥30 years) those identified as obese using BMI were more likely to fail and less likely to attempt the test (Table 4.3). The results also suggested that younger soldiers (<30 years) were more likely to fail than older soldiers (≥30 years) and that obese older soldiers were least likely to attempt the test. When risk is assessed, similar trends were observed with those categorised as having the highest risk being more likely to fail. Furthermore, those older and deemed at some risk were the least likely to take the test.

The four-way loglinear analysis produced a final model that retained the age x BMI group x gender, age x BMI group x AFT result and BMI group x gender x AFT result interactions. The likelihood ratio of this model was χ^2 (6) = 6.62, p= 0.36. Understanding that there were marked differences between the male and female cohorts in terms of study participants (see Table 4.4 for consolidated results by gender), the follow-up analysis focussed on the age, AFT result and BMI group interactions. The age x BMI group interaction was significant (χ^2 (4) = 4090.86, p< .001), as was the age x AFT result (χ^2 (4) = 982.95, p< .05) and it was already known that AFT result x BMI group (χ^2 (4) = 1068.95, p< .001) was also significant. Of note the odds ratio indicated that obese soldiers <30 years of age were most likely to fail the test and that obese soldiers ≥30 years of age were least likely to attempt the test. Specifically for the male study participant the non-obese soldier (regardless of age) were over 4 times less likely to fail the test (<30 years - OR 4.09, 95% CI 3.78-4.39, ≥30 - years, OR 4.09, 95% CI 3.74-4.44) compared to the referent category (≥30 years, ≥30.0 kg/m^2). When WC measurements were added to the BMI data and risks to obesity related ill-health were assessed, similar results were observed for the male cohort. However, the results suggest that while the older (≥30 years) 'no-risk' female study participants have a similar likelihood of failure as their 'some risk' (referent value) counterparts, they are 2 times more likely to attempt the test (Table 4.4).

Personal Fitness Assessment

The PFA was undertaken by 30,852 male and 2,017 female study participants (Table 4.5), and these figures represent 65.4% and 58.3% of the male and female respective study populations. A total of 17,766 did not attempt the test. Of those that attempted the test, 91.9% male soldiers passed (n= 28407) and 91.1% of female soldiers passed (n=1852). When failure rate was assessed alongside BMI (see Table 4.6), the data indicate those who are obese have a 7-fold (male) and 9-fold (female) increase in the level of failure when assessed against their non-obese counterparts. When the PFA outcome is assessed with respect to risk to obesity ill-health, it is clear that those soldiers with higher levels of risk are more likely to fail.

The three way loglinear analyses (gender x BMI group x PFA result) produced a marginally non-significant final model (p=.08). Therefore separate analyses (PFA result x BMI group) were undertaken on the male and female study participants, and both returned highly significant (p<.001) interactions: male (χ^2 (2) = 2187.53), female (χ^2 (2) = 170.19). Odds ratio (Table 4.6) suggest that male obese soldiers were over 6 times more likely to fail the test and nearly 3 times less likely to attempt the test. The female cohort displayed a similar pattern (non-obese females were less likely to fail and more likely to attend). When risks to obesity related ill-health were assessed, the following likelihood ratios were observed for male and female 2-way interactions (PFA result x Risk Group): male (χ^2 (2) = 2401.96, $p< .001$), female (χ^2 (2) = 219.58, $p< .001$). Further interrogation through odds ratios (Table 4.6) indicate that regardless of gender, those classified as having an increased risk to obesity related ill-health were 5 times more likely to fail the PFA and twice as likely not to attempt the test.

Table 4.7 highlights the descriptive results for both male and female study participants by age and separately for BMI and risk to obesity related ill-health. Regardless of gender, PFA pass and fail data suggest that in each weight category (obese and non-obese) the older soldiers are more likely to pass compared to their younger counterparts. However, data suggests that only 41% male and 23% female soldiers categorised as obese and ≥ 30 years attempted the test (compared with 54% and 47% obese and <30 years, male and female respective study participants). Similar patterns were observed for the risk to obesity related ill-health, suggesting those categorised as increased risk fail more readily, and while the older soldiers return better pass rates, the younger soldiers are more likely to attempt the test regardless of risk category.

The four-way loglinear analysis produced a final model that retained the age x gender x PFA result, age x gender x BMI group, and age x PFA result x BMI group interactions. The likelihood ratio of this final model was χ^2 (8) = 16.44, p= 0.36. Understanding that there were marked differences between the male and female cohorts in terms of study participants (see Table 4.8 for consolidated results by age and gender), the follow-up analysis focussed on the age, PFA result and BMI group interactions. Odds ratio suggest that older soldiers (≥30 years) who are not obese are nearly 7 times (male) and 8 times (female) less likely to fail than older soldiers who are obese. As with the AFT, odds ratio indicate that obese soldiers <30 years of age were most likely to fail the test, specifically male obese soldiers in this category were 2 times more likely to fail than the older soldiers in the same obese category. However, these younger obese soldiers were more likely to attempt the test; of note female soldiers <30 years of age were 4 times more likely to attempt the test than the referent (≥ 30 years) category.

When risks to obesity related ill-health were assessed, the four-way analyses produced a final model (age x risk group x PFA result x gender) that was marginally not significant (p=.065). Previous investigation had already established the significant male and female 2-way interactions for PFA result x risk group (male χ^2 (2) = 2401.96, p< .001, female χ^2 (2) = 219.58, p< .001). As previously identified in the AFT results, a suppression of effect was observed for female study participants in respect of failure rate; older (≥30 years) non-obese female study participants had a similar likelihood of failure as their obese (referent value) counterparts (OR 1.23, 95% CI 0.59-1.89). However, these younger, non-obese female study participants were nearly 3 times more likely to attempt the test than their older obese counterparts. Table 4.8 identifies similar patterns of outcome for the male cohort, with those with the highest risk least likely to attend and most likely to fail the assessment. Specifically for age, while those ≥30 years are least likely to fail, they are also least likely to attempt the test.

Table 4.5: PFA result by % of BMI / risk of obesity related ill-health (NICE 2006) groups.

BMI / Risk	Group	Pass n (%)	Fail n (%)	Taken Total (Pass + Fail) n (%)	Not Taken n (%)	BMI Totals (Taken + Not Taken) n (%)
Male BMI	<18.5	89 (76.7)	6 (5.2)	95 (0.3)	21 (18.1)	116 (0.3)
	18.5 – 24.99	13699 (69.6)	535 (2.7)	14234 (46.1)	5459 (27.7)	19693 (41.7)
	25.00 – 29.99	12730 (59)	1158 (5.4)	13888 (45)	7702 (35.7)	21590 (45.8)
	>30.00	1889 (32.7)	746 (12.9)	2635 (8.5)	3139 (54.4)	5774 (12.2)
Female BMI	<18.5	16 (53.3)	0 (0)	16 (0.8)	14 (46.7)	30 (0.9)
	18.5 – 24.99	1292 (61.7)	59 (2.8)	1351 (67)	743 (35.5)	2094 (60.5)
	25.00 – 29.99	486 (46.8)	68 (6.6)	554 (27.5)	484 (46.6)	1038 (30)
	>30.00	58 (19.3)	38 (12.7)	96 (4.8)	204 (68)	300 (8.7)
Male Risk	Underweight	89 (76.7)	6 (5.2)	95 (0.3)	21 (18.1)	116 (0.2)
	No Risk	23628 (66.2)	1247 (3.5)	24875 (80.6)	10830 (30.3)	35705 (75.7)
	Increased Risk	2914 (51.5)	445 (7.9)	3359 (10.9)	2302 (40.7)	5661 (12)
	High Risk	1149 (41.7)	277 (10.1)	1426 (4.6)	1328 (48.2)	2754 (5.8)
	Very High Risk	575 (25.1)	358 (15.6)	933 (3)	1362 (59.3)	2295 (4.9)
	Extreme Risk	52 (8.1)	112 (17.4)	164 (0.5)	478 (74.5)	642 (1.3)
Female Risk	Underweight	16 (53.3)	0 (0)	16 (0.8)	14 (46.7)	30 (0.9)
	No Risk	1464 (61.5)	70 (2.9)	1534 (76.1)	845 (35.5)	2379 (68.7)
	Increased Risk	222 (46.3)	32 (6.7)	254 (12.6)	226 (47.1)	480 (13.9)
	High Risk	111 (33.6)	29 (8.8)	140 (6.9)	190 (57.6)	330 (9.5)
	Very High Risk	38 (18.3)	24 (11.5)	62 (3.1)	146 (70.2)	208 (6)
	Extreme Risk	1 (2.9)	10 (28.6)	11 (0.5)	24 (68.6)	35 (1)

Table 4.6: PFA Odds ratio for failure and attendance by BMI (obese and not-obese) and risk of obesity related ill-health (some-risk and no-risk) (NICE 2006) groups.

	PFA			
	Male		Female	
BMI / Risk Group	Fail Less Likely to OR (95% CI)	Attend More Likely to OR (95% CI)	Fail Less Likely to OR (95% CI)	Attend More Likely to OR (95% CI)
BMI ≥30	1.00	1.00	1.00	1.00
BMI <30	6.17 (6.07-6.29)	2.55 (2.49-2.61)	9.35 (8.90-9.79)	3.29 (3.03-3.55)
Some Risk	1.00	1.00	1.00	1.00
No Risk	4.83 (4.74-4.91)	2.14 (2.09-2.18)	5.43 (5.10-5.76)	2.27 (2.12-2.42)

Table 4.7: PFA result by % of obese and non-obese and no-risk and some-risk of obesity related ill-health (NICE 2006) by age.

Gender	Age Group	BMI / Risk Group	Pass		Fail		Taken Total (Pass + Fail)		Not Taken		BMI Totals (Taken + Not Taken)	
			n (%)		n (%)		n (%)		n (%)		n (%)	
Male	<30 years	Not Obese	17274	(67.1)	1292	(5)	18566	(60.2)	7175	(27.9)	25741	(54.6)
		Obese	672	(34.4)	389	(19.9)	1061	(3.4)	893	(45.7)	1954	(4.2)
	>30 years	Not Obese	9422	(59.5)	407	(2.6)	9651	(31.3)	6007	(37.9)	15658	(33.2)
		Obese	1217	(31.9)	357	(9.3)	1574	(5.1)	2246	(58.8)	3820	(8)
Female	<30 years	Not Obese	1282	(61.5)	92	(4.4)	1374	(68.1)	711	(34.1)	2085	(60.2)
		Obese	32	(27.1)	23	(19.5)	55	(2.7)	63	(53.4)	118	(3.4)
	>30 years	Not Obese	512	(47.5)	35	(3.2)	547	(27.1)	530	(49.2)	1077	(31.1)
		Obese	26	(14.3)	15	(8.2)	41	(2)	141	(77.5)	182	(5.3)
Male	<30 years	No Risk	16154	(68.5)	978	(4.2)	17132	(55.5)	6441	(27.3)	23573	(50)
		Some Risk	1792	(43.5)	703	(17)	2495	(8.1)	1627	(39.5)	4122	(8.7)
	>30 years	No Risk	7563	(61.7)	275	(2.3)	7838	(25.4)	4410	(36)	12248	(26)
		Some Risk	2898	(40.1)	489	(6.7)	3387	(11)	3843	(53.2)	7230	(15.3)
Female	<30 years	No Risk	1081	(65)	55	(3.4)	1136	(56.3)	526	(31.6)	1662	(48)
		Some Risk	233	(43.1)	60	(11.1)	293	(14.5	248	(45.8)	541	(15.6)
	>30 years	No Risk	399	(52)	35	(4.6)	434	(21.5)	333	(43.4)	767	(22.2)
		Some Risk	139	(28.3)	15	(3)	154	(7.6)	338	(68.7)	492	(14.2)

Table 4.8: PFA Odds ratio for failure and attendance by BMI (obese and not-obese) and risk of obesity related ill-health (some-risk and no-risk) (NICE 2006) groups by age.

	PFA			
	Male		Female	
Age BMI / Risk Group	Fail Less Likely to	Attend More Likely to	Fail Less Likely to	Attend More Likely to
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
>30 Years BMI ≥30	**1.00**	**1.00**	**1.00**	**1.00**
<30 Years BMI ≥30	**0.50** (0.34-0.68)	**1.70** (1.59-1.81)	**0.79** (0.04-1.55)	**3.95** (3.45-4.45)
<30 Years BMI <30	**3.96** (3.83-4.09)	**3.70** (3.63-3.77)	**7.92** (7.24-8.59)	**6.61** (6.25-6.97)
>30 Years BMI <30	**6.81** (6.66-6.96)	**2.29** (2.22-2.16)	**8.38** (7.66-9.10)	**3.55** (3.18-3.91)
>30 Years Some Risk	**1.00**	**1.00**	**1.00**	**1.00**
<30 Years Some Risk	**0.43** (0.30-0.56)	**1.74** (1.66-1.82)	**0.41** (0.19-1.01)	**2.58** (2.32-2.84)
<30 Years No Risk	**2.77** (2.65-2.89)	**3.05** (3.00-3.10)	**2.11** (1.51-2.71)	**4.76** (4.55-4.94)
>30 Years No Risk	**4.69** (4.53-4.84)	**2.02** (1.96-2.08)	**1.23** (0.59-1.89)	**2.84** (2.32-3.24)

Discussion

This paper examined the influence of weight status on fitness test results within a sample of British military personnel. For both tests, data show clearly that test outcome and attendance are associated with weight status. For military personnel, physical conditioning is a vital aspect of vocation (Friedl 2012), due to the diverse nature of military tasks and the associated fitness requirements needed to deliver appropriate performance in challenging circumstances.

The results of this study clarify that while the failure rate is low for the load carriage test (AFT), specifically for those male soldiers with a healthy BMI or defined as overweight, the rate of failure is shown to increase markedly in the obese category. Whereas this pattern is somewhat reflected in females, at every level higher rates of failure were observed, suggesting that the occupational strength requirements needed to carry the external load are reduced in obese female soldiers. Alternatively, for the female soldier BMI may effectively identify over-fat women more readily than men (Friedl 2004) and that for weight carriage tasks the relative reduced levels of lean muscle mass support higher failure rates in the overweight and obese female soldier. Specifically in regards to load carriage, researchers have concluded that excess body fat is a ‘dead weight’ when performing load bearing activities and has been observed to impair performance during load-carriage tasks (Haisman 1988). Further research on the topic has suggested that body composition rather than body mass is more closely associated with the metabolic demands of heavy load carriage tasks as undertaken by the military (Lyons, Allsop and Bilzon 2005). When reporting on the metabolic demands of load-carriage, Lyons, Allsop and Bilzon (2005), concluded that efficiency in load carriage was profoundly influenced by the amount of lean body mass compared to the dead mass (load + fat mass).

Research into the biomechanics of load carriage suggests that each 1 kg of added load requires an additional 10 N of force (Birrell, Hooper and Haslam 2007). It follows that over-fat females with reduced lean mass (reduced muscle cross-sectional area, and therefore reduced physical work capability) may have a decreased load-carriage ability compared to their male counterparts. For risk of obesity related ill-health it is clear that those soldiers with some risk fail more readily and, in most cases, do not attempt the test and that the level of attendance is worse in those soldiers above 30 years of age. While information pertaining to military personnel and risk of obesity related ill-health is scarce, one study on UK Royal Naval personnel showed that older (≥35 years of age) navy personnel were more likely to be classified as having an increased risk to obesity related ill-health and of being inactive or moderately inactive compared to the younger navy personnel (Shaw et al 2013).

The current study indicated that when waist circumference data are added, the female cohort display higher levels of risk of obesity related ill-health than the male cohort. One author has suggested that due to sexual dimorphism the reaction to occupational tasks and specific strength training can result in a greater variability in muscle hypertrophy (Friedl 2004); in essence the body composition of male and female soldiers could be different even if the physiological stressors are the same (Knapik et al 2007). When reporting the outcome of a US Army study of light-wheel vehicle mechanics, Friedl (1997), concluded that where occupational performance required strength and power, the strongest Army women tended to carry more weight and fat and have a larger average waist circumference than weaker women, thus increasing their risk for health consequences such as CVD (Friedl 1997). There is therefore a rationale for the army to target physical performance through dedicated strength training to support work capacity as larger individuals with higher levels of muscle mass are ideal in many physically demanding tasks in the armed forces (Harman and Frykman 1992). However, unlike their male counterparts female soldiers may not react to physical stressors with the same level of lean muscle mass development.

Comparable relationships were observed in the PFA; however, the level of association between failure and obesity was more apparent. Similarly, Gantt et al (2008) concluded that BMI was the single most important factor predicting failure in a military physical readiness test. A recent study on US Army personnel indicated that individuals with less body fat were more likely to perform better, compared to those with more body fat, on anaerobic and aerobic activities, as well as press-ups (Crawford et al 2007). Additionally, it has been reported that BMI has a negative influence on performance tasks requiring the projection of the body movement or support of the body off the ground (Hulens et al 2001, Hulens et al 2003). One

Finnish study suggested that the gravitational forces allied to enhanced abdominal obesity and the additional mechanical work needed to afford force production, specifically from inertia, could help explain the negative influence (Fogelholm et al 2006). Certainly in the current investigation there was stark contrast between the ability to attempt and pass the PFA between those defined as ‘no risk’ and at ‘some risk’ of obesity related ill-health, with those males and females categorised as at some risk being 5 times more likely to fail than those categorised as no-risk. Several studies have reported a negative correlation between muscular endurance and body fat (Vaara et al 2012) and waist circumference (Duvigneaud et al 2008, Esco, Olson and Williford 2010). Moreover, higher waist circumference, independent of BMI, has been shown to have a negative relationship with CRF (Duvigneaud et al 2008). Conversely, it may be that individuals with a low waist-to-BMI ratio (high, muscle-to-fat ratio) have a better capacity for CRF and muscle endurance activities. In this situation body composition (through physical activity, diet and genetics) may be an important determinant of fitness, rather than the other way round (Hulens et al 2001).

For male and female study participants in both tests and within each age group, older and obese military personnel were more likely to fail and were less likely to attend the test(s). The relationship between age and obesity (Lindquist and Bray 2001, Robbins et al 2001, Flegal et al 2010) reduced CRF (Trappe et al 1996) and general physical fitness (Robbins et al 2001, Santtila et al 2004) is well reported. Military studies have indicated that transition from active operational roles to more sedentary managerial employment linked to advancing age may reduce activity levels and could induce changes to body composition (Helmhout 2009, Napredit et al 2005). Nevertheless, and beyond any changes to occupational physical activity (OPA), it is well known that skeletal muscle mass decreases with age (Janssen et at 2000) as does strength (Thom et al 2007) and maximal aerobic capacity (Heath et al 1981), and these changes occur in both non-trained and (to a lesser extent) trained individuals (Bortz and Bortz 1996). Therefore it is not surprising that the older and more obese are more likely to fail. However, there is scant information as to the avoidance of physical exercise testing in the armed forces. One recent systematic review suggested that ‘lack of time’ and ‘current level of physical activity’ allied to the priority level given to the engagement in exercise were reported barriers for physical activity engagement (Sanderson, Clemes and Biddle 2011). Another study on military personnel suggested that those who exercise for self-motivated reasons (as opposed to because they have to, due to being in the military) are more likely to benefit in terms of health and enhanced fitness levels (Wilson, Markey and Markey 2012). One could hypothesise that fear of failure or failure avoidance could lead de-conditioned soldiers not to attempt the test. Nevertheless, the current results indicate that only 41% of male and 23% of female soldiers categorised as obese and ≥ 30 years attempted the PFA and in the knowledge that 2 and 4 in every 10 male and female soldiers from these categories fail, it is clear that failure rates would rise should all personnel attempt the test.

Whilst only the outcome of physical testing was assessed and not the engagement in mandatory and leisure time physical activity per se, there is an established link between high BMI with decreased fitness in military personnel (Knapik et al 2001, Friedl 1989). One study into the relationship between female body composition and muscle endurance, suggested that those women categorised by BMI as 'obese' were more physically inactive than their non-obese counterparts (Ross, Freeman and Janssen 2000). Specifically for the PFA, and while BMI may not be an ideal tool to assess military physical readiness, the difference in pass rates between non-obese and obese (>90% and <60% respectively) supports an optimal human body size somewhere in the BMI range of 20-30, with performance risks increasing on either side of this range (Friedl 2012).

While there are obvious strengths to this study, including the very large sample across a major organisation, there are some limitations that should be recognised. First, numerous persons collected the BMI data and administered the fitness tests at a variety of locations. Although many individuals were involved in the measurement processes, all the individuals were either qualified or given training by medical staff. Whereas the use of a cross-sectional study precludes causal inferences, the large sample size offers a representative sample of military personnel, increasing the power and generalizability of the findings. In relation to BMI, the highest levels of obesity were displayed by the male cohort. Several studies have highlighted the restrictions in respect of BMI to clarify weight status (Prentice and Jebb 2001) specifically when applied to athletic (Ode et al 2007, Nevill et al 2005) and military populations (Anandacoomarasamy et al 2008, Prentice and Jebb 2001). Some authors have argued in favour of an elevation of BMI classification to reflect the occupational requirements and associated higher levels of muscle mass (Friedl 2004, Friedl and Leu 2002) postulating that, if set too low, current BMI levels could encourage disordered eating habits, impairing physical and medical readiness (Knapik, Burse and Vogel 1983). In one study involving 951 men from the Finnish Defence Force, Fogelholm and colleagues stated that when adjusted for each other, waist circumference was an indicator of fat-mass and that BMI indicated the level of fat-free-mass (Fogelholm et al 2006). Conversely, another study involving United States (US) Army personnel concluded that BMI was highly correlated with measured body fat percentage (r = 0.75 for men and 0.69 for women). Given the subject population BMI data gives a somewhat crude overview as BMI predicts lean mass as least as well as it predicts fat mass (Friedl 2004), still, the addition of waist circumference allows greater validity (McCarthy and Ashwell 2006). However, a recent investigation on the British Military supported the use of both BMI and waist circumference employed as a two stage assessment to increase the specificity of the findings (Ronal et al 2010).

Conclusion

In conclusion, in this large cohort of British Army personnel, across all age groups, obesity and increased risk of obesity related-ill-health were linked to higher failure and lower attendance on the PFA and the AFT. Whilst in general it would appear that the older army personnel fail less, this is a direct reflection of the low attendance rates of this group. It could be hypothesised that due to the comparative high levels of obesity in those not attempting the physical tests, that, if attempted, overall failure rates would increase. However, it is of importance to health and vocation that the implications of advancing age, increased sedentary duties, and reduced occupational physical activity and motivation towards physical activity are assessed. Whereas, the current study assessed several aspect of fitness through assessment, mandatory and voluntary fitness habits were not assessed. As obesity is more common in physically inactive people than in their active counterparts, it would suggest that an enduring commitment to physical activity is a very effective method of reducing obesity (Hulen et al 2001). Although BMI does not always change, exercise decreases fat mass, waist circumference (Hulens et al 2003), and visceral fat (Hulens et al 2001) and therefore reduces the risk of obesity related ill-health.

Future research, therefore, should attempt to ascertain the mandatory and voluntary fitness levels of the British Army in relation to weight status.

Chapter 5

Predictors of Obesity in the British Army

Chapter 5 Obesity Prediction

Chapter 5 describes the results of a study into the predictors of obesity in the British Army. This secondary analysis reports the predictive ability of variables in relation to age, gender, employment, marital status, physical test outcome, medical status, years employed in the Army and geographical location of unit. Results are presented for obesity as defined by BMI and the risk of obesity related ill-health (BMI and waist circumference combined).

Predictors of Obesity in the British Army

Introduction

Obesity prevalence is a worldwide health issue of significant concern (Finucane et al 2011). In particular the United States of America (USA) and the United Kingdom (UK) have had striking increases in the proportion of their populations with a body-mass index (BMI) in overweight (BMI 25–29·9 kg/m²) and obese (BMI ≥30 kg/m²) ranges (Wang et al 2011). In 2007, the Foresight Institute stated that the UK would be mainly obese by 2050 (Kopelman, Jebb and Butland, 2007), and Sassi (2010) suggested that if current trends are followed, three in four Americans and seven in ten British people will be overweight or obese by 2020. While current information from the UK indicate that almost two-thirds of adults and a third of children are either overweight or obese (NHS 2011), it is clear that the rising prevalence of obesity is a major international health priority.

Specifically for the military, while trend data from the US suggest that between 1998 and 2008 obesity prevalence more than doubled (6.4% - 13.2% respectively) (Bray et al 2009), current information on the British Army indicates that 12% are obese and 24% of the population are at increased risk of obesity related ill-health (Sanderson, Clemes and Biddle, 2014). This suggests that being in the military does not protect against obesity (Bray et al 2006, Sanderson, Clemes and Biddle 2011, Kilminster, Roiz de sa and Bridger 2008, Shaw et al 2013, Michas et al 2013) and obesity related diseases.

There is wide-spread scientific support for a relationship between obesity and premature mortality (Kivimaki et al 2008, Whitlock et al 2009), elevated rates of cardiovascular disease (CVD) risk (Nanchahal et al 2005, Logue et al 2011), increased type 2 diabetes risk (Wang et al 2011), selected cancers (Calle et al 2003, Batty et al 2005), disability (Ferraro et al 2002, Launer et al 1994), and poor mental health (Vieweg et al 2006, McCrea, Berger and King 2012). In addition, several papers on military populations have concluded that obesity effects recruitment (Niebuhr et al 2009), training success (Knapik et al 2001; Poston et al 2002), occupational fitness (Robbins et al 2001, Bohnker et al 2005) and retention (McLaughlin and Wittert, 2009) of individuals in the armed services. Moreover, one study on US Armed Forces personnel concluded that obese individuals were more prone to absenteeism and lower productivity while at work (Dall et al 2007); the author suggested that overweight and obesity were costing the US Department of Defence 1.1 billion (USD) per year. It is therefore vital that the predictors of obesity in the armed services are better understood.

The research outlined in Chapter 3 investigated the socio-demographic correlates of obesity in the British Army (see also Sanderson, Clemes and Biddle, 2014). It was concluded from this chapter that age, marital status, military rank and employment were all significant in their ability to predict obesity and the risk to obesity related ill health. Chapter 4 investigated the relationship between weight status and fitness test outcome, the results suggested that obesity can negatively impact on the ability to pass and attend the physical tests of the British Army. However, other potential significant predictors were not included in these preliminary findings.

The aim of the research reported in this chapter therefore is to report the predictive ability of, age, marital status, rank, employment, physical test outcome, medical category, years served, and geographical location in relation to obesity and the risk to obesity related ill-health in a large representative sample of the British Army.

Methods

Data presented are based on secondary analyses undertaken using an existing data set produced for the British Army by the Defence Analytical Services and Advice (DASA), from information captured through the Army Fitness Information Statistical Software (FISS) system (DASA 2011). From the original study population (N=54,854), 4219 individuals were removed as they did not meet the study cohort criteria of being regular army personnel with complete anthropometric information. Personnel were removed for the following reasons: 2562 due to Reservist status, 1109 for being in initial training and 245 for being cadets or university officer training corps personnel. Measurement error withdrew a further 233 individuals, and 70 were removed from the data set due to incomplete BMI information. The final cohort reflected 49.5% (*n*=50,635) of the British Army. Males accounted for 93% (*n*=47,173) and 7% were female (*n*=3,462), which is representative of the current army population. Demographic and specific military employment information were collected, and were categorised into groups according to age, marital status, gender, rank, operationally defined employment category, fitness test outcome, occupational medical status, years employed in the army and geographical location of unit.

The cross sectional data are in support of the Armed Forces Weight Management Policy (WMP), which stipulates that all personnel are required to provide bi-annual BMI and Waist Circumference measurements. Ethical clearance was given by the MoD to undertake the analysis.

Anthropometric Assessment

Body mass and height were measured by medical staff (nurse) or by the unit Physical Training Instructor (PTI), who were trained to undertake these procedures.

Body Mass: Individuals were weighed to the nearest 0.1 kg using digital scales (Seca, Hamburg, Germany) wearing a t-shirt and shorts.

Height: Height was measured to the nearest 0.1 cm. Individuals removed their footwear before standing on the stadiometer (Invicta, Leicestershire, England). Feet, buttocks and scapulae were in contact with the back of the stadiometer, and the individual was instructed to look directly ahead.

Body Mass Index (BMI): BMI was calculated from the equation of body mass (kg) divided by height in meters squared (kg/m^2).

Waist Circumference: This was measured using anthropometry tape at the level of the naval (usually the smallest diameter between the costal margin and the iliac crest) to the nearest 0.1 cm.

Classifications

Weight status was classified by BMI and waist circumference using the current National Institute of Health & Clinical Excellence (NICE) guidelines (NICE 2006) based on the WHO recommendations (WHO 2000). These guidelines are explained fully in the methods section of Chapter 3 (pg 32). The NICE guidelines attribute a level of risk of obesity-related ill-health (particularly type 2 diabetes and coronary heart disease) using a combination of BMI and waist circumference measurements (NICE 2006). These guidelines were broadly based on several investigations (Lean, Han and Morrison 1995, Han, Lean and Seidell 1996, Zhu et al 2002, 2004; Janssen, Katzmarzyk and Ross 2004) that showed the benefit of adding waist circumference measurements to BMI to give a more informed representation of abdominal obesity and visceral fat and therefore ‘health’ risk. This ‘health’ risk is referred to in the text as ‘level of risk’ (see Figure 4.1).

Statistical Plan

Participants were categorised into groups according to age, marital status, gender, rank, operationally defined employment category, fitness test outcome, occupational medical status, years employed in the army and geographical location of unit. Age in years was reflected by the following groups (17-24, 25-34, 35-44, and ≥45); with gender being either male or female. The terms Direct Entry (DE) Officer, Late Entry (LE) Officer and Soldier (all enlisted ranks) were utilized in the study. It was felt that the officer class required a further sub classification due to the potentially confounding nature of the LE Officer’s age in relation to the DE Officer. LE Officers commission from the ranks and are typically 37+ years at the rank of Captain (43+ years = Major, 50+ years = Lieutenant Colonel). DE Officers commission direct from the civilian population and are typically 27+ years at the rank of Captain (30+ years = major, 35+ years = Lieutenant Colonel).

The operationally defined employment categories of Combat, Combat Service Support, Combat Support Services and Other were employed. Military personnel were categorised as Combat if they generally had direct contact with enemy forces. Combat Service Support were those personnel who offered direct support to combat elements, while Combat Support Services provided indirect support to combat elements and Others were supportive to all personnel (primarily through training).

Two physical training tests were investigated; the Annual Fitness Test (AFT) and the Personal Fitness Assessment (PFA). The AFT represents the minimum maintenance standard of individual basic vocational fitness required by Army personnel. This load carriage activity required participants to complete a 12.8km loaded march in a maximum time of 2 hours, carrying a load that directly reflected the requirements of their specific combat employment groups (CEG's) within the army (load range 15-25 kg). The PFA is an assessment of cardiovascular fitness and muscle endurance, designed to encourage improved physical performance and the maintenance of good health. The test is split into three areas of press-ups (to measure the performance of arm and shoulder extensor muscles and trunk stability), sit-ups (to measure the performance of abdominal and hip flexor muscles) and a 1.5 mile (2.4 km) run (to measure aerobic capacity). In each test the participants were categorised into groups reflecting a pass, fail or non-attendance. These tests are explained in greater detail in Chapter 4 (see pages 47-49).

Occupational medical category is a system used by the British Army to categorise medical fitness for front-line employment (deployment) and is split into three groups. The groupings state that the individual is medically fit deployable (MFD), medically limited deployable (MLD) or medically non deployable (MND). These groupings are the result of a medical board. The eventual categorisation reflects both medical / psychological fitness and specifically the medical needs of the individual in austere (remote) locations. Years spent in the armed forces were split into three groups (0-12 years, 13-24 years and 25-36 years). The categorisation of geographical location, grouped individuals as to their current unit location and not place of birth. For geographical location individuals were assigned to the following groups: United Kingdom (UK) South (including South East, South West and London), UK Central (including East and West Midlands), UK North (including North East and North West), Scotland, Northern Ireland, Wales, Germany, World Combined (including France, Italy, United States, Belize, Cyprus). Those without location assignation were coded as missing.

Through further analysis, outliers were identified through the calculation of z-scores, with a score of 3.29 constituting an outlier; these scores were then replaced with a value of the mean + 3 x the SD (Field 2005). The reported values were expressed as the proportion of individuals within each category. For categorical data, Chi-squared tests were used to compare the prevalence of obesity and risk of obesity-related ill-health in the demographic sub-groups. Multiple logistic regressions were used to identify independent predictors of obesity (BMI ≥30.0 kg/m^2) and increased risk of obesity related ill-health (including those categorised as increased, high, very high and extreme risk). Significant predictors were used to calculate the odds of being obese and the odds of having an increased risk of obesity-related ill-health. Statistical significance was assessed with 95% confidence intervals.

The analyses were conducted separately by gender due to differences in both the prevalence of obesity and risk of obesity-related ill-health. Referent values were assigned within each predictor group (age - 17-24, marital status - single, rank – officer, employment group – combat, AFT – pass, PFA – pass, medical category – MFD, years in the Army – 0-12 and geographical location – UK South). Model 1 incorporated the categories identified above, and the output represents the outcome of univariate analyses only. Model 2 used multivariate analyses through multiple logistic regressions and was reflective of previous research in the specific population. Model 3 analysed all study variables to enable the identification of significant demographic predictors, with potential confounders controlled. As an analogue to the R^2- value, the measure described by Hosmer and Lemeshow (1989) was utilised to express the ratio of what the model can explain (Field 2005), this version of the coefficient of determination is expressed as R^2_L. Analyses were performed using SPSS version 18, and statistical significance was set at an alpha level of 0.05.

<u>Results</u>

Descriptive

Table 5.1 illustrates the sociodemographic characteristics of the British Army cohort. The study population, whilst primarily male, single and soldier (as opposed to officer), remains typical of the demographic of the British Army. Whilst above half of the soldiers in the study had passed both physical tests, the results suggested that by percentage males failed the PFA more than the females and that the opposite was true for the AFT. The medical deployability results indicated that 5% could not be employed in front-line posts and an additional 14% were restricted in their employment at the front-line. In both cases the female study participants displayed higher levels of limited and non-deployability. The majority of the participants in the study had served less than 12 years in the army and were primarily from the southern areas of the UK and Germany. These findings are in-keeping with the general demographic population of the British Army.

Table 5.1: Sociodemographic Characteristics for British Army total study cohort and by gender for age, marital status, military status, employment, fitness test result, medical deployment category, years served in the army and geographical location of unit - (DASA 2011).

Variable	Sub Group	All = 50,635		Male = 47,173		Female = 3,462	
		N (%)		N (%)		N (%)	
Age Group	17 - 24	17,707	(35.0)	16,448	(35.0)	1,259	(36.4)
	25 – 34	20,949	(41.4)	19,343	(41.0)	1,606	(46.4)
	35 – 44	10,448	(20.6)	9,915	(21.0)	533	(15.4)
	45+	1,531	(3.0)	1,467	(3.0)	64	(1.8)
Marital Status	Single	29162	(57.6)	26,602	(56.4)	2560	(73.9)
	Married	21473	(42.4)	20,571	(43.6)	902	(26.1)
Military Status	Officer	3683	(7.3)	3,232	(6.9)	451	(13.0)
	LE Officer	780	(1.6)	739	(1.6)	41	(1.2)
	Soldier	46,172	(91.1)	43,202	(91.5)	2,970	(85.8)
Employment Group	Combat	15,663	(31.0)	15,594	(33.1)	69	(2.0)
	Com Services Support	14,738	(29.1)	14,043	(29.7)	695	(20.1)
	Com Support Services	15,269	(30.1)	13,817	(29.3)	1,452	(42.0)
	Other	4,818	(9.5)	3,576	(7.6)	1,242	(35.9)
	Missing	147	(0.3)	143	(0.3)	4	(0.0)
PFA	Pass	30,259	(59.8)	28,407	(60.2)	1,852	(53.5)
	Fail	2,610	(5.2)	2,445	(5.2)	165	(4.8)
	Not taken	17,766	(35.1)	16,321	(34.6)	1,445	(41.7)
AFT	Pass	26,718	(52.8)	25,399	(53.8)	1,319	(38.1)
	Fail	470	(1)	355	(0.8)	115	(3.3)
	Not taken	23,447	(46.3)	21,419	(45.4)	2,028	(58.6)
Medical Deployment Category	MFD[1]	40,817	(80.6)	38,377	(81.5)	2440	(70.7)
	MLD[2]	7,152	(14.3)	6,459	(13.7)	693	(20.7)
	MND[3]	2,599	(5.1)	2,279	(4.8)	320	(8.6)
Years Served	0-12	36,357	(71.8)	33,654	(71.3)	2,703	(78.1)
	13-24	13,090	(25.9)	12,360	(26.2)	730	(21.1)
	25-36	1,188	(2.3)	1,159	(2.5)	29	(0.8)
Geographical Location	**South**	17,697	(35)	16,673	(35.3)	1,024	(29.6)
	Central	8,102	(16)	7,280	(15.4)	822	(23.7)
	North	4275	(8.4)	3,972	(8.4)	303	(8.8)
	Wales	740	(1.5)	546	(1.2)	194	(5.6)
	Scotland	1674	(3.3)	1,579	(3.3)	95	(2.7)
	N Ireland	1444	(2.9)	1,435	(3)	9	(0.3)
	Germany	12623	(24.9)	11,902	(25.2)	721	(20.8)
	World Combined	2084	(4.1)	1,996	(4.2)	88	(2.5)
	missing	1996	(3.9)	1,790	(3.8)	206	(6)

Notes

1. MFD = Medically Fully Deployable
2. MLD = Medically Limited Deployable
3. MND= Medically Non-Deployable

Univariate and Multivariate Analyses

The results of the univariate and multivariate regression analyses with respective odds ratio (OR) and 95% confidence intervals (CI) are shown for male study participants in Table 5.2 (BMI) and Table 5.3 (risk of obesity-related ill-health). For female study participants, Table 5.4 shows the results for BMI and Table 5.5 displays the results in regards to risk of obesity-related ill-health.

Multivariate analyses suggest male and female personnel classified by BMI as obese had greater odds of being older, enlisted, and limited in their medical status, and of failure in both the AFT and PFA. In addition those male personnel, who had been employed in the army for more than 12 years, married and employed in a non-combat role, were more likely to be obese. For female personnel, marital status and employment category were not significantly linked to BMI status. When waist circumference measurements were added to BMI data and the risk of obesity-related ill-health was assessed, a similar outcome was observed. However, for the male study participants those soldiers employed within the Combat Services Support vocation were now observed as the group having the highest levels of risk of obesity related diseases compared against the Combat group.

Across all study participants and in respect of both obesity and risk of obesity related ill-health, closer inspection of significance values and the Wald statistic indicated that the outcome of the PFA was the most influential statistic (specifically the ability to pass the test). Also highly placed in their predictive ability were age (≥35 years) and medical status (MLD).

Male: Table 5.2 displays the results for males when obesity (as measured by BMI) was regressed against age, marital status, rank and employment. When each predictor was controlled for each other, the multivariate analyses produced a final model (χ^2 (9) = 4252.78). The R^2_L = 0.156, suggested that the variables included in the model explained 16% of the variance. When the additional variables of physical test result, medical employability, years served and geographical location were added the final model (χ^2 (24) = 4965.21) explained 22% of the variance R^2_L = 0.224.

Table 5.2: Male Obesity - Logistic Regression from least adjusted (univariate), regression based previous research (age, marital status, military status and employment), most adjusted, adding (fitness test result, medical deployment category, years served in the army and geographical location of previous unit).

Variable	Sub-Variable	Least adjusted uni-variate				Based on Previous research				Most adjusted multi-variate			
		Sig	OR	95% CI		Sig	OR	95% CI		Sig	OR	95% CI	
				H	L			H	L			H	L
Age Group	**17-24**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	25-34	***	**4.12**	3.78	4.85	***	**3.46**	3.16	3.80	***	**2.37**	2.12	2.64
	35-44	***	**13.01**	11.85	14.28	***	**10.51**	9.45	11.70	***	**4.81**	4.13	5.61
	45+	***	**12.12**	10.21	14.40	***	**14.43**	11.61	17.93	***	**5.29**	4.05	6.90
Marital Status	**Single**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Married	***	**3.87**	3.64	4.12	***	**1.74**	1.61	1.87	***	**1.50**	1.37	1.62
General Rank	**Officer**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	LE Officer	***	**3.58**	2.72	4.70	*	**1.54**	1.14	2.09	*	**1.50**	1.08	2.08
	Soldier	***	**1.46**	1.27	1.68	***	**3.35**	2.87	3.90	***	**2.50**	2.12	2.94
Combat Group	**Combat**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Support Services	***	**1.15**	1.07	1.24		**1.03**	0.95	1.12		**0.95**	0.86	1.05
	Service Support	***	**1.47**	1.36	1.58	*	**1.12**	1.03	1.22		**0.94**	0.85	1.03
	Other	***	**2.14**	1.91	2.39		**0.95**	0.84	1.08	*	**0.86**	0.74	0.99
PFT test result Personal Fit Test	**Pass**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Fail	***	**10.11**	8.96	11.41					***	**11.43**	9.72	13.45
	Not taken	***	**4.17**	3.91	4.45					***	**2.10**	1.93	2.29
AFT test result Annual Fit Test	**Pass**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Fail	***	**6.11**	4.61	8.10					***	**3.45**	2.39	4.99
	Not taken	***	**2.63**	2.47	2.79					***	**1.47**	1.36	1.60
Medical Cat	**Fit to Deploy**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Limited Deploy	***	**7.18**	6.64	7.75					***	**2.68**	2.42	2.97
	No Deploy	***	**3.11**	2.75	3.51					***	**1.62**	1.40	1.89
Years in Army	**0 - 12**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	13 - 24	***	**3.60**	3.34	3.87					***	**1.43**	1.27	1.62
	25 - 36	***	**3.17**	2.32	4.33					*	**1.65**	1.07	2.53
Location	**Eng South**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Eng Central	*	**0.91**	0.83	0.99					*	**0.89**	0.80	0.99
	Eng North		**0.95**	0.85	1.06						**0.98**	0.85	1.13
	Wales	***	**0.54**	0.43	0.69					**	**0.61**	0.45	0.81
	Scotland		**0.97**	0.82	1.14						**0.90**	0.73	1.11
	N Ireland	*	**1.23**	1.04	1.45					**	**1.44**	1.16	1.79
	Germany		**1.03**	0.95	1.11					***	**1.20**	1.09	1.32
	World Combined		**0.96**	0.82	1.12						**0.92**	0.76	1.12

*** = P<.0001, ** P< .001, * P< .05

Table 5.3: Male Risk - Logistic Regression from least adjusted (univariate), regression based previous research (age, marital status, military status and employment), most adjusted, adding (fitness test result, medical deployment category, years served in the army and geographical location of previous unit).

Variable	Sub-Variable	Least adjusted uni-variate				Based on Previous research				Most adjusted multi-variate			
		Sig	OR	95% CI		Sig	OR	95% CI		Sig	OR	95% CI	
				H	L			H	L			H	L
Age Group	**17-24**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	25-34	***	**2.60**	2.45	2.76	***	**2.32**	2.18	2.47	***	**1.78**	1.65	1.92
	35-44	***	**6.07**	5.70	6.47	***	**5.14**	4.78	5.53	***	**3.03**	2.73	3.36
	45+	***	**6.96**	6.21	7.79	***	**7.40**	6.41	8.54	***	**3.86**	3.25	4.59
Marital Status	**Single**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Married	***	**2.55**	2.45	2.67	***	**1.40**	1.33	1.47	***	**1.26**	1.19	1.33
General Rank	**Officer**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	LE Officer	***	**2.49**	2.10	2.95	*	**1.24**	1.03	1.50		**1.19**	.974	1.45
	Soldier	*	**1.14**	1.05	1.25	***	**1.93**	1.76	2.12	***	**1.62**	1.47	1.79
Combat Group	**Combat**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Support Services	***	**1.19**	1.12	1.26	***	**1.12**	1.06	1.19		**1.05**	0.98	1.11
	Service Support	***	**1.50**	1.42	1.58	***	**1.26**	1.19	1.33	*	**1.10**	1.03	1.18
	Other	***	**2.02**	1.87	2.19	**	**1.16**	1.07	1.27		**1.06**	0.96	1.16
PFT test result Personal Fit Test	**Pass**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Fail	***	**4.81**	4.42	5.24					***	**4.94**	4.45	5.50
	Not taken	***	**2.55**	2.44	2.67					***	**1.57**	1.48	1.66
AFT test result Army Fit Test	**Pass**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Fail	***	**3.63**	2.94	4.49					***	**2.37**	1.84	3.07
	Not taken	***	**2.06**	1.97	2.15					***	**1.38**	1.31	1.45
Medical Cat	**Fit to Deploy**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Limited Deploy	***	**4.04**	3.83	4.27					***	**2.06**	1.92	2.20
	No Deploy	***	**2.39**	2.18	2.61					***	**1.51**	1.36	1.68
Years in Army	**0 - 12**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	13 - 24	***	**2.48**	2.36	2.61					***	**1.28**	1.19	1.39
	25 - 36	***	**2.65**	2.16	3.26					*	**1.36**	1.04	1.78
Geographical Location	**Eng South**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Eng Central	***	**0.86**	0.81	0.92					***	**0.85**	0.80	0.91
	Eng North	**	**0.88**	0.81	0.95					*	**0.88**	0.78	0.97
	Wales	***	**0.53**	0.45	0.62					***	**0.60**	0.50	0.72
	Scotland		**0.99**	0.88	1.12						**1.00**	0.87	1.16
	N Ireland		**0.94**	0.83	1.07						**0.87**	0.75	1.02
	Germany	**	**0.91**	0.86	0.92						**1.03**	0.97	1.10
	World Combined	***	**0.76**	0.68	0.86					*	**0.74**	0.65	0.85

***= P<.0001, ** = P< .001, * = P< .05

The risk of obesity related ill-health was assessed (see Table 5.3) against the variables of age, marital status, rank and employment (χ^2 (9) = 4292.20). Inspection of the original log-likelihood (LL) and the change in LL produced by the model suggested that the predictors included in the model explained 8% of the variance (R^2_L =0.083). The addition of the variables pertaining to physical test result, medical employability, years served and geographical location, produced a final model (χ^2 (24) = 5085.14) that explained 12% of the variance (R^2_L = 0.12).

Female: Table 5.4 displays the results for females when obesity was regressed against age, marital status, rank and employment. When each predictor was controlled for, the multivariant analyses (χ^2 (9) =98.03), R^2_L = .06, suggested that the variables included in the model explained 6% of the variance. When the additional variables of physical test result, medical employability, years served and geographical location were added (χ^2 (24) =441.19), the R^2_L = 0.10 indicated a better fitting model, explaining 10% of the variance. However, this final model is suggestive of a reduced fit compared to the male final model (female 10% and male 22% of variance explained respectively).

Table 5.5 refers to the results for females when the risk of obesity related ill-health (BMI and WC combined) was regressed against age, marital status, rank and employment (χ^2 (9) =179.19, R^2_L = .04). Analyses of the final regression model, which included the additional variables of physical test result, medical employability, years served and geographical location, returned a final model of χ^2 (24) = 374.61, R^2_L = 0.11. The R^2 statistic indicated that 11% of the variance was explained by the variables included in the analyses.

Table 5.4: Female Obesity-Logistic Regression from least adjusted (univariate), regression based previous research (age, marital status, military status and employment), most adjusted, adding (fitness test result, medical deployment category, years served in the army and geographical location of previous unit).

Variable	Sub-Variable	Least adjusted uni-variate				Based on Previous research				Most adjusted multi-variate			
		Sig	OR	95% CI		Sig	OR	95% CI		Sig	OR	95% CI	
				H	L			H	L			H	L
Age Group	17-24		**1.00**	NA	NA		**1.00**	NA	NA		**1.00**	NA	NA
	25-34	***	**2.47**	1.80	3.40	***	**2.36**	1.63	3.42	*	**1.86**	1.24	2.80
	35-44	***	**4.40**	3.03	6.39	***	**3.84**	2.48	5.94	***	**3.20**	1.80	5.68
	45+	***	**9.15**	4.66	17.95	***	**10.48**	4.68	23.50	**	**5.78**	2.11	15.79
Marital Status	Single		**1.00**	NA	NA		**1.00**	NA	NA		**1.00**	NA	NA
	Married	***	**1.69**	1.30	2.19		**1.06**	.801	1.41		**0.92**	0.67	1.26
General Rank	Officer		**1.00**	NA	NA		**1.00**	NA	NA		**1.00**	NA	NA
	LE Officer	*	**4.70**	1.71	12.95		**2.27**	.754	6.80		**1.98**	0.59	6.64
	Soldier	***	**2.54**	1.59	4.06	***	**4.06**	2.45	6.75	***	**2.66**	1.54	4.59
Combat Group	Combat		**1.00**	NA	NA		**1.00**	NA	NA		**1.00**	NA	NA
	Support Services		**0.70**	0.26	1.87		**0.58**	0.21	1.61		**1.01**	0.32	3.21
	Service Support		**1.16**	0.45	2.99		**0.96**	0.35	2.58		**1.41**	0.46	4.29
	Other		**1.29**	0.50	3.34		**0.81**	0.30	2.20		**1.26**	0.41	3.88
PFT test result Personal Fit Test	Pass		**1.00**	NA	NA						**1.00**	NA	NA
	Fail	***	**14.52**	8.94	23.59					***	**11.85**	6.44	21.82
	Not taken	***	**6.08**	4.48	8.25					***	**2.69**	1.84	3.94
AFT test result Army Fit Test	Pass		**1.00**	NA	NA						**1.00**	NA	NA
	Fail	***	**3.42**	1.77	6.59					*	**2.79**	1.23	6.35
	Not taken	***	**3.63**	2.65	4.96					***	**2.07**	1.41	3.04
Medical Cat	Fit to Deploy		**1.00**	NA	NA						**1.00**	NA	NA
	Limited Deploy	***	**6.63**	5.04	8.70					***	**3.08**	2.15	4.40
	No Deploy	***	**2.81**	1.88	4.20						**1.47**	0.90	2.39
Years in Army	0 - 12		**1.00**	NA	NA						**1.00**	NA	NA
	13 - 24	***	**1.83**	1.32	2.55						**0.70**	0.41	1.19
	25 - 36	*	**4.76**	1.06	21.41						**2.19**	0.33	13.72
Location	Eng South		**1.00**	NA	NA						**1.00**	NA	NA
	Eng Central		**0.95**	0.67	1.34						**0.90**	0.60	1.34
	Eng North		**0.90**	0.58	1.39						**0.86**	0.51	1.46
	Wales		**0.42**	0.06	3.18						**0.73**	0.08	6.45
	Scotland	*	**2.47**	1.37	4.44					*	**2.10**	1.03	4.29
	N Ireland		**1.36**	0.71	2.59						**1.42**	0.66	3.07
	Germany		**0.80**	0.57	1.12						**0.95**	0.62	1.44
	World Combined	*	**2.33**	1.32	4.11					*	**2.05**	1.03	4.07

*** = P< .0001, ** = P< .001, * = P< .05

Table 5.5: Female Risk-Logistic Regression from least adjusted (univariate), regression based previous research (age, marital status, military status and employment), most adjusted, adding (fitness test result, medical deployment category, years served in the army and geographical location of previous unit).

Variable	Sub-Variable	Least adjusted uni-variate				Based on Previous research				Most adjusted multi-variate			
		Sig	OR	95% CI		Sig	OR	95% CI		Sig	OR	95% CI	
				H	L			H	L			H	L
Age Group	**17-24**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	25-34	***	**1.58**	1.34	1.88	***	**1.78**	1.49	2.13	**	**1.46**	1.16	1.83
	35-44	***	**2.69**	2.16	3.34	***	**3.21**	2.53	4.06	***	**2.52**	1.79	3.56
	45+	***	**2.67**	1.60	4.45	***	**3.99**	2.22	7.16		**1.97**	0.97	4.03
Marital Status	**Single**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Married	***	**1.50**	1.27	1.76	*	**1.22**	1.02	1.44		**1.00**	0.83	1.22
General Rank	**Officer**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	LE Officer	*	**2.92**	1.49	5.72		**1.82**	0.89	3.71		**1.59**	0.73	3.48
	Soldier	***	**2.17**	1.69	2.80	***	**2.88**	2.21	3.75	***	**2.29**	1.71	3.06
Combat Group	**Combat**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**		**1.00**	**NA**	**NA**
	Support Services		**0.62**	0.37	1.04		**0.63**	0.37	1.08		**0.70**	0.37	1.30
	Service Support		**0.84**	0.51	1.39		**0.79**	0.47	1.32		**0.89**	0.48	1.62
	Other		**0.77**	0.46	1.27		**0.61**	0.36	1.03		**0.67**	0.37	1.24
PFT test result Personal Fit Test	**Pass**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Fail	***	**5.40**	3.89	7.50					***	**5.86**	3.81	9.02
	Not taken	***	**2.71**	2.33	3.17					***	**1.76**	1.43	2.16
AFT test result Army Fit Test	**Pass**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Fail	***	**2.64**	1.78	3.92					*	**1.95**	1.15	3.32
	Not taken	***	**2.28**	1.94	2.68					***	**1.62**	1.32	1.99
Medical Cat	**Fit to Deploy**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Limited Deploy	***	**3.27**	2.74	3.90					***	**1.84**	1.46	2.31
	No Deploy	***	**2.16**	1.70	2.76						**1.30**	0.96	1.74
Years in Army	**0 - 12**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	13 - 24	***	**1.64**	1.32	2.03						**0.87**	0.63	1.21
	25 - 36		**2.74**	0.73	10.24						**2.75**	0.62	12.13
Location	**Eng South**		**1.00**	**NA**	**NA**						**1.00**	**NA**	**NA**
	Eng Central		**0.92**	0.75	1.13						**0.88**	0.67	1.13
	Eng North		**0.97**	0.75	1.26						**0.92**	0.67	1.26
	Wales		**1.34**	0.62	2.99						**1.52**	0.59	3.94
	Scotland	**	**2.00**	1.32	3.03					*	**1.94**	1.18	3.19
	N Ireland		**1.33**	0.89	1.98						**1.39**	0.86	2.24
	Germany		**0.95**	0.79	1.15						**1.04**	0.82	1.32
	World Combined		**1.19**	0.78	1.80						**1.05**	0.65	1.69

*** =P< .0001, ** = P< .001, * = P< .05

Discussion

The aim of the research reported in this chapter was to report the predictive ability of age, marital status, rank, employment, physical test outcome, medical category, years served, and geographical location in relation of obesity and the risk of obesity related ill-health in a large representative sample of the British Army.

In Chapter 3 the same study sample was investigated and reported the prevalence of obesity in relation to age, marital status, rank and employment, the current study concluded that age represented a clear relationship across both genders with obesity and obesity related ill-health (Sanderson, Clemes and Biddle 2014). This relationship is generally accepted across military (Napredit et al 2005, Mullie et al 2008, Bray et al 2009, Fear, Sundin and Rona 2011, Shaw et al 2013), and civilian populations (Flegal et al 2010, NHS 2011, Wang et al 2011). In the current study this relationship remained, although to a lesser extent with the inclusion of the additional variables (physical test result, medical employability, years' served and geographical location). Previous studies into the military population have suggested that declining activity levels (Shaw et al 2013) transition into sedentary roles (Helmhout 2009), and reduced attendance at mandatory physical training and increased likelihood of injury (reported in Chapter 4), could all be supportive of an age related increase in obesity and obesity related ill-health.

Studies to date have not ascertained whether the reduction of occupational physical activity (OPA) aligned to advancing age is a volitional act. However, investigations into sedentary behaviour have contested that prolonged periods of sitting and the absence of whole body movement is distinctly related to chronic disease and adverse metabolic consequences, independent of physical activity (Healy et al 2008, Owen et al 2010).

Although age remained an important predictor of both obesity and enhanced risk of obesity related ill-health, the outcome of the personal fitness assessment (PFA) was the most dominant predictor. Specifically those male and female study participants defined as at 'some risk' were 5 times more likely to fail and nearly twice as likely not to attend the test compared to those deemed at 'no risk' of obesity related ill-health. Similarly, Gantt et al (2008) concluded that BMI was the single most important factor predicting failure in a US military physical readiness test. In addition, Troumbley et al (1990) reported that US soldiers categorised as normal weight by BMI displayed lower health risks, better health status and better physical fitness test scores than those categorised as overweight and obese. Of the two army physical tests, the PFA has a higher aerobic and cardiorespiratory fitness (CRF) component. Several studies have alluded to a relationship between obesity and low CRF (Bertoli et al 2003, Fogelholm et al 2006, Ross and Katzmarzyk 2003); additionally there is substantial evidence to suggest that CRF attenuates much of the health risk attributed to obesity (Barlow et al 1995, Wei et al 1999). Studies have also concluded that the benefits gained from CRF can be elicited from moderate and not just vigorous PA (Ross and Katzmarzyk 2003). In addition to the CRF component of the PFA (1.5 mile best effort run), there are neuromuscular events that require muscle endurance (press-ups and sit-ups). Some studies have suggested that BMI and specifically abdominal obesity may have a negative influence on physical tasks that require projection of body movement or support of the body off the ground (Hulens et al 2003, Fogelholm et al 2006). The rationale to support this assertion lie in the additional mechanical work needed by the obese individual to increase force production, and the additional gravitational pull attracted by the greater abdominal mass (Hulens et al 2001).

While the PFA and variants of the PFA are widely employed across several military populations (UK, US, Australian Defence Force), some have argued that the present test favours the lighter (and not always fitter) individual (Vanderburgh and Crowder 2006, Vanderburgh 2008). Beyond the arguments and assessments of weight related fitness the authors have contested that the PFA is not an occupational test. However, within the current study those with some-risk as opposed to no-risk to obesity related ill health were also significantly (male=$P<0.001$, female $P<0.05$) more likely to fail the occupational (load carriage) test (AFT). It could be that for both tests (PFA and AFT) metabolic changes have impaired performance through reductions to muscle function, oxidative capacity and motor unit activity (Waring et al 2006, Wadstrom et al 1991, Newcomer et al 2001). Specifically for load carriage, research has suggested that body composition rather than body weight is more closely associated with the metabolic demands of heavy load carriage tasks as undertaken by the military (Lyons, Allsop and Bilzon 2001). Haisman (1988) described excess body fat as an additional 'dead weight', impairing performance during load-carriage tasks. The results of the current study suggest that for both tests, those deemed as obese or at some-risk of obesity related ill-health fail more readily and attend less readily than those deemed not obese or not at risk, however, the predictive ability was stronger for the outcomes of the PFA. This could suggest that those deemed obese by BMI are disadvantaged by simply being larger, nevertheless, the inclusion of waist circumference data to assess risk would indicate that failure and in some cases failure to attend is linked to enhanced risk of obesity related ill-health.

For the military, fitness level is also used as a predictor for combat military duties (Haddock et al 2007). To ensure that soldiers are medically and psychologically ready for the rigours of combat, military personnel undertake regular medical appointments. Indeed it is an occupational requirement for all soldiers to be ascribed a medical *fitness for deployment* grading. Within the current study, medical category for deployment was a significant predictor of both obesity and risk of obesity related ill-health. It is well reported that obesity increases the risk of occupational injury (Lin et al 2013), disability (Robroek et al 2013, Roos et al 2013) and musculoskeletal disorders (Anandacoomarasamy et al 2008). Due to the occupational requirement for high levels of robustness and fitness the military is a population with high levels of musculoskeletal injury (Knapik et al 2004). Some studies have suggested that alterations to body geometry (Hue 2007) reduced movement efficiency (Reynolds 2006, Attwells 2002) in obese individuals could put undue strain on the connective soft tissue supporting skeletal movement and joint congruity (Ding et al 2005, Gaida et al 2010). Within the current study, those participants deemed medically limited deployable (MLD) were significantly more likely to be at some-risk (as opposed to no-risk) of obesity related ill health, specifically soldiers in the MLD category were twice as likely than the referent 'MFD' category to be at some-risk of obesity related ill-health. Similarly one study on the UK Royal Navy (Kilminster, Roiz De Sa and Bridger 2008) concluded that obesity was significantly associated with medical category. Further studies on military personnel have also suggested that obesity is an outcome associated with long-term injury (Lohmander et al 2007, Knapik et al 2004). Whilst it is not known from the study on the UK Royal Navy or in the current study if obesity caused or was the result of the injury, the predictive strength of the variable and the high level of correlation with BMI and to a greater extent risk of obesity related ill-health warrants further investigation.

Rank within the military has being linked to socioeconomic status (SES) with some studies suggesting that educational attainment (Grotto et al 2008), and pay group (Bray et al 2006), are both linked to obesity status. Therefore it may not be surprising that obesity was more common in the lower paid 'enlisted ranks' as opposed to the higher paid 'officer class' (Bray et al 2006, Sanderson, Clemes and Biddle 2011). This statement was still supported within the current study as soldiers (enlisted ranks) were three times more likely to be obese, and twice as-likely to be at some-risk of obesity related ill-health than the referent category (DE Officer). However, the stratification of the officer cohort to reflect primarily younger DE Officers and generally older LE Officers, suggest that age explains much of the variance, due to the changes in effect from univariate analyses to subsequent multi-variate analyses controlling for age. Based on the work of Wardle, Waller and Jarvis (2002), previous investigations on this study population have suggested that, when adjusted for age, the impact of SES is diminished, offering a possible explanation for the results of the British Army (Sanderson, Clemes and Biddle 2014, Chapter 3)

As reported in Chapter 3 (Sanderson, Clemes and Biddle 2014) both marital status and combat employment group remained significant predictors of obesity and obesity related ill-health for the male participants. The findings of the current study suggest that while the male soldiers employed within the combat element are more likely to be obese, they are at least risk of obesity related ill health (BMI and WC combined) than those in the non-combat and supportive elements. In respect of BMI, similar findings were reported on the Royal Thai Army by Napradit et al (2005), who concluded that the inability of BMI to distinguish between fat and fat free mass is a probable explanation for the contrasting findings. These findings highlight the limitations of BMI when reporting body composition in military (McLaughlin and Wittert 2009, Prentice and Jebb 2001) and athletic (Ode et al 2007, Nevill et al 2005) populations, and has been previously alluded to in all previous chapters in this thesis. As BMI predicts lean mass at least as well as it predicts fat mass (Friedl 2004, Rasmussen, Johansson and Hansen 1999) it should not be used in isolation (without an accompanying waist circumference measurement) to define occupational readiness in military personnel.

For male study participants (and while the strength of effect was diminished in the current study) being married (as opposed to single) was a significant predictor of both obesity and obesity related ill-health and is consistent with previous findings (Bray et al 2006, Kaplan et al 2003, Martinez et al 1999). Based on a small sample of US Army officers, Sigrist, Anderson and Auld (2005) concluded that lack of time, low priority, low skill and enjoyment of cooking were all associated barriers to healthy eating and health enhancing behaviours. Supporting the notion that service personnel and their spouses require specific nutrition and cooking education. As lack of cooking confidence, ability and enjoyment could enforce a reliance on convenience foods, many of which are high in fat (WHO 2003).

Independent of age, years spent in the army (≥13 years) was predictive of obesity and obesity related ill-health compared against those with <13 years service. There are no other studies with which to compare, however, as with age, protracted engagement in a military career will (in most cases) bring additional responsibility and managerial duties (Friedl 2004). In many cases this change from 'high activity' to 'low activity' reduces total activity and increases time being sedentary (Allman-Farinell et al 2010). One could hypothesise that when OPA and opportunities for PA are reduced, some soldiers may not seek to redress the activity deficit. A recent investigation into the exercise motivations of military personnel identified that those who sought controlling forms of motivation for exercise were more likely to be reduced in their general health and fitness, with the opposite being true for those who were autonomous in their exercise motivation (Wilson, Markey and Markey 2012). This may be an issue for Armed Forces personnel as much engagement in physical fitness is externally motivated, reducing the chances to internalise health enhancing behaviours (Drystad, Miller and Hallen 2007).

While geographical location was significantly linked to risk of obesity related diseases, this outcome should be viewed with caution for the female population due to the reduced numbers involved. For males there were marginal, but significant relationships between being located in Germany and the South of UK (increased risk of obesity related ill-health) compared with those study participants located primarily in Wales and UK Midlands (comparatively reduced risk of obesity related ill-health). Information pertaining to European obesity prevalence, would suggest that the UK has a higher prevalence than Germany (Berghofer et al 2008). While UK data (Jebb, Rennie and Cole 2004) indicate that levels of obesity are higher outside England (e.g. Wales, Scotland and Northern Ireland); with prevalence lowest in London and a broad variation across other English regions (HSE 2012). However, due to the amount of time away from the unit location and the mobile nature of Army life, the credibility of the findings in respect of geographical location may be questionable.

Limitations to this study included data collection and research design as numerous persons collected the BMI data used to establish weight status in the British Army study at a variety of locations. Although many individuals were involved in the measurement process, all the individuals were given training by medical staff. Whereas the use of a cross-sectional study precludes causal inferences, the large sample size offer a representative sample of military personnel, increasing the power and generalizability of the findings.

Conclusion

In the current study data suggest that failure of mandatory fitness tests, being older (≥35 years), reduced medical capability and enlisted status are the primary predictors of obesity and obesity related ill health in the British Army. In addition, for male participants, years served (≥12), being married, employment category and geographical location unit were also indicative of increased risk of obesity related ill-health. The current study concurs with the earlier findings of Kress et al (2005) in that a career in the military does not confer any long-term protection against obesity and the associated co-morbidities.

For an occupation whose selection criteria is based on medical fitness and physical potential (Kilminster, Roiz De Sa and Bridger 2008), obesity is primarily a reversible illness resulting from personal choice (Gantt 2008). Preventing illness is intuitively more economically viable than the cost of treatment, and has less impact on individual health and collective operational capability (NAO 2010). Therefore, Army leaders and personnel should: (1) seek to enhance the priority of personal and collective fitness training, testing and conditioning; (2) formulate age related PA opportunities to enhance total PA, in order to reduce sedentary behaviour and the incidence of musculoskeletal injury; (3) encourage career-long engagement with PA, to enhance the protective effect of PA to mediate the reduction of OPA associated with protracted army careers; (4) provide health education strategies that benefit both serving members and their families; and (5) have an awareness of the potential impact of obesity related ill-health as an occupational, economic and public health burden.

Chapter 6

Obesity and Health Behaviours in the British Army

Chapter 6 Health Behaviours

Chapter 6 gives an insight into the health behaviours of British soldiers. This study outlines the results of a questionnaire based study that captured the responses of over 1000 serving soldiers in the UK 3rd Division. Data capture sought to highlight the relationships between obesity and mandatory physical training, leisure-time physical training, motivation towards exercise, dietary behaviour, sedentary behaviour and restrictive eating. Correlations and logistic regressions are reported and discussed.

Obesity and Health Behaviours in the British Army

Introduction

United Kingdom (UK) estimates indicate that almost two-thirds of adults and a third of children are either overweight or obese (NHS 2011). With a recent paper based on 50,000 British Army personnel stating that over 12% were obese and 24% of the population was at increased risk of obesity related ill-health (Sanderson, Clemes and Biddle 2014), it is clear that the armed forces are not protected against the obesity epidemic.

It is generally accepted that obesity is a multi-factorial disease (Nammi et al 2004) with a causative pathway linked to a combination of physical inactivity, diet and metabolic factors influenced by genetic factors (Lindquist and Bray 2000). Research into military populations suggests that recent technological advances have decreased physical activity in the workplace (Craig et al 1999). Specifically, Friedl (2004) suggested that as soldiers move to increasingly sedentary jobs as they progress in their careers their total energy expenditure would reduce, even if they continued to maintain voluntary fitness habits. Supporting the notion that sedentary time, independent of physical activity (PA) is related to risk of obesity and cardiometabolic ill-health (Healy et al 2008).

Beyond the utilization of occupational physical activity (OPA) as the primary activity facilitator, evidence suggests that vigorous and moderate PA accumulated through leisure-time physical activity (LTPA) may play a key preventative role in obesity (Hamilton et al 2008). The engagement of voluntary PA in isolation, or in addition to mandatory physical training (PT), may help re-address the imbalance between high levels of sedentary behaviour and reduced OPA, as obesity is more common in physically inactive people than their active counterparts (Kyrolainen et al 2008). As the role that exercise plays in an individual's life is likely to change over the lifespan (Duncan et al 2010), it is of importance that the motivational constructs that facilitate / inhibit PA engagement are understood as various types of motivation have been found to influence effort expended during exercise sessions as well as intentions to continue exercising (Wilson et al 2004). Indeed it is widely accepted that the health benefits acquired by PA are reliant on currency of engagement (Paffenbarger et al 1986).

Whilst some studies have investigated the weight status of some armed forces personnel in relation to distinct socio-demographic and health behaviour variables, such as age (Sanderson, Clemes and Biddle 2014, Fear et al 2011), injury (Ross and Woodward 1994, Cowan et al 2011), alcohol consumption (Taylor et al 2007), occupational physical activity (Haddock et al 2007), physical inactivity (Grotto et al 2008), exercise motivations (Wynd and Ryan-Wenger 2004, Wilson, Markey and Markey 2012), sedentary behaviour (Costa et al 2011), diet behaviour (Sigrist, Anderson and Auld 2005), marital status (Sanderson, Clemes and Biddle 2014, Bray et al 2006), SES (Grotto et al 2008) and employment (Sanderson, Clemes and Biddle 2014). There is scant information, apart from one recent systematic review (Sanderson, Clemes and Biddle 2011), to offer a collective informed opinion on how these factors may interact to influence obesity in military populations.

The health effects associated with obesity are broadly acknowledged (Ezzati et al 2002), however, the negative implications may be potentially greater when military personnel engage in poor health practises, as they compromise their own health and reduce the operational effectiveness of their unit (Bray et al 2006). To facilitate a broader understanding of the factors that contribute to obesity and to inform current and future policy, it is imperative that the health behaviours in relation to weight status are identified.

Aim

The aim of the research conducted in this chapter was to identify relationships between health behaviours that were not supportive of healthy weight and to understand the predictive influence of individual and collective behaviour in relation to obesity and the risk of obesity related ill-health in military personnel.

Methods

A convenience sample of 1227 Army personnel from the UK 3rd Division (male 91%, female 9%), aged 18 – 52 years completed a questionnaire between June and September 2013. The study consisted of 57% private soldiers, 33% junior non-commissioned officers (JNCO), 8% senior non-commissioned officers (SNCO) and 2% commissioned officers. The sample size was based on the equation proposed by Green (1991), whereby a minimum of 530 participants were required to be measured for a regression model consisting of 60 variables (HBQ = 61 variables), an alpha value of 0.05 and a power of 0.08. Data collection included both Northern and Southern based unit personnel. Personnel were recruited across the 3 Operational Brigades (1, 4 and 12 Brigades) that form the UK 3rd Division. Units within these 3 operational brigades are spread across the United Kingdom (UK), however, the main troop concentrations are to the South West of England (Salisbury Plain) and the North East of England (Catterick). Within the Brigades, each major unit was given 50 questionnaires, with direction to sample across all ages, ranks and physical abilities. From the 1500 distributed questionnaires (30 x 50), 1227 completed (anonymous) questionnaires were returned. The reduced number of returns reflects the operational nature of the division, in that some units were away from their geographical location, or were reduced in number due to army directed tasks. From the study sample (n=1227), 104 were withdrawn due to incomplete and incorrect information. The study received ethical clearance from the UK MoD.

A pilot study was conducted on one of the southern based units to test the applicability of the Health Behaviour Questionnaire (HBQ) in a military sample. The pilot study did not highlight any semantic concerns that would preclude questionnaire completion without external assistance.

Volunteers completed a short demographics questionnaire (Appendix 2) and included questions in relation to age, gender, ethnicity, employment, rank, years completed in the British Army, location, marital status, habitation status, height, body mass, BMI, waist circumference, eating location, educational level, diet, smoking status, alcohol consumption, injury status, the International Physical Activity Questionnaire (Appendix 3), the Treatment Self-Regulation Questionnaire (Exercise) (Appendix 4), the Dutch Eating Behaviour Questionnaire-Restrictive Eating Scale (Appendix 5) and a question set on sedentary behaviour (Appendix 6). Anthropometric measures (height, body mass and waist circumference) were by self-report. A brief was given to each project officer at each of the 31 unit locations. This provided information (participant information sheet is attached at Appendix 7) to the participants and stated that the study was voluntary and that personnel did not need to provide a reason if they did not wish to participate.

Measures

In addition to the general demographic questions relating to age, gender, employment, rank, years completed in the British Army, unit location, marital status, height and weight, waist circumference and educational attainment. The HBQ required individuals to answer several specific questions in relation to habitation status, weekday and weekend food preparation, injury status, smoking status, alcohol consumption, and diet information (fruit and vegetables, high fat food and snacking). Physical training (PT) attendance was assessed. The respondent was asked to indicate how many mandatory PT sessions they attended in an average week (none, 1-2, 3-4, 5-6, 7+). These sessions were subjectively assessed to last 40 minutes (15 moderate PA (MPA) and 25 minutes vigorous PA (VPA).

Physical Activity: The International Physical Activity Questionnaire (IPAQ) short form (Craig et al 2003) was utilized to assess the amount of walking, moderate and vigorous physical activity (MVPA) the study participants had undertaken in the last 7 days. The internal consistence of the IPAQ measured by Cronbach's alpha (α) show acceptable reliability in both long (α =0.73) and short versions (α=0.60) (Mannocci et al 2010).

Data from the questionnaire were summed within each item (walking, vigorous and moderate activity), to estimate the total amount of time spent undertaking PA per week. Total daily PA (MET-min day) was estimated by summing the product of reported time within each item by a MET value specific to each category of PA, and expressed as a daily average MET score (where MET is metabolic equivalent; 1 MET = resting energy expenditure) according to the official IPAQ scoring protocol (www.ipaq.ki.se). Vigorous intensity of PA was assumed to correspond to 8 METs, moderate-intensity activity to 4 METs and walking to 3.3 METS (www.ipaq.ki.se).

The Total physical activity MET-minutes/week was defined as: sum of Walking (METs*min*days) + Moderate (METs*min*days) + Vigorous (METs*min*days) (www.ipaq.ki.se). The categorical scores to reflect (low, medium and high) PA were employed (www.ipaq.ki.se). In addition to the IPAQ, a categorical question regarding LTPA during the last 6 months was included to ascertain the duration of the current PA behaviour. The validity of this question has not been formally tested; however, a similar question was used for the New Zealand version of the IPAQ (Moy et al 2003). The respondents were asked to indicate the length of time that they had undertaken LTPA (in this instance a minimum exercise bout time was set at 10 min (Haskell et al 2007)). The question had 5 categories ranging from “I have engaged in regular LTPA for more than 6 months” to “I have not engaged in LTPA, and do not intend to”.

Motivation to undertake PA: The Treatment Self-Regulation Questionnaire (TSRQ) is a theoretically derived scale which assesses the degree of autonomous self-regulation regarding why people engage or would engage in healthy behaviour (Ryan and Connell 1989). The TSRQ is based on the theoretical approach of Self-Determination Theory (SDT) (Deci and Ryan 1985, 2000).

SDT considers motivation from a multidimensional perspective distinguishing between amotivation, autonomous and controlled types of motivational regulation and their differential impact on an individual’s psychological well-being, behavioural quality, persistence, functioning, and learning (Ryan and Deci 2000). When autonomously motivated, individuals endorse their own actions, acting with a full sense of volition because they find the activity to hold inherent interest and/or personal value (Ryan and Deci 2006). In contrast, when an individual’s behaviour is governed by external and/or internal pressures such as being coerced, persuaded, and/or seduced their motivation is classed as being controlled (Moller, Deci and Ryan 2006).

The TSRQ is a 15 item scale concerning why people do or would do exercise. A validation paper by Levesque et al (2007) stated that the internal consistency of each subscale was acceptable (most α values >0.73) for use across various settings. For the 15-item scale responses are given using a 5-point Likert scale ranging from 1 (not true for me) to 5 (very true for me). Of the 15 items: 6 assess autonomous motivation, 6 assess controlled motivation and 3 assess amotivation. The autonomous motivation subscale consist of items – 1, 3, 6, 8, 11 & 13; the controlled motivation subscale consists of items – 2, 4, 7, 9, 12 & 14 and the amotivation subscale consists of items 5, 10 & 15. In each subscale the scores are averaged to form an individual reflection of motivation (autonomous, controlled or amotivated) to the target behaviour (exercise).

Restrictive Eating: The term restrictive eating has been employed to encapsulate the process oscillation between calorie restriction and overeating in order to maintain weight (Heatherton et al 1988). The process of restrained eating has been shown to contribute to overeating (Herman, Polivy and Leone 2005), dieting, as well as disinhibited eating (un-successful dieting), and body dissatisfaction (Laessle et al 1989). The restrained eating scale is one of the three measures of the Dutch Eating Behaviour Questionnaire (DEBQ) (Van Strien et al 1986).

The restricted eating scale had shown good internal consistency (Van Strien et al 1986) and reliability in normal weight individuals (α=0.93) and in overweight samples (α=0.89) for restrained eating (Van Strien 2007). The 10 item (e.g. "Do you deliberately eat food that are slimming?") restrictive eating scale employed a 5-point Likert scale. Response categories range from 1 ('never') to 5 ('very often'), (see Appendix 6).

Sedentary Behaviour: The Sedentary Behaviour Research Network (2012) define sedentary behaviour as "any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture" The Marshall Domain Specific Sitting Time questionnaire was used to assess sedentary behaviour across the following five domains: (a) while travelling to and from places (e.g., work, shops); (b) while at work; (c) while watching television; (d) while using a computer at home; and (e) at leisure not including watching television (e.g., visiting friends, movies, eating out) on a weekday and a weekend day. This questionnaire has been shown to be a reliable and valid measure of sitting time in adults (Marshall et al 2010; Clemes et al 2012).

Data from the sitting time questionnaire were used to create an estimate of total weekday and weekend day sitting time (Marshall et al 2010); this was achieved by summing sitting across each domain and multiplying by 5 (weekday) and 2 (weekend day). A maximum cut-off of sitting time over 18 hours per day was applied (allowing for 6 hours sleep). A maximum value of 18 hours was applied to any summed totals of sitting beyond 18 hrs.

Health behaviours: A previous study on the UK Royal Navy (Shaw et al 2013) assessed the relationship between four identified lifestyle risk factors (current smoker, consumption of less than 5 portions of fruit and vegetables a day, consumption of alcohol in excess of the UK Government guidelines and low levels of physical activity) and weight status. It is known that combined detrimental effect of poor health behaviours on 'all cause mortality' is substantial (Khaw et al 2008, Kvaavik et al 2010). Therefore a measure of lifestyle risk factors based on Shaw et al (2013) was employed.

The four-lifestyle risk factors (RFs) were assessed in reference to UK guidelines. For this study and to adequately reflect PA from PT and LTPA, the total PA accumulated by the individual was PT/mins/week + LPTA/mins/week = total PA. The total PA output was used to assess weekly PA against the current UK Government guidelines of 150 mins of MPA or 75 mins of VPA per week (DoH 2011). The dichotomous result would indicate if the study participants were below or above the UK Guidelines. From their responses to the HBQ, the frequency and amount of alcohol was computed. Alcohol consumption was assessed against the guidelines of 3-4 units and 2-3 units per day for male and females respectively (HoCSTC 2012). A single question on the HBQ assessed fruit and vegetable consumption; this was assessed against the guidelines of 5-a-day (DoH 2004). A single question on the HBQ assessed smoking status, being a current smoker was assessed as a risk factor. For analysis participants were grouped according to the number of risk factors (0-4) in which they engaged.

Classifications

Weight status was clarified by BMI, derived from self-reported height and weight, and self-reported waist circumference using the current National Institute of Health & Clinical Excellence (NICE) guidelines (NICE 2006) based on the WHO recommendations (WHO 2000). The specific details have been explained in greater detail in methods section of chapter 3 (pg 33).

Statistical analyses

The reported values were expressed as the proportion of individuals within each category. Descriptive statistics were determined for age, gender, ethnicity, employment, rank, location, marital status, habitation status, height, body mass, BMI, waist circumference, eating location, educational level, diet, smoking status, alcohol consumption, injury status, mandatory physical training attendance, LTPA, motivation for exercise, restrictive eating and sedentary behaviour. Normality checks were performed. Where data were found to be not normally distributed the equivalent non-parametric statistical analyses were applied.

Independent samples t-tests were conducted to determine significant differences between male and female study participants in relation to age, body mass, height and BMI. BMI Classification (obese versus not obese) and NICE risk classification (some-risk, including those categorised as increased, high, very high and extreme risk, versus no-risk) were analysed using Pearson's Chi-Square Test. Spearman rank order correlations were employed to establish relationships between the risks of obesity related ill-health (no risk versus some risk) and significant ranked variables (age: 18-24, 25-34, 35-44, and 45+; years in the army: 0-6, 7-12, 13-18, 19-24, 24+; injury status: not injured, injured; PT sessions: 0, 1-2, 3-4, 5-6, 7+; LTPA currency: no LPTA and no intention, no LPTA with intention, some LPTA, regular LPTA <6 months, regular LPTA > 6 months; LPTA MET: low, medium, high; DEBQ Restricted eating: never, seldom, sometimes, often, very often; PA below (UK guidelines): above, below; sedentary above (total sedentary behaviour per day was assessed against the current UK average, this is assessed as 9.5 hours (NHS 2009): below, above.

Multiple logistic regression was used to identify independent predictors of risk for obesity related ill-health (no risk versus some-risk). Significant predictors were used to calculate the odds of being obese and the odds of having some risk towards obesity-related ill-health. Statistical significance was assessed with 95% confidence intervals. Referent values were assigned within each predictor group (age - 18-24, personal status - single, rank – soldier, injury status – not injured, sedentary behaviour – below UK daily civilian average (9.5 hours), LTPA motivation – LPTA undertaken regularly for over 6 months, Food Preparation in the working week – centralised feeding, food preparation at the weekend – centralised feeding, Dutch Eating Behaviour Questionnaire-Restricted Eating Scale – never undertake (restrictive eating). In addition autonomous motivation and controlled motivation (in regards to exercise) were accessed by a low to high scale. The final model utilised multiple logistic regression to enable the identification of significant demographic predictors, while potential confounders were controlled (each predictor variable was controlled for). Hosmer and Lemeshow (1989) was utilised to express the ratio of what the model can explain (Field 2005), this version of the coefficient of determination is expressed as R^2_L. Analyses were performed using SPSS version 18, and statistical significance was set at an alpha level of 0.05. Due to the irregularities in the data pertaining to BMI and NICE categorised risk of obesity ill-health the final Spearman's rank order correlations and logistic regression focus on the results in relation to risk to obesity related ill-health (BMI and WC combined).

Results

Socio-Demographic and Physical Characteristics: Table 6.1 identifies the socio-demographic characteristics of the study participants, whilst the study population were predominantly male, white, single, <25 years of age with less than 6 years service with a rudimentary educational profile, this is generally representative of the personnel of the 3rd Division in the British Army. Lower ranks (private and junior non-commissioned officer) account for the majority of the study participants and were reflective of the fighting component of the British Army. Table 6.2 highlights the physical characteristics of the study participants, the results indicate that male study participants were significantly taller, heavier and had a higher BMI than the female study participants ($P<0.05$). BMI categorised 11% of the study participants as obese (male 11%, female 9%). The NICE Risk categorisation (NICE 2006) suggested that 24% of the study participants were at "some-risk" of obesity related ill-health (male 23%, female 32%).

Table 6.1: Health Behaviour Questionnaire Sociodemographic Characteristics of the Study Participants

Sociodemographic Characteristics	N	(%)
Gender		
Male	1022	(91)
Female	102	(9)
Race/Ethnicity		
White	1017	(90)
Black /Caribbean/African/other	52	(5)
Asian/Indian/Chinese/other	32	(3)
Other	23	(2)
Education		
No Qualifications	136	(12)
O Level/CSE/GCSE/School Certificate	464	(41)
A Level/AS Level/Higher School Certificate	199	(18)
Technical or Trade Diploma	282	(25)
First Degree (BA, BSc)	42	(4)
Higher Degree (MA, MSc, PhD)	1	(0)
Age		
17-24	562	(50)
25-34	471	(42)
35-44	84	(7)
45+	7	(1)
Years in the Army		
0-6	696	(62)
7-12	298	(27)
3-18	100	(9)
19-24	26	(2)
24+	4	(0)
Personal Status		
Never Married / Civil Partnership	523	(47)
Living with someone / in a long-term relationship	216	(19)
Married / Civil Partnership	319	(28)
Separated but still Married	35	(3)
Divorced	28	(3)
Widowed	3	(0)
Rank		
Private	643	(57)
JNCO (Junior Rate)	368	(33)
SNCO (Senior Rate)	95	(8)
Officer	18	(2)
Operational Brigade		
1 Brigade	208	(19)
4 Brigade	500	(44)
12 Brigade	416	(37)

Table 6.2: Health Behaviour Questionnaire Physical Characteristics of the Study Participants

	All		Male		Female		P
	N	**(SD)**	**N**	**(SD)**	**N**	**(SD)**	
Age	25.7	(5.7)	25.6	(5.6)	26.7	(6.1)	0.076
Height	178	(8.1)	179	(7.2)	167	(8.8)	<0.001
Body Mass	81.8	(12.4)	83	(11.7)	69.5	(11.7)	<0.001
BMI	25.8	(3.4)	25.9	3.4)	24.9	(3.7)	<0.01
	N	**(%)**	**N**	**(%)**	**N**	**(%)**	
BMI Group							
<18.5	2	(0.2)	1	(0.1)	1	(1)	
18.5-24.99	515	(46)	454	(44)	61	(60)	
25-29.99	485	(43)	454	(44)	31	(30)	
30-34.99	102	(9)	96	(9)	6	(6)	
35-39.99	16	(1)	13	(1)	3	(3)	
40+	4	(0.5)	4	(0.5)	0	(0)	
Waist Circumference							
Healthy (<94 cm M, <80 cm F)	835	(74)	785	(77)	51	(50)	
Overweight (<102 cm M, <88 cm F)	261	(23)	218	(21)	43	(42)	
Obese (>102cm M, >88 cm F)	27	(2)	19	(2)	8	(8)	
Risk Group							
Underweight	2	(0.2)	1	(0)	1	(1)	
No Risk	856	(76)	787	(77)	69	(68)	
Increased Risk	157	(14)	137	(13)	20	(20)	
High Risk	78	(7)	73	(7)	5	(5)	
Very High Risk	24	(2)	19	(2)	5	(5)	
Extreme Risk	7	(1)	5	(1)	2	(2)	

Age: There was an association between age group and BMI classification ($\chi^2(3)=18.59$, P<0.001), whereby participants in the 35-44 year age group were nearly 4 times more likely (odds ratio (OR) 3.6, 95% confidence intervals (CI) 2 - 6.6) to be obese than the study participants in the 18-24 year age group. Similarly an association between age group and NICE Risk classification ($\chi^2(3)=20.23$, P<0.001) was identified, whereby participants in the 35-44 year age group were 3 nearly times more likely (OR 2.9, 95% CI 1.8 – 4.7) to be obese than the study participants in the 18-24 year age group was identified (Table 6.3).

Table 6.3: Health Behaviour Questionnaire BMI / NICE Risk Classification - Age

	17-24		25-34		35-44		45+	
	N	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
Not Obese	520	(93)	411	(87)	65	(77)	6	(86)
Obese	42	(7)	60	(13)	19	(23)	1	(14)
No Risk	455	(81)	348	(74)	50	(60)	5	(71)
Some Risk	107	(19)	123	(26)	34	(40)	2	(29)

Health Behaviours: Table 6.4 reports the general health characteristics assessed in the study. By percentage, female study participants displayed a higher-level of injury and a lower level of physical training attendance than the male study participants. Male study participants displayed higher percentages of physical activity and alcohol consumption, whilst females consumed more fruit and vegetables and smoked less. Investigation of the 4 collated lifestyle risk behaviours (PA, alcohol, smoking and diet) did not suggest any significant differences between the male and female study participants.

Further analyses assessing BMI and NICE risk classification for obesity related ill-health (NICE 2006) in relation to health behaviours identified the following findings.

*Injury (Table 6.5)***:** An association between injured personnel and obesity ($\chi^2(1)=36.61$, $P<0.001$) and injured personnel and those deemed at some-risk of obesity related ill health ($\chi^2(1)=53.77$, $P<0.001$) was identified. Those who were injured were more than 3 times (OR 3.41, 95% CI 2.3-5.0, P=0.001) more likely to be obese and 3 times (OR 3.13, 95% CI 2.3-4.2, P=0.001) more likely to be at 'some-risk' to obesity related ill-health than those who were not injured.

Table 6.4: Health Behaviour Questionnaire General Characteristics of the Study Participants

General Characteristics	All		Male		Female	
	N	(%)	N	(%)	N	(%)
Injury Status						
Injured	262	(23)	232	(23)	30	(29)
Not Injured	862	(77)	79	(77)	72	(71)
Physical Training						
No Physical Training	40	(4)	32	(3)	8	(8)
1-2 Sessions per week	129	(11)	108	(11)	21	(21)
3-4 Sessions per week	643	(57)	592	(58)	51	(50)
5-6 Sessions per week	273	(24)	254	(25)	19	(19)
7+ Sessions per week	39	(4)	36	(4)	3	(3)
Physical Activity *(*RF)*						
*Under UK Gov. Recommendations**	*157*	*(14)*	*135*	*(13)*	*22*	*(22)*
Over UK Gov. Recommendations	967	(86)	887	(87)	80	(78)
Smoking *(*RF)*						
*Smoker**	*301*	*(27)*	*277*	*(27)*	*24*	*(24)*
Non Smoker	823	(73)	745	(73)	78	(76)
Alcohol *(*RF)*						
*Over UK Gov. Recommendations**	*467*	*(42)*	*435*	*(43)*	*32*	*(31)*
Under UK Gov. Recommendations	657	(58)	587	(57)	70	(69)
Fruit and Vegetables *(*RF)*						
Over 5 a Day	156	(14)	136	(13)	20	(20)
*Under 5 a Day**	*968*	*(86)*	*886*	*(87)*	*82*	*(80)*
Multiple Lifestyle Risk Factors (RF)						
0	*84*	*(7)*	*69*	*(7)*	*15*	*(15)*
1	*432*	*(38)*	*398*	*(39)*	*34*	*(33)*
2	*393*	*(35)*	*357*	*(35)*	*36*	*(35)*
3	*185*	*(16)*	*171*	*(17)*	*14*	*(14)*
4	*30*	*(3)*	*27*	*(3)*	*3*	*(3)*

Table 6.5: Health Behaviour Questionnaire Injury Status / Obesity /Nice Risk Classification

Injury Status	Not Obese		Obese		No Risk		Some Risk	
	N	(%)	N	(%)	N	(%)	N	(%)
Injured	205	(78)	57	(22)	154	(59)	108	(41)
Not Injured	797	(92)	65	(8)	704	(82)	158	(18)

Physical Training (Table 6.6): Whilst there was an association between BMI and how many Physical Training sessions were attended ($\chi^2(4)=14.81$, $P<0.01$); subsequent analysis did not identify any significant difference between BMI groups. However, there was an association between NICE Risk classification and how many physical training sessions were attended ($\chi^2(4)=26.21$, $P<0.001$), OR indicated those personnel who attended ≥7 sessions were 8 times less likely (OR 8, 95% CI 2.1 – 30.5) to be obese than the study participants who did not attend any physical training session.

Table 6.6: Health Behaviour Questionnaire Physical Training / Obesity /Nice Risk Classification

Physical Training Sessions	Not Obese		Obese		No Risk		Some Risk	
	N	(%)	N	(%)	N	(%)	N	(%)
No Physical Training	35	(87)	5	(13)	24	(60)	16	(40)
1-2 Sessions / week	110	(85)	19	(15)	86	(67)	43	(33)
3-4 Sessions / week	566	(88)	77	(12)	485	(75)	158	(25)
5-6 Sessions / week	252	(92)	21	(8)	227	(83)	46	(17)
7+ Sessions / week	39	(100)	0	(0)	36	(92)	3	(8)

Multiple Lifestyle Risk Behaviours (Table 6.7): Those study participants who did not achieve UK Government guidelines for PA displayed an association between obesity ($\chi^2(1)=4.39$, $P<0.05$) and some risk of obesity related ill-health ($\chi^2(1)=28.63$, $P<0.001$). The odds ratios suggest that the study participants failing to achieve the recommended levels of PA were nearly 3 times (OR 2.7, 95% CI 1.9-3.8, P<0.001) more likely to be at 'some-risk' of obesity related ill-health (as opposed to no-risk) and nearly twice (OR 1.7, 95% CI 1.1-2.7, P<0.05) as likely to be obese (as opposed to not obese), than those attaining the recommended levels of PA. However, further analyses on diet, smoking and alcohol were not suggestive of any significant associations. Data are indicative of high levels of alcohol consumption and smoking, with low levels of fruit and vegetable consumption irrespective of weight / risk category. The analyses of the collective multiple lifestyle risk behaviours did not support any significant relationships between amount of risk behaviours and obesity (P=0.06) or the risk to obesity related diseases (P=0.19).

Table 6.7: Health Behaviour Questionnaire Multiple Lifestyle Risk Factors / Obesity /Nice Risk Classification

	Not Obese		Obese		No Risk		Some Risk	
	N	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
Physical Activity								
Under UK Gov. Rec	132	(13)	25	(20)	92	(11)	65	(25)
Over UK Gov. Rec	870	(87)	97	(80)	766	(89)	201	(75)
Smoking								
Smoker	272	(27)	29	(24)	239	(28)	62	(24)
Non Smoker	730	(73)	93	(76)	619	(72)	204	(76)
Alcohol								
Over UK Gov. Rec	423	(42)	44	(36)	364	(42)	103	(39)
Under UK Gov. Rec	579	(58)	78	(64)	494	(58)	163	(61)
Fruit and Vegetables	137	(14)	19	(16)	119	(14)	37	(14)
Over 5 a Day	865	(86)	103	(84)	739	(86)	229	(86)
Under 5 a Day								
Multiple Lifestyle Risk Factors (RF)								
0	70	(7)	14	(11)	61	(7)	23	(9)
1	388	(39)	44	(36)	339	(40)	93	(35)
2	351	(35)	42	(34)	297	(35)	96	(37)
3	170	(17)	15	(12)	143	(17)	42	(16)
4	23	(2)	7	(6)	18	(2)	12	(5)

Leisure Time Physical Activity: The study participants undertook (mean, standard deviation (SD)), 634.2 (496.9) of LTPA minutes per week, this represents 91 minutes per day (vigorous PA = 29 minutes (199.9 (241.7)), moderate PA = 22 minutes (152.3 (180.8)), walking 40 minutes (281.9 (329.1)).

The IPAQ results suggested that male study participants were more physically active in their leisure-time than female study participants (Table 6.8). Subsequent analyses on the MET derived categories indicated that a significant association existed for both obesity ($\chi^2(2)=6.91$, $P<0.05$), and risk to obesity related ill-health ($\chi^2(2)=35.96$, $P<0.001$). Odds ratios suggest that those categorised as low for LTPA were nearly twice as likely (OR 1.77, 95% CI 1.15-2.73, P=0.01) to be obese and 2.65 (95% CI 1.91-3.67, P<0.001) more likely to be at some-risk of obesity related ill-health than those categorised as high in their LTPA interaction (Table 6.9). Table 6.10 indicates that by percentage female study participants were less likely to engage in LTPA.

Further analyses (Table 6.11) indicated a significant association between obesity and NICE defined categories for obesity related ill health ($\chi^2(4)=35.95$, P<0.001) and ($\chi^2(4)=103.13$, P<0.001), respectively). Analyses through logistic regression clarified that each group (not engaged in LTPA/do not intend to, not engaged in LTPA but intend to, have engaged in some LTPA, have engaged in regular LTPA (<6/12)) were significantly more likely to be obese (P<0.05) and defined as at 'some-risk' (P<0.001) the referent category (have engaged in regular LTPA (>6/12)). Odds ratios suggested that those study participants 'not engaged in LTPA and do not intending to be engaged in LTPA' were 6.8 times (95% CI 3.4-13.8) more likely to be obese and over 11 times (OR 11.3, 95% CI 6.5-19.5) more likely to be at some-risk to obesity related ill-health than the referent category.

Table 6.8: Health Behaviour Questionnaire Leisure Time Physical Activity (LTPA) – MET Category

LTPA MET Category	All		Male		Female	
	N	**(%)**	**N**	**(%)**	**N**	**(%)**
Low	336	(30)	296	(29	40	(39)
Moderate	299	(27)	275	(27)	24	(24)
High	489	(44)	451	(44)	38	(37)

Table 6.9: Health Behaviour Questionnaire Leisure Time Physical Activity (LTPA) – MET Category / Obesity /Nice Risk Classification

MET Category	Not Obese		Obese		No Risk		Some Risk	
	N	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
Low	287	(29)	49	(40)	218	(25)	118	(44)
Moderate	269	(27)	30	(25)	234	(27)	65	(24)
High	446	(45)	43	(35)	406	(47)	85	(32)

Table 6.10: Health Behaviour Questionnaire Leisure Time Physical Activity (LTPA) – Engagement

LTPA Engagement	All		Male		Female	
	N	(%)	N	(%)	N	(%)
not engaged in LTPA and do not intend to	83	(7)	74	(7)	9	(9)
not engaged in LTPA but intend to	131	(12)	110	(11)	21	(21)
have engaged in some LTPA	305	(27)	288	(28)	18	(18)
have engaged in regular LTPA for <6 months	221	(20)	201	(20)	20	(20)
have engaged in regular LTPA for >6 months	383	(34)	349	(34)	34	(33)

Table 6.11: Health Behaviour Questionnaire Leisure Time Physical Activity (LTPA) – Engagement / Obesity /NICE Risk Classification

LTPA Engagement	Not Obese		Obese		No Risk		Some Risk	
	N	(%)	N	(%)	N	(%)	N	(%)
not engaged in LTPA/do not intend to	63	(76)	20	(24)	37	(45)	46	(55)
not engaged in LTPA but intend to	116	(89)	15	(11)	81	(62)	50	(38)
have engaged in some LTPA	262	(86)	44	(14)	222	(73)	84	(27)
have engaged in regular LTPA (<6/12)	195	(88)	26	(12)	173	(78)	48	(22)
have engaged in regular LTPA (>6/12)	366	(96)	17	(4)	345	(90)	38	(10)

Sedentary Behaviour (sitting time): The study participants undertook (mean, standard deviation (SD)), 2882.7 (1961.2) of sitting time (minutes) per week, this represents 6 hours and 52 minutes per day. In the working week the study population sat for 6 hours and 29 minutes (1945.0(1515.5) ÷ 5) and on non-working days the study population sat for 7 hours and 49 minutes (937.7 (688.8) ÷ 2).

Table 6.12 describes the results in respect of sitting time. It is clear that when assessed against the UK Civilian data that (by percentage) female study participants spent more time sitting that the male study participants. The obesity and risk of obesity related ill-heath classification by sedentary behaviour group data (above or below UK Civilian norm) in Table 6.13 suggest that those classified as obese or defined as at some-risk were more likely to be sedentary. Subsequent analyses clarified that an association existed between obesity ($\chi^2(1)=12.42$, P<0.001) and NICE defined risk of obesity related ill-health ($\chi^2(4)=17.87$, P<0.001). Whereby those highly sedentary study participants (above 9.5 hours) were twice as likely to be obese (OR 2.1, 95% CI 1.4-3.2) and twice as likely (OR 2.0, 95% CI 1.5-2.7) to be at some-risk (as opposed to no-risk) of obesity related ill-heath, than those categorised below the UK norm (below 9.5 hours).

Table 6.12: Health Behaviour Questionnaire sitting time assessed against a UK average of 9.5 hours

Sedentary Behaviour	All		Male		Female	
	N	(%)	N	(%)	N	(%)
Above UK Civilian Norm	294	(31)	257	(30)	37	(41)
Below UK Civilian Norm	655	(69)	601	(70)	54	(59)

Table 6.13: Health Behaviour Questionnaire sitting time / Obesity /Nice Risk Classification by percentage assessed against a UK average of 9.5 hours

Sedentary Behaviour	Not Obese		Obese		No Risk		Some Risk	
	N	(%)	N	(%)	N	(%)	N	(%)
Above UK Civilian Norm	246	(84)	48	(16)	201	(68)	93	(32)
Below UK Civilian Norm	600	(92)	55	(8)	531	(81)	124	(19)

Motivation for Exercise: Table 6.14 reports the results by mean and standard deviation and are suggestive of a significant difference (P<0.05) in the controlled motivation for exercise between male and female study participants. Further analyses of the relationships between motivations for exercise and obesity, and the risk to obesity ill-health are described in Table 6.15. Of note, Pearson correlations indicate significant positive relationships were found between controlled motivation for exercise and obesity, and risk to obesity related diseases (P<0.01). A significant negative relationship was shown between risk to obesity related diseases and autonomous motivation for exercise (P<0.001).

Table 6.14: Health Behaviour Questionnaire Treatment Self Regulation Questionnaire Exercise mean and standard deviations (SD)

Motivation Type	All		Male		Female		
	M	(SD)	M	(SD)	M	(SD)	P
Amotivation	2.45	1.00	2.46	1.00	2.38	0.99	0.45
Controlled	2.91	0.85	2.90	0.86	3.06	0.75	0.047*
Autonomous	3.84	0.84	3.84	0.85	3.85	0.77	0.95
RAI	0.93	1.00	0.94	1.00	0.79	0.99	0.14

Table 6.15: Health Behaviour Questionnaire Obesity and risk of obesity related ill-health correlations with motivation to exercise (amotivation, controlled and autonomous motivation and relative autonomy index)

Variable		Obesity	Some-Risk	Amotivation	Controlled	Autonomous	RAI
Obesity	Cor	1.000	.627**	.043	.101**	-.032	-.122**
	Sig.		.000	.155	.001	.228	.000
Some-Risk	Cor		1.000	.115**	.096**	-.130**	-.190**
	Sig.			.000	.001	.000	.000
Amotivation	Cor			1.000	.310**	-.337**	-.543**
	Sig.				.000	.000	.000
Controlled	Cor				1.000	.291**	-.601**
	Sig.					.000	.000
Autonomous	Cor					1.000	.590**
	Sig.						.000
RAI	Cor						1.000
	Sig.						

** Significant at the 0.01 level (2 tailed)

Restrictive Eating: Table 6.16 identifies the breakdown of responses in respect of the restricted eating scale by gender. Examination of the mean scores indicated that females (M=2.74, SD 1.01) were significantly ($P<0.05$) more restrictive in their eating than males (M=2.41, SD 1.10). When the restrictive scale was analysed (categorically) to identify any associations to obesity and risk to obesity related ill health (Table 6.17) it became apparent that an association existed between those defined as most restrictive in their eating, with obesity and NICE defined risk of obesity related ill-health.

Logistic regression results clarify that those study participants who sometimes, often or very often undertook restrained eating were twice as likely (OR 2.0, 95% CI 1.2-

3.5, OR 2.3, 95 % CI 1.4-4.1, OR 2.3, 95% CI 1.1-4.6 respectively) to be at risk of obesity related ill heath than those who never restrained their eating (P<0.05). When obesity was assessed against restrictive eating through logistic regression a similar significant result (P<0.05) was observed. With those who sometimes (OR 2.6, 95% CI 1.1-6.3), often (OR 3.9, 95% CI 1.6-9.5) and very often (OR 4.1, 95% CI 1.5-11.3) being more likely to be obese that the referent (never undertake restrictive eating) category.

Table 6.16: Health Behaviour Questionnaire Dutch Eating Behaviour Questionnaire (DEBQ) – Restrictive Eating Scale by percentage

Restrictive Eating	All		Male		Female	
	N	(%)	N	(%)	N	(%)
Never	110	(10)	99	(10)	11	(11)
Seldom	333	(30)	313	(31)	20	(20)
Sometimes	353	(31)	325	(32)	28	(27)
Often	260	(23)	227	(22)	33	(32)
Very Often	68	(6)	58	(6)	10	(10)

Table 6.17: Health Behaviour Questionnaire Restrictive Eating / Obesity /Nice Risk Classification by percentage

Restrictive Eating	Not Obese		Obese		No Risk		Some Risk	
	N	(%)	N	(%)	N	(%)	N	(%)
Never	104	(95)	6	(5)	90	(82)	20	(18)
Seldom	324	(97)	9	(3)	309	(93)	24	(7)
Sometimes	307	(87)	46	(13)	243	(69)	110	(31)
Often	212	(82)	48	(18)	171	(66)	89	(34)
Very Often	55	(81)	13	(19)	45	(66)	23	(34)

BMI versus NICE defined risk of obesity related ill-health: A closer inspection of the data in relation to BMI and NICE defined risk category of obesity related ill-health highlights certain disparities between the two indices. The results at Table 6.18, suggest that 12% of male and 23% of female study participants would be classified differently. Understanding the restrictions of BMI with this specific population, subsequent analyses concentrated on correlations and predictions of risk (no-risk versus some-risk) of obesity related ill-health (BMI and WC combined).

Table 6.18: Health Behaviour Questionnaire Obesity versus NICE Categorisation Obesity related ill-health by number of participants

BMI (kg/m²)*	Waist Circumference (N)					
	Men < 94 cm Women < 80 cm		Men 94-101.9 cm Women 80-87.9 cm		Men ≥ 102 cm Women ≥88 cm	
	M	F	M	F	M	F
Healthy	429	43	22	19	4	0
Overweight	334	8	115	20	5	3
Obese	22	0	81	4	10	5

*
Obesity = <25 kg/m^2
Overweight = ≥25 kg/m^2-29.99 kg/m^2
Obese ≥30 kg/m^2

Key / NICE Categorisation Obesity related ill-health

No Risk	0
Increased Risk	0
BMI Classification Concerns	0

Correlations: Table 6.19 reports the results of the Spearman's correlations for the ranked categorical variables. Significant (P<0.01) positive correlations existed between risk to obesity related ill-health and age, years spent in the army, being injured, sedentary behaviour, restrictive eating and reduced PA. Of note the amount of PT sessions attended, LTPA METS and LTPA engagement were all significant negative correlates of risk of obesity related ill-health.

Table 6.19: Health Behaviour Questionnaire Spearman's Correlations between HBQ Factors

		BMI	Risk	Age group	Years	Injured	PT sessions	LTPA currency	LTPA METS	DEBQ	PA below	Sedentary above
BMI	Cor	1.000	.652**	.191**	.185**	.190**	-.105**	-.190**	-.086**	.276**	.103**	.073*
	Sig.		.000	.000	.000	.000	.000	.000	.004	.000	.001	.025
Risk	Cor		1.000	.134**	.129**	.239**	-.145**	-.297**	-.173**	.229**	.169**	.147**
	Sig.			.000	.000	.000	.000	.000	.000	.000	.000	.000
Age group	Cor			1.000	.678**	.135**	-.092**	.103**	.070*	.131**	-.081**	.046
	Sig.				.000	.000	.002	.001	.018	.000	.007	.156
Years in Army	Cor				1.000	.170**	-.103**	.107**	.059*	.134**	-.088**	.049
	Sig.					.000	.001	.000	.050	.000	.003	.134
Injured	Cor					1.000	-.190**	-.152**	-.099**	.086**	.057	.057
	Sig.						.000	.000	.001	.004	.056	.080
PT session	Cor						1.000	.172**	.186**	-.026	-.117**	-.054
	Sig.							.000	.000	.378	.000	.095
LTPA currency	Cor							1.000	.510**	-.019	-.439**	-.113**
	Sig.								.000	.517	.000	.000
LTPA MET	Cor								1.000	-.022	-.524**	-.065*
	Sig.									.465	.000	.046
DEBQ	Cor									1.000	-.001	.043
	Sig.										.969	.183
PA below	Cor										1.000	.099**
	Sig.											.002
Sedentary above	Cor											1.000
	Sig.											

*Significant at P<0.05
**Significant at P<0.01

Logistic Regression: Table 6.20 represents the final logistic regression model that incorporated all of the variables (and sub variables) that retained a significant (P<0.05) predictive relationship with some-risk (as opposed to no-risk) of obesity related ill-health.

Table 6.20: Health Behaviour Questionnaire Logistic Regression final model: predictors of risk of obesity related ill-health as defined by NICE categorisation (NICE 2006) with p value odds ratio (OR) with 95% confidence intervals (CI)

Predictor	P	OR	95% CI High	95% CI Low
Age Group	*			
17-24 years	N/A	1.0	N/A	N/A
25-34 years	0.06			
35+ years	**	2.3	1.2	4.4
LTPA Engagement	***			
have engaged in regular LTPA (>6/12)	N/A	1.0	N/A	N/A
not engaged in LTPA/do not intend to	***	7.1	3.3	15.0
not engaged in LTPA but intend to	***	3.4	1.9	6.3
have engaged in some LTPA	***	2.8	1.7	4.5
have engaged in regular LTPA (<6/12)	**	2.2	1.3	3.7
Food Preparation (workday)	**			
Centralised feeding	N/A	1.0	N/A	N/A
Food Outlet	**	4.5	1.7	12.0
You	**	2.0	1.3	3.2
Your Partner	0.18			
Other	0.58			
Restrained Eating	***			
Never	N/A	1.0	N/A	N/A
Seldom	0.08			
Sometimes	*	2.1	1.1	4.3
Often	*	2.3	1.1	4.7
Very Often	*	2.7	1.1	6.7
Injury Status				
Not Injured	N/A	1.0	N/A	N/A
Injured	**	1.9	1.3	2.7
Sedentary Behaviour				
Below UK Norm	N/A	1.0	N/A	N/A
Above UK Norm	*	1.5	1.0	2.1
Autonomous Motivation for Exercise	**	0.7	0.6	0.9
Controlled Motivation for Exercise	*	1.3	1.0	1.7

*P<0.05, **P<0.01, ***P<0.001

The logistic regression returned a significant (P<0.001) predictive model that represented 21% of the variance $R^2_L = 0.2058$). Interrogation of the significance values and Wald statistic suggests that in this specific study population, restrained eating, LTPA engagement, food preparation in the working week, injury status, age, sedentary behaviour and type of motivation for exercise were the most influential predictors of the risk of obesity related ill-health.

Discussion

The aim of this study was to identify the significant predictors of obesity and risk of obesity related ill-health in regards to socio-demographic characteristics and health behaviours among Army personnel.

In this study 55% of the male participants were overweight, with 11% of those being classified as obese and while the female population displayed less obesity (9% of 39% overweight), they displayed higher levels of risk of obesity related ill health than their male counterparts (32% and 23% respectively). The results corroborate those in a recent paper (Sanderson, Clemes and Biddle 2014) based on 50,000 soldiers in the British Army (57% overweight of those 12% were obese and 30% of females and 23% of males deemed at some-risk). However, the identified levels are lower than those reported in the UK Royal Navy (65% male and 44% female navy personnel deemed as overweight or obese) (Shaw 2013) and in the UK general population (NHS 2011). Similarly for the assessment of risk of obesity related ill-health Shaw et al (2013) reported that 30% of both male and female study cohorts were classified as at some-risk.

This data suggest that UK Navy personnel display higher levels of obesity and are at greater risk of obesity related ill-health than British Army soldiers. This outcome also reflects information pertaining to the United States Armed Forces (Bray et al 2006), where US Navy personnel displayed higher levels of obesity compared to US Army personnel. However, it is also clear that the British soldiers in the current study were at considerably less risk of obesity related ill-heath than their civilian counterparts, as currently 57% and 56% of UK males and females respectively are categorised by NICE (2006) as at ‘some-risk’ of obesity related ill-health (NHS 2011).

Age

As in the civilian population age was predictive of higher levels of obesity (specifically those study participants over 35 years of age) and is a generally accepted outcome within military (Sanderson, Clemes and Biddle 2011, Sanderson, Clemes and Biddle 2014, Grotto et al 2008, Bray et al 2009) and civilian populations (NHS 2011, Flegal 2010). Correlations from this study also suggest that as soldiers' progress age they injure more readily, undertake less formal physical training, and are more prone to restrictive eating habits.

Injury

Injured personnel were significantly more likely to be obese; moreover injury status was a significant predictor in the logistic regression final model. These findings are consistent with research on military (Ross et al 1994, Knapik et al 2007, Cowan et al 2011) and civilian populations (Murphy, Connolly and Beynnon 2011, Anandacoomarasamy et al 2009). Whilst the cross sectional nature of the current study could not state whether obesity was the cause of injury or the result of being injured, other studies have suggested that obesity is a significant factor in both directions (Kilminster, Roiz De Sa and Bridger 2008, Lohmander et al 2007, Knapik et al 2004).

Several authors have cited that the most likely reason for increased injury rates in heavier individuals is due to increased strain on soft tissues such as tendons, cartilage and fascia (Ding et al 2005, Gaida et al 2010). Studies on body geometry have suggested that abdominal obesity alters postural stability (de Sousa 2007, Hue 2007) reducing movement efficiency and increasing the risk of injury (Reynolds 2006, Attwells 2002). However, one report into obesity in the UK Navy (Kilminster, Roiz De Sa and Bridger 2008) concluded that obesity was significantly associated with medical category, namely those reduced in their medical capability were significantly more likely to be obese compared to those with no medical restrictions. Whilst other studies have observed that obesity was one outcome associated with long-term injury (Lohmander et al 2007, Knapik et al 2004).

Health Behaviours

Health behaviours were assessed individually and collectively against UK normative data or current guidelines. The current population displayed high levels of alcohol consumption and an increased participation in smoking compared to UK civilian alcohol guidelines (HoCSTC 2012) and current smoking trends (NHS 2013). However, these two indices were not associated with obesity or obesity related ill-heath, an explanation could lie in the fact that the study sample was particularly young in its demographic with current smoking trends (NHS 2013) indicating a relationship between younger adults (<35 years of age) and smoking, as opposed to older adults (≥35 years of age). It is generally accepted that long-term alcohol intake has been observed to increase BMI (Breslow and Smothers 2004), and the results of the present study support the notion that the military is an institution with an habitually high alcohol intake (Kilminster, Roiz De Sa and Bridger 2008). It would seem that high alcohol consumption across all BMI and risk categories (42% above UK guidelines) are not significantly different in the present sample and therefore not associated with obesity.

The individual sum total of time spent undertaking formal physical training and LTPA was utilized to assess total PA. In this study low levels of PA were associated with obesity and some-risk to obesity related ill-health. In a study on the Israeli Army, Grotto et al (2008) concluded similar findings. However, a study on the US Military by Bray et al (2006) stated that the observed increase in the prevalence of obesity from 1995 – 2002 measured by BMI was associated with an increase in strenuous exercise across the same time period. However, this proposition highlights the issue of the use of BMI in isolation when assessing body composition in a military population, as the increase in BMI may simply reflect greater muscle mass (McLaughlin and Wittert 2009), which could be the result of strenuous training.

As a collective the lifestyle risk factors (smoking, alcohol, diet and PA) were not associated with the risk of obesity related ill-health. However, only 6% did not engage with any risk behaviours. This result is much higher that the resent results on the UK Royal Navy (26%), moreover at each level, the British Army display more collective lifestyle risk factors. Of note in the current sample 16% engaged in 3 risk behaviours and 3% engaged in all four-risk behaviours, this is compared to 1% and

0% respectively in the Royal Navy sample (Shaw et al 2013). While data suggests this study population undertake several risk behaviours analysis does not support a significant relationship between these heath behaviours and obesity. However, research indicates that poor health behaviours have a substantial impact on 'all cause mortality' (Khaw et al 2008, Kvaavik et al 2010).

Physical Training

Physical performance in the military is an occupational requirement (Rona et al 2010) and fat-free mass, which is highly associated with BMI, is also highly associated with maximal performance (Fitzgerald et al 1986, Harman and Frykman 1992). Within the British Army physical training is undertaken on a mandatory basis, however, the uptake is dependent on the individual unit chain of command and available time. The specific unit physical training requirements are documented in the unit PT programme, and covers all of the main aspects of fitness (strength, speed, endurance, power, flexibility) encapsulated within a functional and occupationally relevant package. Those who have failed an annual physical training test and those on conditioning and re-conditioning programmes also require mandatory PT. Therefore, high levels of attendance at unit PT may not simply reflect high levels of physical fitness (as the opposite may be true).

Within the present study and in the initial analyses the amount of PT sessions attended was not significantly different across the BMI defined groups; however, it was significantly different for those deemed to have 'some-risk' as opposed to 'no-risk' of obesity related ill-health. Given the subject population, BMI data gives a somewhat crude overview, as BMI predicts lean mass as least as well as it predicts fat mass (Friedl 2004), however, the addition of waist circumference allows greater validity (McCarthy and Ashwell 2006).

Leisure-Time Physical Activity

Clearly the PA accumulated through PT is important as it helps define activity output. However, due to the externally motivated system employed to undertake mandatory PT it tells us little about the individual's health beliefs in regards to exercise. Moreover, individual participation in LTPA cannot be misread as it is purely down to the volition of the individual. Nevertheless, there very few studies that have investigated LTPA aligned to employment in a physically challenging vocation (Leino-Arjas et al 2004).

In the present study both output categorised into MET groups (low, medium and high) and intention to engage with LTPA (no intention - sustained engagement (≥ 6 months)) were significantly associated with obesity and to a greater extent risk of obesity related ill-health. Research into occupational PA (OPA) has indicated that the greatest health benefits are associated with the highest levels of OPA and LTPA (Probert, Tremblay and Connor-Gorber 2008). Some authors concluded that having a highly active occupation could reduce the likelihood of being obese by 42% even without LTPA participation (King et al 2001). It could be hypothesised that high levels of OPA linked to the early careers of predominantly infantry soldiers has a prophylactic effect irrespective of LTPA and mandatory PT, however, this level of health protection may decline as soldiers progress in age and transition into managerial roles. In the present study age was linked to a reduction in mandatory PT, and although there was a positive association with age and LTPA, the transition into increasingly sedentary roles may be of greater significance.

Sedentary Behaviour

In the present study being highly sedentary (above 9.5 hours) was linked to higher levels of obesity and risk of obesity related ill-health. Specifically in this highly active study population 32% of those over the UK civilian average for sitting-time were at 'some risk' of obesity related ill health (compared to 19% of those under the UK civilian average for sitting-time). Stronger significant correlations (r=.147 versus r=.073) were apparent for risk, as opposed to obesity. In addition, high levels of sedentary behaviour were positively correlated to low PA levels and negatively correlated to both LTPA MET outcome and currency of engagement. In the final analyses sedentary behaviour remained a significant predictor ($P<0.05$) of risk of obesity ill-heath.

Unfortunately there are no corresponding data on military populations with which to contrast, however, one study comparing the risk factors for metabolic syndrome in the Brazilian Navy (da Costa et al 2011) did conclude that sedentary behaviour was a significant factor in abdominal obesity. Nevertheless, the dearth of population ‘defined’ knowledge should not detract from current opinion on sedentary behaviour, specifically that self reported PA and sedentary behaviour are independently associated with a number of adverse health outcomes including mortality (Dunstan et al 2005, Ford et al 2005). Moreover, one paper has suggested that sedentary time may have a stronger influence on waist circumference (and therefore obesity risk) than moderate to vigorous PA (Healy et al 2008), and the impact from ‘inactivity physiology’ may be more influential than the benefits accrued via PA. This raises distinct concerns in light of the results of the current study, and indeed for the UK Armed Services, and could be an issue of importance across the UK public health arena.

Motivation for exercise

In the present study controlled motivation was observed to be positively associated and autonomous motivation was found to be negatively associated with risk of obesity related ill-health. This relationship existed in the final analyses when controlling for all other significant variables. Clearly the direction of effect supports the notion that those who are autonomously motivated towards exercise are less likely to be at risk of obesity related ill-health, than those who are controlled in their motivation. This result is of importance to the military, as the PT element of PA is externally motivated (and therefore part of the controlling motivation spectrum). Studies have repeatedly demonstrated the negative association between the more controlling types of behavioural regulation and exercise bout duration (Duncan et al 2010), intensity (Wilson et al 2004) and prolonged persistence (Duncan et al 2010, Williams et al 1998). Conversely, autonomous motivation within an exercise domain is positively linked to exercise bout duration (Wilson et al 2004), persistence (Ryan et al 1997) and frequency (Wilson et al 2004).

In a military population one study has suggested that those who exercise for self-motivated reasons (as opposed to because they have to, due to being in the military) are more likely to benefit in terms of health and enhanced fitness levels (Wilson, Markey and Markey 2012). It is also very possible that those individuals who exercise for external reasons may undertake these actions only to appease the hierarchical chain of command within the military. Due to the high correlation observed in the current study between controlling types of motivation and amotivation, it is also possible that an individual motivated by controlling mechanisms will be amotivated. These individuals may engage in exercise without feeling any motivation, or they will exhibit a complete lack of intention to perform exercise (Ryan 1995). Significantly for military personnel motivated by controlling types of motivation, this could mean a reduction of exercise intensity and therefore health benefit of the exercise session. At worst it could mean individuals could cease to undertake exercise and may seek to avoid PA altogether, enhancing the risk of obesity related ill-health, increasing injury susceptibility and reducing individual and collective capability.

Diet

Across gender, those who were obese or had some-risk of obesity related ill-health were most restrained in their eating, furthermore in the final analyses, a rise in level of restrictive eating increased odds of obesity related ill-health risk.

Within the military food choice and preparation are externally directed, removing some individual choice (Bingham et al 2012a), and while some investigators have attempted to influence soldiers' food choices they have found this challenging (Sproul et al 2003). Across BMI and NICE obesity risk categorised groups the soldiers in the present study did not differ significantly in their high fat food or snacking behaviour, however, over 40% of the study population consumed high-fat foods on most or every day. Similarly only 14% self reported consuming 5 portions of fruit / vegetables per day (UK Civilian norm 20%). In light of the current results and in the knowledge that one recent study into armed forces eating behaviours suggested the effect of service in the armed forces increases consumption of sugar rich foods (Bingham et al 2012b). The general picture therefore is a sub-population with relatively poor dietary behaviours.

In the current study, location of food consumption / preparation within the working week was retained in the final logistic regression model. This suggested food consumption (and preparation) by the study participants in centralised feeding arrangements (offered by the various units) was associated with the least risk of obesity related ill-health (compared against the other sub-variables). While eating at a food outlet was significantly associated with obesity risk and is in keeping with previous research on the UK Royal Navy (Shaw et al 2013). Those who prepared food in their own house / location were also more likely to be at some-risk compared to those who ate in the centralised facilities. Previous studies have suggested a lack of cooking confidence, ability and enjoyment may impact on the ability to prepare healthy and inexpensive meals (Hyland 2006) and could enforce a reliance on convenience foods, many of which are high in fat (WHO 2003). Alternatively a recent systematic review (Sanderson, Clemes and Biddle 2010) reported that soldiers might simply ascribe a low priority and insufficient time for healthy eating and undertaking PA (Sigrist, Anderson and Auld 2005). Nevertheless the British Army recruits from a broad spectrum of UK society and some Foreign and Commonwealth Countries. It is a well accepted notion that those who are most prone to poor dietary habits lack appropriate dietary knowledge, come from a lower socioeconomic background, are prone to peer pressure and subjective norms (Groth, Fagt and Brondsted 2001, Stallone et al 1997), and since the Army has a substantial proportion of new recruits emanating from such backgrounds, it heightens the requirement for specific education in relation to nutrition and food preparation. This process may be difficult within an institutional environment where autonomy is reduced and many health decisions are externally motivated. However, the results of the current study suggest that soldiers may require specific nutritional education to assist in both food preparation and healthy food choices.

Limitations

There were several limitations to the present study. The self-report measures employed could have been open to social desirability factors and inflated reporting. Additionally, the cross sectional nature of the design prevents conclusions of a causal nature. The IPAQ categorical question required recall of PA history, which is open to false reporting. However, asking subjects to categorise their answer probably facilitated recall. The study participants were all from the British Army and specifically UK 3RD Division, the deployable component of the UK based British Army and thus would be at a higher state of physical readiness. However, a cross section of trades and fitness levels were assessed to enhance the generalisability of the findings, and in essence the population was not dissimilar to those in the armed forces and other vocations that require occupational physical fitness. In the interests of completeness comparisons for male and female soldiers were included. It should be noted that whilst representative of the British Army the study has a small female sample and may influence the ability to offer suitably informed assessment.

<u>Conclusion</u>

In this specific study population, food preparation in the working week, injury status, age, sedentary behaviour, LTPA engagement and type of motivation for exercise were the most influential predictors of the risk of obesity related ill-health. Data also suggested that restrained eating may be an influential factor, however many of factors that influence dietary restraint were not assessed.

In the current study it was observed that the transition into sedentary roles and reduction of mandatory PT by primarily older individuals may not be suitably compensated by LTPA. In essence the time spent being sedentary may be more influential for risk of obesity related ill-health than the time spent being moderately to vigorously active. This has occupational resonance for the British Army as many areas of health behaviour are external motivation, specifically physical training. A reliance on external motivation will not support ownership of health behaviours, for exercise it may induce avoidance and cessation, increasing the risk of obesity related ill-health.

It was also evident that high levels of injury were correlated with obesity risk and advancing age. For older (≥35) army personnel in order to achieve the health benefits associated with physical activity, it is important to exercise regularly and at an appropriate intensity (Wilson et al 2004). Due to the physiological implications of age and long periods of sedentary behaviour, specific conditioning regimes may be required that enhance total PA output, whilst offering an amount of injury and health protection.

Chapter 7

General Discussion

Chapter 7 General Discussion

Chapter 7 presents a discussion of the findings. These findings are presented in the context of the thesis aims. The importance of the findings and evidence-based recommendations are contextualised within this chapter.

Overview

This thesis aimed to increase our understanding of the prevalence, correlates and predictors of obesity in the British Army. In order to achieve this, the thesis has the following objectives:

- To assess the current knowledge in respect of the correlates and treatment of obesity in military populations.
- To establish the current prevalence of obesity in the British Army in relation to age, gender, marital status and occupationally defined employment.
- To understand the impact of weight status on occupational fitness.
- To clarify through a large sample the predictors of obesity in the British Army.
- To gain a broader understanding of the health behaviours and physical characteristics and specific motivations linked to BMI and the risk to obesity related ill-health.

This chapter summarises the main findings and outcomes within this thesis, contextualises the importance of the findings set against the thesis objectives, individual health needs and military occupational requirement. The limiting factors are discussed in respect of each objective. General conclusions and recommendations are given; in addition future lines of investigation are proposed.

General Discussion

The obesity epidemic (Ezzati 2002) has meant that militaries are faced with counteracting the consequences of societal trends of decreased physical fitness and increased obesity among youth (Kyrolainen and Nindl 2012). The high and rising prevalence of obesity in the civilian population makes it more difficult for the military to find acceptable numbers of quality recruits (Yamane 2007, McLaughlin and Wittert 2009). Extrapolations indicate that the UK will be mainly obese by 2050 (Kopelman, Jebb and Butland 2007), this would suggest that the military will be required to draw from a more obese recruitment population. Significantly, obesity is also linked with reduced job performance within military populations (IOM 2004, Naghii 2006), higher health care costs (Dall et al 2007) and degraded occupational and operational performance (Kyrolainen and Nindl 2012). A scientifically based clarification of obesity prevalence, correlates and prediction is of central importance, as it will enhance the knowledge of military leaders in respect of the causal mechanisms, prevention and treatment of obesity.

Thesis Objective 1: To assess the current knowledge in respect of the correlates and treatment of obesity in military populations.

While the study of obesity, treatment, correlates and prevention is commonplace in the civilian sector, the systematic review identified a limited amount of credible papers for review. Within the specific criteria set for the systematic review only seventeen papers were included, significantly none of the papers reflected the UK military. Therefore, the interpretation of the results needs the caveat, which the generalisability (although contextualised) may not extend to the UK military population.

Due to my background and employment, I was able to contact other militaries direct to ensure that all possible information pertaining to obesity was reviewed. While this 'grey literature' search returned 18 potential papers, the specific nature of the investigation precluded inclusion in the review. In the main, these papers focussed on 'military policy' regarding obesity classification and associated regulations.

In the initial stages of the systematic review, the prevention of obesity was included in the search strategy, however, only a single credible paper was identified and therefore, the review of this paper was removed from the published paper (Sanderson, Clemes and Biddle 2011) and does not feature in Chapter 2. However, this none randomised controlled trial had a large US Air Force sample (*n*=68, 541) with 3,502 individuals meeting 'treatment' selection criteria (BMI 24.0 to 29.9 kg/m^2- pre-overweight to pre-obese). The study by Robbins et al (2006) compared a treatment group recruited from five US Air Force bases, receiving self-directed behaviour change booklets, with a control group based throughout sixty US Air Force bases. The intervention facilitated significant results for a smaller male sub-group (*n*=7,518), where actual weight loss was observed (mean = -1.3lb). However, in the majority of the male sample 78% (*n* = 52,302) weight increased (mean = +0.3lb) and thus annual weight gain was not prevented.

The sub groups were stratified by US Air Force 'rank'; the smaller 'successful' group reflected the higher ranks / pay grades. Rank has been described as a proxy for socioeconomic status (SES) in military populations (Robbins et al 2006). Internationally, lower SES is associated with higher levels of obesity (Power et al 2004). This suggests that efforts to promote health benefits may be less successful in military populations with traditionally low SES populations (Klein 1965). One review has associated low SES with lower educational attainment mediating the persistence of obesity in later life (Yu et al 2009) therefore; the higher SES status of the associated sub-group may have acted as a mediator between the intervention and rank. The author indicated that the lower pay grade group reflected a sample with ≤3 years of service, and thus may not have made the conscious decision to make military service a career (Robbins et al 2006), suggesting that the high pay grade group had 'more-to-lose' from severance of service employment due to failure to maintain 'maximum allowable weight for height' (MAW). The decision to additionally stratify the high pay group only with individuals with a weight above the MAW implies that by US Air-force definition this group was defined as overweight, it is therefore questionable whether the intervention represented prevention or treatment. This process nullifies the ability to afford comparison of the groups, due to the systematic error in the recruitment process.

In addition, the intervention employed a low-intensity PA process focussed on accumulating 30 min/day of moderate activity on most 'if not all' days of the week. Whilst these recommendations are in-keeping with current values for general health (DOH 2007), current guidelines indicate that 45-60 min/day is required to prevent the transition to overweight or obesity (Saris et al 2003), and may suggest a possible reason for the reduced efficacy of the intervention across the 'total' study sample. However, the relative success of the intervention utilizing a comparatively low-cost initiative, using standardised messages, through a web-based platform, has some empirical support (Tate et al 2001, Winett et al 2005) and could offer a suitable health communication tool for the Armed Forces. Although this intervention benefited from a large study population, the singular nature of the review based on a US population prevents 'suitably informed' recommendations for the British Army in terms of obesity prevention, and underline the requirement for further investigation in this area.

The dearth of studies in the area of prevention is of some concern, as prevention is more cost effective and has less impact on occupational and operational capacity (NAO 2011). This lack of engagement could be viewed as ambivalence born of ignorance of the potential individual and collective impact of obesity (IOM 2004). Within the environment of the armed services, programmes that are incorporated into the organisational structure and viewed as not specific intervention, but as an extension of workplace culture and institutional policy may be more successful (Marshall, Owen and Bauman 2004). These passive interventions (Williams 1982) are viewed as powerful enhancement strategies within health promotion (Stokols 1995). Moreover as part of a Social Ecological approach, they have the capacity to benefit many people, across many settings (Stokols 1995).

Added to the problems associated with the lack of studies, and whilst the systematic review followed the guidelines articulated in the National Institute of Clinical Excellence (NICE) (NICE 2009) and the National Health Service (NHS) Centre for Reviews and Dissemination (CRD) guidance (NHS 2001). The quality of several of the studies was questionable, as nine of the treatment studies and all of the correlate studies were observational in their design. In the comparison between observational and experimental design, some researchers have observed larger (inflated) estimates of effect (Guyatt et al 2000, Miller, Colditz and Mosteller 1989), while some researchers have found no difference in effect (Concato, Shah and Horwitz 2000, Benson and Kerr 2000). It is understood, however, that studies that lack rigour of execution or have poor design can result in biased estimates of effect (Khan, Daya and Jadad 1996, Moher et al 1998). Nevertheless, the development of a specific quality assessment instrument utilizing the guidance outlined in (NHS 2001) ensured that quality assessment was rigorous and consistent across all studies.

For the treatment of obesity the reviewed papers suggest that a multilevel approach to obesity within the military offers the most effective method. These programmes should include PA, nutritional counselling, behavioural change, self-monitoring and continuous structured support. Due to the short follow-up process employed by the majority of the interventions, the long-term efficacy cannot be clarified. This fact remains problematic as most weight loss programmes can achieve satisfactory initial weight loss over the short-term (Lang and Froelicher 2006), however, maintenance of weight loss is rarely retained and many individuals regain all weight lost within 1-5 years (Wing 1997). Nevertheless, many of the constructs employed by the interventions adopting a cognitive behavioural approach such as self-monitoring, stress management, problem solving, social support, relapse prevention and a high frequency of patient and therapist interaction, have empirical support (Lang and Froelicher 2006, Perri and Corsica 2002) to achieve better long-term outcomes.

Within the Healthy Lifestyles, Exercise and Emotions, Attitudes and Nutrition' (LEAN) interventions, individuals were, through education and protracted support (over 1 year), made aware of their immediate social environment, enhancing the ability of the patient to control health thoughts and impulses (James et al 1999). This enduring level of support and the multi-level and multi-disciplinary process were central tenants of the LEAN programme; indeed the LEAN programmes were the most successful in terms of weight loss. However, whilst in most cases clinical professionals were used within their sphere of expertise, trained educators were not employed to deliver the educational component. There is general consensus that efficacy of multidisciplinary approaches on obesity treatment are enhanced when supported by suitably trained professionals (Sharma 2007), utilizing procedures and language that affords replication (Abraham and Michie 2008).

Most of the papers (*n*=9) reported an intervention based on behavioural theory, with the majority utilizing the Cognitive Behavioural Theory (CBT). Previous reviews have highlighted the value of using behavioural theory to establish how interventions work (Baranowski et al 2003), clarification of individual component effectiveness (Sharma 2007), and the influence of mediating variables (Baranowski, Anderson and Carmack 1998). Collectively, all papers made reference to the various constructs of behavioural theories employed and the initial assessment of some psychological processes (e.g., attitude and emotions), however, with the exception of one paper (Dennis et al 1999) no reference was given to the measurement of changes in constructs that predict or mediate behaviour. Dennis et al (1999) indicated, through self-report, changes to eating behaviours and levels of situational self-efficacy, offering some data to substantiate selected elements of CBT. The cognitive behavioural approach ascribed to in the LEAN programme(s) does not offer any insight as to the efficacy of the intervention regarding to self-worth and self-control, two of the central elements of the supporting theory (Fairburn, Shafran and Cooper 1998). The absence of theoretical supportive data will reduce the ability to offer an informed opinion as to the predictive and mediating effect of theoretical constructs; this information is vital for the evolution (Sharma 2007) and applicability (Baranowski et al 2003) of the intervention. Incomplete knowledge of construct interaction and efficacy will also preclude replication of effective behavioural interventions and underline the requirement for a “taxonomy of behavioural change techniques” (Abraham and Michie 2008).

The review indicated that the majority of the studies reported utilising a combination of group and individual therapy. Four programmes used one-to-one treatment in isolation and one programme employed group therapy alone. In general the interventions that used a combined approach were more successful. The use of one-to-one counselling was a central construct of all of the CBT interventions. Due to the many mediating variables, the individual efficacy of the counselling process cannot be defined, however, the collective success of the interventions indicate that one-to-one counselling can be an effective tool for weight reduction (Sharma 2007). Previous systematic reviews have either failed to compare group and individual setting of delivery (Melcarne, Cognolato and Santonastaso 1996), concluded in favour of individual treatment (Avenell et al 2004), or more recently, indicated that group-based interventions were more effective (Paul-Ebhohimhen and Avenell 2009). Whilst, for some, an individual focus for treatment may be of importance (Renjilian et al 2001), the collective nature of daily and operational military activity suggests that cohesion is central to vocation. Indeed military personnel are placed in a setting where individuality is diminished (Bingham et al 2012), and may well benefit from the peer support that is associated with group-based interventions (Wing and Jeffery 1999, Christakis and Fowler 2007). Furthermore, the concept of group-based treatment is not new for the British Army, as it currently utilises group-based therapy in the treatment of musculoskeletal injuries to great affect (DMRP 2010).

One recent review from the USA concluded that the decline in PA energy expenditure (PAEE) observed since the middle of the 20^{th} century was of central influence to the recent rise in bodyweight and obesity experienced in the USA (Archer and Blair 2012). Given that PA is the major modifiable component of total daily energy expenditure (TDEE), (Westerterp 2008) and PA as a construct of obesity prevention and treatment has proven to be of central importance in most interventions (Wareham, van Sluijs and Ekelund 2005). It was disappointing that PA as an intervention construct was poorly described, with little reference made to the prescriptive elements. This point highlights the possibility of professional bias within research and intervention, where some clinicians (although part of a multidisciplinary team) may not be able to fully appreciate the value of the other intervention constructs, and therefore the complexity of obesity intervention (Rutter 2012). Archer and Blair (2012) recently commented on a lack of appreciation of the necessity of PA and exercise in the maintenance of health, as well as a lack of implementation of PA interventions in the primary prevention and treatment of none communicable diseases (NCDs). In the systematic review most of the interventions were led by a health psychologist and therefore, there may have been a professional leaning towards the psychological constructs at the expense of the PA requirements.

Within the systematic review all of the six LEAN programmes advocated low to moderate intensity PA (a target pulse rate of 60% - 70% of maximum heart rate) for 40 minutes (Mon-Fri = 200 min/week) (30). Current recommendations advocate that 45-60 mins/day of moderate intensity activity is required to prevent the transition to overweight or obesity and that 60-90 mins/day is required for the prevention of weight regain in formerly obese individuals (Saris et al 2003). The LEAN programmes advocacy of low-intensity PA is based on one study using a female sample, presented as a journal article and as a conference paper (Jakicic et al 1995, Jakicic et al 1995b). Current opinion suggests that recommendations for PA in the treatment of obesity may need to consider gender differences and that high volume PA may favour men who tend to undertake more vigorous PA for longer periods of time (Saris et al 2003). Furthermore, one recent meta-analysis (Thomas, Elliott and Naughton 2006) demonstrated that resistance training (RT) significantly reduces total fat mass. This study also demonstrated the benefits of structured resistance training on multiple metabolic risk factors, including obesity, diabetes and metabolic syndrome (Strasser, Siebert and Schobersberger 2010). Interventions that use resistance training as part of a multi-disciplinary approach may suit the needs of the military in regards to body composition, health requirement and occupational need, and therefore should be incorporated into future obesity treatment interventions.

Bodyweight was the main measured outcome in eleven of the thirteen studies, and as a main measure of intervention efficacy within a military population, this does not display a broad understanding of the physiological requirements of armed service personnel. Obesity is defined as “an unhealthy excess of body fat” (Villareal et al 2005) or “excess body fat accumulation with multiple organ-specific pathological consequences” (Haslam et al 2006), ergo, a high bodyweight might not necessary be implicit with obesity and obesity related ill-health. Moreover, armed services employment is synonymous with distinct occupational fitness and strength requirements (Friedl 2004). Indeed higher bodyweights may actually be supportive of occupational need, as larger individuals with higher levels of muscle mass are ideal in many physically demanding tasks in the armed forces (Harman and Frykman 1992). While several studies on the civilian population have reported a negative correlation between neuromuscular and cardiorespiratory fitness and body fat (Vaara et al 2012) and waist circumference (Duvigneaud et al 2008, Esco, Olson and Williford 2010). Research on military populations suggests that body composition, rather than body mass is more closely associated with the metabolic demands of many occupational tasks undertaken by the military (Lyons, Allsop and Bilzon 2005). Therefore, changes to body composition and specifically body fat should be used as a measurement of intervention efficacy for obesity related interventions on military personnel.

Collectively, the reviewed papers would suggest that military programmes are universally ignoring important determinants such as supportive environments (Wareham 2007). Many military personnel often live and work within the confines of a specific environment that has both positive and negative aspects associated with maintaining physical fitness and healthy weight (IOM 2004). On the positive side, they have ready access to fitness facilities and health care providers; in addition many rarely leave the confines of the military real estate and therefore can gain maximum impact from any environmental intervention. On the negative side newly acquired health behaviours may be under pressure of relapse, due to the mobile nature of employment. While research has suggested that environmental stressors and geographical mobility can impact on behavioural change (Stokols 1995). A combination of active and passive interventions that span individual, local and organisational levels may reduce the impact of the inherent mobility, linked to armed forces employment. Within the military, obesity treatment and health promotion need to recognise the influence of multiple settings and workplaces and engineer such interventions that are replicable within supportive environments (McLeroy et al 1994). Ecological models (Sallis and Owen 2002) that are specifically multilevel in their approach, reflecting the intrapersonal, interpersonal and behavioural components, whilst remaining cognisant of the physical environment and policy requirements, may offer a suitable approach for future interventions (Marcus et al 2007). However, if such programmes are to be successful they will require support at the various levels of local and corporate leadership (Gantt et al 2008), and will need to reflect the impact of the general and specific military environment, and the nuances of organisational culture (Whiteman, Snyder and Ragland 2001).

The review suffered from a lack of credible papers to review and (in some cases) the low quality of the papers included within the review. This fact underpins the requirement for further work in this area. Specifically there is a requirement for high quality research papers addressing the obesity issue within the UK Military. In addition all of the interventions reviewed were undertaken within armed forces real estate, with all personnel subject to military rules therefore, attendance might not have been purely voluntary.

A total of nineteen correlates were identified from the four papers, with all of the evidence being based on one of the studies, or two studies with conflicting evidence; and therefore the quality of the evidence is classified as weak or mixed. Moreover, the cross sectional nature of all four studies precludes the ability to infer causal relationships between the hypothesized correlates and obesity. Whilst this is an issue for the current systematic review, comparable issues relating to study quality have been raised in regards to papers concerning PA correlates (Trost et al 2002). Similarly, there is a clear requirement for longitudinal and intervention correlate studies in the area of PA, and specifically for obesity in military populations.

Throughout the review, educational level was the only correlate to attract either opposing or additional support. In a study based on the Israeli Military (Grotto et al 2008), lower educational level (for study subject and male parent) was proposed as a correlate of obesity. However, Bray et al (2006) suggested a higher educational level was a correlate of obesity. While the conclusions of Grotto et al (2008) are based on a young adult population, precluding the ability to comment on the socioeconomic status (SES) throughout adulthood (Karvonen, Rimpela and Rimpela 1999). General opinion concurs with the findings of Grotto et al (2008) and is supportive of a relationship between lower educational attainment and higher levels of obesity (Martinez et al 1999). In a large study into the variables independently associated with obesity across the European Union, Martinez et al (1999) concluded an inverse association existed for men and women between BMI and educational level. Although this conclusion was in support of a previous review (Seidell and Rissanen 1998). Further studies have suggested that this statement may be too simplistic, as the relationship between low SES and higher levels of obesity, is more clearly defined in women than in men (Krieger, Williams and Moss 1997, Wardle, Waller and Jarvis 2002). However, in a overview of health behaviours, Power et al (2005) postulated that educational level was a strong determinant of health related behaviours, including diet and PA.

Socioeconomic status is generally understood to reflect education, income and occupational status (Krieger, Williams and Moss 1997). Within their review on the US Military, Bray et al (2006) concluded that 'pay group' status of military personnel was correlated with obesity, stating those on lower pay displayed higher levels of obesity. Therefore, in the US study, two of the components of SES are suggesting opposing conclusions. The published results (Sanderson, Clemes and Biddle 2014) and the logistic regression data presented in Chapter 5, suggest that for the British Army while rank may have an association with obesity, age may moderate this affect. Civilian studies have shown that when adjusted for age, the impact of SES is diminished (Wardle, Waller and Jarvis 2002).

Obesity was found to be more prevalent in males aged ≥35 years (Bray et al 2006). The notion as age progresses, obesity increases is a generally accepted concept in civilian (NHS 2011, Flegal 2010) and military studies (Napredit et al 2005, Shaw et al

2013). However, an informed comparison with civilian samples across the life-cycle is somewhat problematic due to limitations applied in respect of surveyed groups (≤20, 21-25, 26-34 and ≥35 years), gender demographic (male 86%, female 14%), and the restrictions applied to age (18 – 55) for employment in the military. For the British Army the results presented in Chapter's 3 and 5 supports this relationship. In addition, and based on a different study population the results of Chapter 6 (HBQ) suggest that older ≥35 years British Army personnel are significantly more likely to be at risk of obesity related ill-health (BMI and waist circumference combined). Although the review revealed scant information, the additional information from subsequent studies would suggest that age represents a significant correlate of obesity in military populations.

The hypothesised correlate of ethnicity, specifically African-American / Hispanic relates to a study US Armed Forces (Bray et al 2006), based on a large study sample with data drawn from 1995, 1998 and 2002. Studies on the US population have generally supported this conclusion (Flegal et al 2002, Flegal et al 2010). Some studies have suggested that social and behavioural factors may help explain the prevalence of obesity between different ethnic groups (Kumanyika et al 1993), in that African-Americans have a greater cultural tolerance for obesity (Glass et al 2002). Physiological investigations have indicated differences between muscle fibre type and lipid disposal may offer an explanation as to the positive fat balance observed in African-Americans (Tanner et al 2002). Therefore, for the American population and the US military ethnicity may well be influential factor. However, there are marked differences between the population demographic of the UK and the US. The British Army is 93% white (Berman and Rutherford 2013), data presented in Chapter 6 suggests that ethnicity is not linked to causality of obesity in the British Army. However, the study was based on 1000 soldiers did not stratify for ethnicity and therefore, may have lacked sufficient power to ascertain a defendable statement in regards to ethnicity.

The review suggested that being married as opposed to single was a correlate of obesity. The relationship between marital status and obesity is generally supported (Kaplan et al 2003, Martinez et al 1999). Armed service members are significantly more likely to be married that their civilian counterparts of the same age and social demographic (Karney, Loughran and Pollard 2012). The hypothesised correlate of married status is deserving of further scrutiny. Additional information regarding the British Army (Sanderson, Clemes and Biddle 2014) indicates that married status is a correlate of obesity for male, but not female soldiers. Due to the changes observed between univariate and multivariate analyses presented in Chapters 3 and 5 it would appear age explains some of the variance in relation to being married and weight status. Although data were not available from the studies included in the systematic review, the results of the HBQ suggest location of food preparation and consumption may be more influential than marital status.

Data presented in Chapter 6 indicates that British Army soldiers who use the centralised feeding offered by the UK military are least likely to be at risk to obesity related ill-health, compared to those who did not use these facilities. In addition a higher likely hood of obesity related ill-health was observed for those soldiers frequenting food outlets, or for those who indicated that food preparation took place in their own house. The findings in relation to food outlets are in keeping with previous research on the UK Royal Navy (Shaw et al 2013). Furthermore, it is distinctly possible that a lack of cooking confidence, ability and enjoyment may impact on the ability to prepare healthy and inexpensive meals (Hyland 2006). In essence, to describe marital status as a correlate of obesity may be too simplistic; however, evidence does suggest that both service personnel and their spouses may benefit from specific education in relation to nutrition and food preparation.

Two of the reviewed papers gave conflicting evidence in relation to PA. Bray et al (2006) suggested an increase in the prevalence of obesity in military personnel from 1995 – 2002 measured by BMI was associated with an increase in strenuous exercise across the same time period. The review by Grotto et al (2008) on the Israeli Army concluded that high levels of PA (≥4 aerobic sessions p/week) were negatively associated with an increase in BMI, and that low levels of PA (<1 aerobic session p/week) were positively associated with overweight in females.

The comments by Bray et al (2006), could suggest that those soldiers that undertake more strenuous exercise are indeed more likely to be obese. However, BMI cannot differentiate between lean mass and fat mass, indeed BMI predicts lean mass at least as well as it predicts fat mass (Friedl 2004, Rasmussen, Johansson and Hansen 1999). The use of BMI in isolation could be misleading in a military population, as the BMI may simply reflect greater muscle mass (McLaughlin, Wittert 2009). Specifically, strength training will increase fat-free body mass and a greater muscle mass generates higher body strength values, which are advantageous for military occupational fitness (Harman and Frykman 1992). However, Grotto et al (2008) also utilised BMI as a main measure of outcome and this could reflect a different physical training emphasis, as the combination of endurance training and moderate energy intake will lead to an improvement in endurance capability and body weight (Harman and Frykman 1992). Nevertheless, the evidence is generally supportive of a relationship between low PA and obesity in military (IOM 2004, Napredit et al 2005) and civilian populations (Martinez-Gonzalez 1999, Lee et al 2012).

The reviewed papers did not attempt to gain an understanding as to why military personnel eat the food they eat or why they participate in PA, a greater understanding of the correlates that inform these processes will make for more effective intervention programmes (Baranowski 2003). Due to the prospective impact of dietary habits and PA, the behavioural attributes that inform these decisions should be investigated in future studies.

The results presented in Chapters 5 and 6 in reference to medical status and injury status respectively, suggest that obesity and the risk of obesity related diseases is linked to injury status in the British Army. Whilst, this information on the British Army reflects the first investigation into this area, it is not the first to conclude that injured personnel are more likely to be obese, and that medical category is linked to weight status. Studies on the UK Royal Navy have indicated that obesity was significantly associated with medical category, namely those reduced in their medical capability were significantly more likely to be obese compared to those with no medical restrictions (Kilminster, Roiz De Sa and Bridger 2008). Further corroboration for this working hypothesis is gained from the research by Ross et al (1994), Knapik et al (2007) and Cowan et al (2011). There is sufficient information to suggest that a relationship between injury status and weight status exists, and therefore warrants future research.

The studies available for review did not have a full appreciation of the physical environment. Beyond the access to fitness facilities and a reference to reduced healthy food choices and mixed media 'nutrition' based messages by Sigrist, Anderson and Auld (2005), little was mentioned. Moreover, Sigrist, Anderson and Auld (2005) were reporting data gathered from a small sample of senior US Army officers, therefore certain generalisability issues exist. It is recommended that future correlate studies attempt to evaluate the physical, socio-cultural and economic environmental factors that may facilitate obesity (Wendel-Vos et al 2007)

Thesis Objective 2: To establish the current prevalence of obesity in the British Army in relation to age, gender, marital status and occupationally defined employment.

To fully understand the obesity related problem facing the British Army an evidence-based investigation was required to clarify current prevalence in regards to age, gender, marital status and employment. Previous studies regarding prevalence in the UK Military have suffered from a lack of subjects and generalisability (Wood 2007), and were not primarily focussed on the British Army (Kilminster, Roiz de sa and Bridger 2008). Beyond the conclusions of Durnin, McKay and Webster (1984), who observed mean BMI measurements of 23.4 kg/m² and 24.9 kg/m² for males (aged 20-24 years and 35 to 39 years respectively), and Wood (2007), who observed 15% of Caucasian military males and 12.5% Caucasian military females categorised as obese (Body mass index (BMI) ≥ 30 kg/m²). While accepting the studies by Rona et al (2010) were not representative (reporting obesity as 11% of the UK Army). The data published (Sanderson, Clemes and Biddle 2014) reflects the only credible information regarding obesity in the British Army.

While information regarding foreign military populations is scarce further investigations revealed the following data to aid comparison across this specific population:

United States: Bray et al (2009) reported the results of the United States Department of Defence (US DoD) 2008 survey. This cross-sectional survey tool has been employed to assess health practises throughout the US DoD and Coast Guard

Service since 1980. The survey population consists of all active duty military personnel (except recruits, service academy students and those absent without leave (Lindquist and Bray 2001). The representative sample reflected active-duty DoD employees across many US National and international military instillations. Officers and women were oversampled and consisted of large survey population (*n*= 24,690) comprised of 73% (n=17,939) male and 27% (n=6.751) female armed forces personnel. The BMI cut-offs employed in the study are generally based on the National Heart, Lung, and Blood Institute (NHLBI, 1998). These guidelines defined four levels of overweight, regardless of age or gender: (a) overweight—BMI of 25.0 to 29.9 kg/m^2; (b) obesity I— BMI of 30.0 to 34.9 kg/m^2; (c) obesity II—BMI of 35.0 to 39.9 kg/m^2; and (d) extreme obesity—BMI of 40.0kg/m^2 or greater. However, for the 2008 report, a BMI of 25.0 kg/m^2 or greater is used to determine overweight and a BMI of 30.0 kg/m^2 or greater was utilized as the working definition of obesity.

Netherlands: The Royal Netherlands Army (RNLA) was the focus of a North Atlantic Treaty Organisation (NATO) study (Helmhout 2009). The study specifically investigated fitness, musculoskeletal injuries and health and lifestyle related problems associated with the RNLA. Cross-sectional Data were provided to reflect two RNLA subpopulations; military staff from education and training unit for logistic personnel (*n*=165, 163 male and 2 female) and staff from the RNLA command staff (*n*=97, 88 male and 9 female). Both of the samples represented a broad age bracket (*m*=44, range 24-57) and (m=46, range 26-57) respectfully; importantly the mean for both groups is relatively old for a serving military population. BMI measurements of 25.5 – 29-5 kg/m^2 were employed to define overweight and a BMI of above 29.5 kg/m^2 reflected obesity.

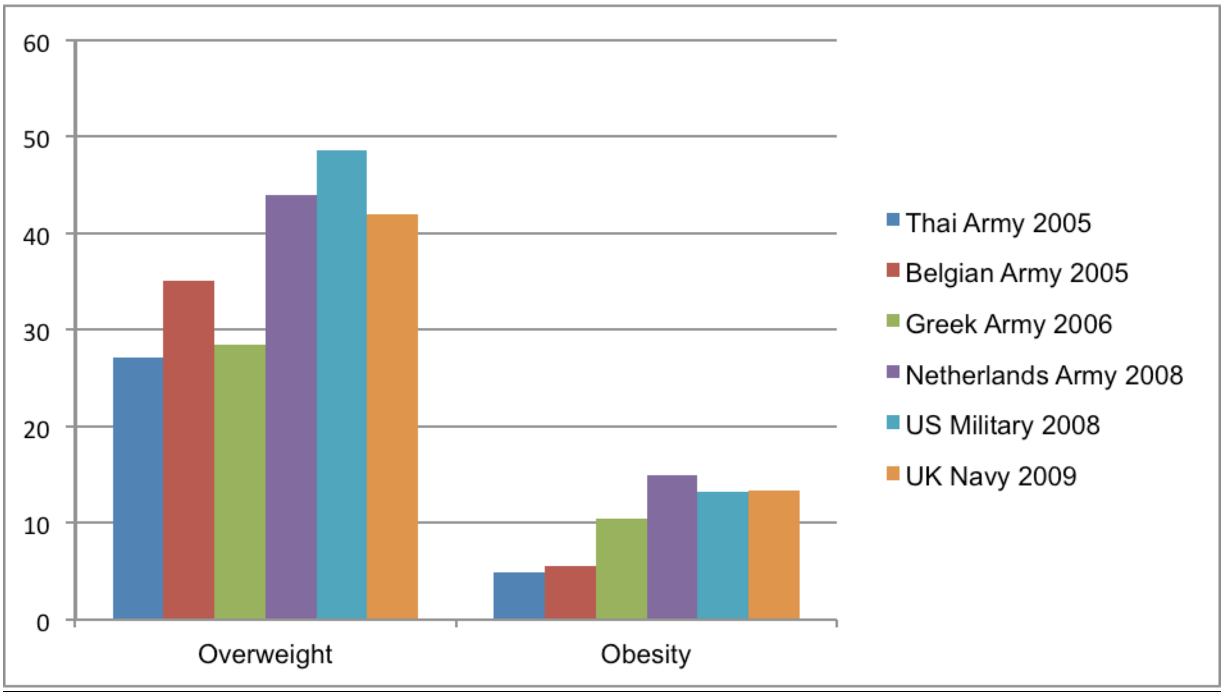
Belgium: In a study on the Belgian military, Mullie et al (2008) used the biomedical data of all personnel who participated in international peacekeeping missions between Jan 1992 – Dec 2005, the variables registered reflected date of birth, self reported weight and height, sex and military rank. The study employed multiple cross-sectional data within a longitudinal design to evaluate BMI and investigated two samples. The first was drawn from a total cohort of 49,784 male and female military personnel. Due to the reduced representation by females (*n*=934) only the male population was studied, a further 5507 participants were withdrawn due to incomplete data, leaving a cohort of 43,343 men (Mullie et al 2008). Additionally paired data for 1497 Belgian male Army personnel, who had carried out two peacekeeping missions (1992-1994 and 2003-2005), these data were utilized to compare changes to BMI. The study employed the BMI classifications as described by the World Health Organisation (WHO 2002), reflecting normal weight (≥18.5 – 24.9 kg/m^2), overweight (>25.0 – 29.9kg/m^2), obesity (>30.0 kg/m$^{2)}$.

Greece: Papadimitriou et al (2007) investigated conscripts from the Greek Army (*n*=2568); the study included measurements for BMI and questions relating to place of residence (rural or urban). Additionally level of education was assessed to offer a robust indicator of socioeconomic status (SES) (Papadimitriou et al 2007). The cross-sectional study had a male cohort were aged 19-26. Obesity and SES were compares with previous studies on the military population recorded in the years 1969 and 1990. The classification of weight status by BMI reflected ≥ 25.0 - >30.0 (overweight) and ≥ 30.0 (obesity).

Thailand: The Royal Thai Army (RTA) was the focus of a cross-sectional study by Napradit et al (2007). The study population (*n*=4,276) was recruited through January – July 2005 from 11 Army Units and represented 91% male (*n*=3,893) and 9% female (*n*=383). The average age was (male) 41.5 ± 8.5 years and (female) 38.5 ± 10.1 years (range 20-60 years). The participants also completed a health questionnaire; additionally waist circumference (WC) and hip circumference (HC) measurements were taken to calculate waist-to-hip ratios (WHR). Weight status was classified according to WHO criteria, overweight = BMI 25.0 – 29.9 kg/m^2, and obesity = BMI ≥30.0 kg/m^2.

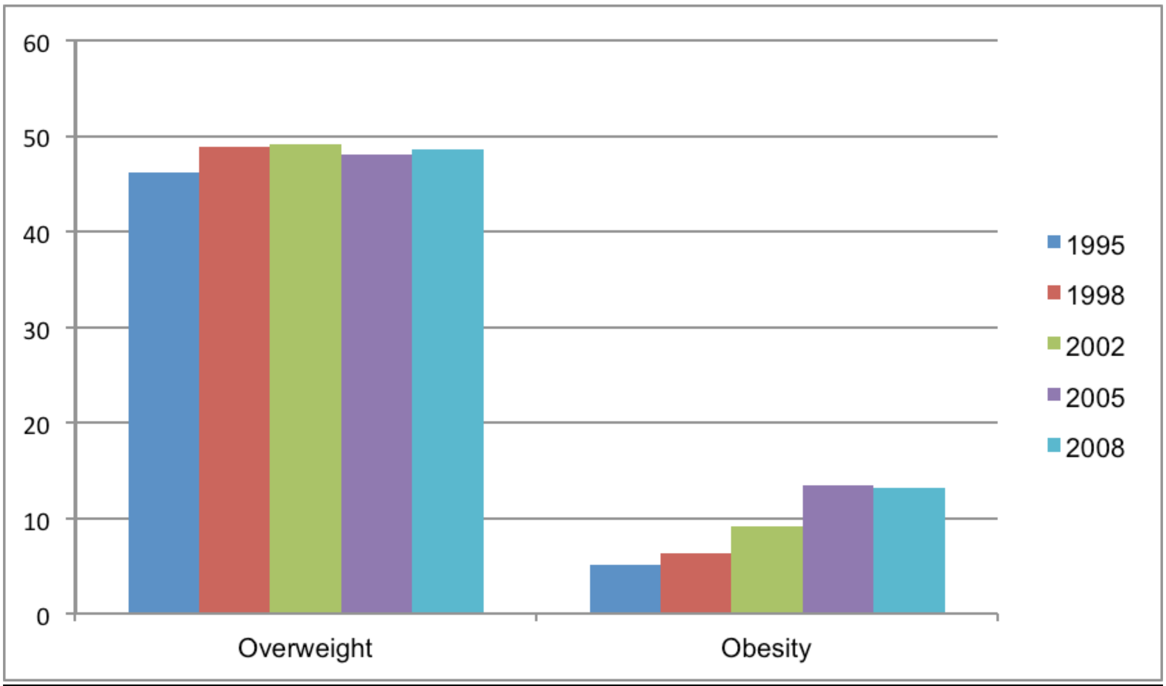
Figure 7.1 presents the main overweight and obesity prevalence information (by BMI) in regards to the international comparison. In addition information from the UK Navy is added for UK context (Kilminster, Roiz de sa and Bridger 2008). This study reflects the responses of 2596 UK Navy personnel (1599 males and 997 females) from a stratified and random sample (n=4951). This survey utilised the WHO criteria outlined above to define overweight and obesity.

Figure 7.1: Prevalence of Overweight and Obesity as measured by BMI in military populations between 2005 and 2009



This information Suggest that the prevalence of overweight and obesity is a current problem in the armed forces. Where current historical data are available (US Armed Forces) figure 7.2, there has been little change to the level of overweight from 1998 thought until 2008 (48.8% and 48.6%). However, this level of stability is not replicated within the obese (≥30.0 kg/m^2) population, where the prevalence has more than doubled (6.4% - 13.2% respectfully).

Figure 7.2: Trends in US DoD BMI (Age 20+) – Source: 2008 Health Related Behaviours Survey



Obesity Prevalence in the British Army: The data presented in Chapter 3 are based on secondary analyses of data set produced for the British Army by the Defence Analytical Services and Advice (DASA 2011). From the original study population (N=54,854), 4219 individuals were removed, as they did not meet the pre-set study cohort criteria of being regular army personnel with complete anthropometric information.

To enhance the security of the data an amount of data 'cleaning' was required; in the main this was because individuals had been entered onto the database were not regular army soldiers. For some, their reservist nature meant that they were excluded from the study. It was felt that these individuals did not reflect occupational restrictions and benefits as their regular army counterparts. Similarly over a thousand individuals were withdrawn due to the fact that they were still undertaking initial training and therefore, were not trained soldiers (were not undertaking the occupational tasks given to the trained element). Measurement error withdrew a further 233 individuals, and 70 were removed from the data set due to incomplete

BMI information. The system employed for anthropometric assessment, was mentioned in the limitations to this study in the published paper (Sanderson, Clemes and Biddle 2014). While body mass and height were measured by medical staff (nurse), the majority were measured by a unit Physical Training Instructor (PTI). Training was given to these individuals; however, some data input errors were detected and could suggest a lack of consistency across some of the training, nevertheless all inaccuracies were rectified.

The eventual observational cohort reflected 49.5% (*n*=50,635) of the British Army (*n*=102,202). Males accounted for 93% and 7% were female, which is representative of the current army population (Berman and Rutherford 2013). A major advantage of the data, were that the investigation could report prevalence in relation to BMI and BMI and waist circumference combined, and followed the National Institute of Clinical Excellence (NICE) guidelines for obesity related ill-health (NICE 2006). These guidelines attribute a level of risk to obesity-related ill-health (particularly type 2 diabetes and coronary heart disease) using a combination of BMI and waist circumference measurements (NICE 2006). These guidelines were broadly based on several investigations (Lean, Han and Morrison, 1995, Han, Lean and Seidell, 1996, Zhu et al 2002, 2004; Janssen, Katzmarzyk and Ross, 2004) that showed the benefit of adding waist circumference measurements to BMI to give a more informed representation of abdominal obesity and visceral fat and therefore 'health' risk. This 'health' risk is referred to in the text as 'level of risk'. Additionally the ability to report both BMI and WC combined has further utility in this specific 'athletic' population (Friedl 2004) due to the limitations of BMI (McLaughlin and Wittert 2009). However, it is understood that athletic training rarely increases BMI above 32 kg/m^2 (Han et al 2006), and at this point excess fat as opposed to lean tissue will be the explanatory factor (Stensel and Hardman 2009). Of note 5.6% (n=2850) of the study population in the secondary analysis displayed a BMI of ≥32 kg/m^2.

According to BMI the main results suggested 56.7% of the study population were overweight and of those individuals 12% were obese. Males were more overweight and obese than females, with 45.8% of males being overweight and 12.2% obese, compared to females who were 30% and 8.6% respectively. When waist circumference data were added to the BMI data, and the risk to obesity related ill-health was assessed, the results indicate that 24.5% of the study population were at increase risk, with females displaying higher levels of risk than males (30.4% and 24% respectively). Female study participants were shown to be nearly one and a half times more likely to be at an increase risk of obesity-related ill-health than male study participants. The data presented in Chapter 6 in respect of the HBQ offers further support for these findings, as BMI categorised 11% of the study participants as obese (male 11%, female 9%). The NICE risk categorisation (NICE, 2006) suggested that 24% of the study participants were at “some-risk” to obesity related ill-health (male 23%, female 32%). However, the large data set that supported the current study was more representative of the British Army, as the HBQ study participants were drawn from UK 3 Division. This Division is the deployable component of the UK based Army, and therefore has a higher level of occupational readiness. As enhanced levels of physical preparedness are linked to enhanced occupational readiness (Rona et al 2010), this could help explain the slight reduction in BMI and risk to obesity related ill-health observed in the male soldiers surveyed in the HBQ.

In regards to the risk of obesity related ill-heath, the results suggest that male soldiers are at reduced risk compared to female soldiers. Whilst these results are comparable with recent information pertaining to the UK Royal Navy (Shaw et al 2013), the Navy sample did not detect any gender difference (30% of male and female personnel deemed at ‘some risk’). In addition whilst the levels of risk were higher, a gender difference was not detected in the Health Survey for England (2010). In the current study the higher BMI and lower risk to obesity related ill-health observed in the male as opposed to the female study participants, may be linked to the occupational physical requirement. In a study of US Army light-wheel vehicle mechanics, Friedl (1997), suggested the strongest Army women tended to carry more weight and fat and have a larger average waist circumference than weaker women, thus increasing their risk for male type health consequences such as CVD.
Additionally men generally have greater lean body mass values, with associated higher metabolic rates linked to higher energy consumption (Tharion et al 2005). Conversely it could simply be that for the British Army, BMI is a better measure of lean tissue in male soldiers and fat tissue in female soldiers. Independent of BMI, several studies have linked abdominal obesity (measured by waist circumference), to

several chronic adverse health outcomes (Lean, Han and Morrison 1995, Han et al 2004, Janssen, Katzmarzyk and Ross 2004, Hall et al 2011). Irrespective of the BMI defined levels of overweight, it is of great concern that nearly one quarter of the British Army are at categorised as having an increased risk of obesity related ill health.

The need for higher occupational levels of PA (OPA) may have influenced the results in the employment category. The military are required to undertake a broad range of vocational employment to support operational and peacetime tasks. Indeed, Tharion et al (2005) has reported daily energy requirements for military tasks ranging from 2332 kcal for administration to 6678 kcal for operational training. It could be hypothesised that soldiers employed within the combat category are required to undertake more tasks that require high levels of physical fitness (than those employed within the remaining three categories). As highlighted above higher levels of physical performance are linked to higher fat free mass and higher BMI (Fitzgerald et al 1986, Harman and Frykman 1992). The study on the Thai Army supports this aspersion (Napradit et al 2005), as they concluded that those soldiers employed in combat groups were more likely to be overweight, but not obese. The authors suggested that the none-combat groups had higher levels of sedentary behaviour compared to their combat unit counterparts. Specifically the obesity levels reported in the report on the Royal Netherlands Army (Helmhout 2009) were the highest observed (15%) and reflected a group of older support staff. Moreover, the same study reported even higher levels of obesity (19%) in a group of 'command staff'. Whilst both of these groups were employed in a supporting role, as opposed to a combat role, they were also older. However, these results bring into question the suggested relative homogeneity of BMI in populations with high levels of physical activity (Rose 1991). As the technological advances have decreased PA in the civilian workplace (Craig et al 1999), similar advances have occurred in the military influencing many of the supportive tasks, in essence for some the physical component may have become secondary to the technological component (IOM 2004).

As suggested in Chapters 2, 3, 5 and 6, age represented a significant correlate of obesity and risk to obesity ill-health in the British Army. A similar observation was alluded to in reference to the Thai Army. Napradit et al (2005) concluded that for Thai soldiers representing 50 – 60 years age group exhibited the highest levels of overweight (35.6%), with obesity levels peaking within the 40 – 49 years age group (5.7%). While male soldiers from Belgium displayed the most profound difference in the level of obesity between the 20 – 29 and 30 – 39 year old groups with a 3+ fold increase (1.5% - 5.1% respectively) (Mullie et al 2008). For the British Army male soldiers ≥45 years old were observed to be seven times more likely to be at some-risk to obesity related ill-health (female four times) than those study participants in the 18-24 years old age group. Further investigation presented in Chapter 5 reduces this effect for male risk to four times more likely and repositions the female 35 to 44 age group as having the most risk of obesity related ill-health (two and a half-time more likely). In addition, both Shaw et al (2013) and (Wood 2007) in their respective investigations on the Royal Navy and UK Military reported similar findings on a UK Military population. The evidence suggest that age is a correlate of obesity and the risk of obesity related ill heath, prevention strategies should seek to address the reduction of OPA associated with the transition into sedentary roles that are allied to advancing age in the military.

The output of the published prevalence study (Sanderson, Clemes and Biddle 2014) concluded that enlisted soldiers were more likely to be obese than officers. This conclusion was supported in the final prediction study outlined in Chapter 5. Both studies had the benefit of stratification in respect of the officer cohort (a full description of this stratification is given in Chapter 3), indeed both studies suggested that male Late Entry (LE) Officers were one and a half times more likely to be obese that their Direct Entry (DE) counterparts. While it is true those LE Officers who commission from the ranks are generally older compared to their DE Officer counterparts, however, both logistic regression models controlled for age. Nevertheless, it should be acknowledged that in the final analysis presented in Chapter 5 that the variable ‘general rank’ whilst still significant, only accounted for R^2.00301of the variance. Suggesting that .03% of the eventual 22% was explained by rank. Nevertheless, these results suggest something other than age increases obesity risk in those officers commissioned from the ranks, at the very least it indicates that a career in the British Army does not protect against obesity.

Although not reported the systematic review further analysis was undertaken in respect of rank, and is presented below in table 7.1. The results suggest it may be too simplistic to say that enlisted ranks *per say* are a correlate of obesity, as some ranks are more susceptible than others. In their study on the UK Royal Navy Kilminster, Roiz de sa and Bridger (2008), concluded that obesity levels increased with seniority within both enlisted and officer cohorts, proposing that much of the affect was due to age (although this study did not control for age). In addition Da Costa et al (2011) observed higher levels of metabolic syndrome (MS) in sergeants compared to private soldiers. The results of the current study indicate that sergeants are at increased risk of obesity compared to private soldiers and more senior warrant officers. For the British Army this suggests that the relationship between the enlisted component and obesity is not explained by the seniority within this component. One could hypothesis that the private soldiers will have higher levels of OPA, and that only the best enlisted soldiers will achieve warrant officer status, however, this is without evidential support.

Table 7.1. Selected enlisted ranks: percentage of male total, percentage of male obese total and obese percentage of specific rank by odd ratios with 95% confidence intervals and significance level.

Rank Group	Male Total (%)	Obese Totals (%)	(%) of Rank Group Defined as Obese	Odds Ratio	95% Confidence Intervals (CI)		Sig
					Lower	Higher	
Private	18272 (39)	1220 (21)	(7)	1.00	na	na	P>0.001
Sergeant	4305 (9)	931 (22)	(22)	5.66	5.23	6.17	P>0.001
Warrant Officer	574 (1)	70 (1)	(12)	2.60	2.02	3.34	P>0.001

Thesis Objective 3: To understand the impact of weight status on occupational fitness.

The impact of low occupational fitness spans across military performance aspects of training, attrition and operational readiness (Fogelholm et al 2006, Knapik et al 2004, Haddock et al 2007). Furthermore, low aerobic fitness and muscular endurance are associated with a higher susceptibility to injury (Knapik et al 2007) and medical discharge from the armed services (Poston et al 2002). While acute health risks, such as obesity and type-2 diabetes, have the potential to degrade soldier physical performance (Friedl 2004). Obesity and to a lesser extent overweight have been observed to be predictors of low fitness in the US Air Force (Robbins et al 2001).

For the British Army the study presented in Chapter 4 aimed to clarify the relationship between weight status and fitness test outcome. The study utilised the secondary analysis of the DASA (2011) data set to investigate the outcome of two British Army physical tests. The physical tests are explained fully in Chapter 4; however, the Annual Fitness Test (AFT) represents the main occupational fitness test of the army. This load carriage test is required twice annually by all the active component of the British Army (18 years to 50 years). It requires the combat component to carry more weight (25 kg) and those in support to carry less weight (15 kg), but does not discriminate between male and female. The Personal Fitness Assessment (PFA) is a measure of aerobic capacity and muscle endurance, again this assessment has the same annual requirements, and however, all personnel are expected to attempt the test. The standards for the PFA are age and gender fair (achievement standards are adjusted for gender and age, to reflect well documented physiological differences that occur between genders and with increasing age (Knapik et al 2009, MoD 2002). Failure of either test is followed by remediation and could influence career and may result in administrative action (MATT 2012).

Due to the enhanced levels of personal fitness required to meet the demands of military training and the operational environment, occupational physical assessment is a requirement of most armed forces (Knapik et al 2009, NATO 2009). It can also be a useful tool to increase individual and collective fitness levels (Kyrolainen et al 2008). In this large cohort of British Army personnel, across all age groups, obesity and increased risk of obesity related-ill-health were linked to higher failure and lower attendance on the PFA and the AFT. Unfortunately, there are no other studies from the UK Military to gain any comparative insight. However, Shaw et al (2013) recently stated (based on self reported data) that older Navy personnel (35-44 years of age) were more likely to be inactive or moderately inactive compared to study participants in the younger age groups.

Greater context may be gained from a study on active duty US Military personnel stationed at a Naval Medical Centre (Gnatt et al 2008). In this study 3306 staff of which 10.5% (n=347) were obese and 42.5% (n=1,408) were overweight, 67% (n=2,204) attempted the US Navy's Physical Readiness Test (PRT). The results of the study indicated that those defined as obese failed the test more than any other BMI defined group. While the study did not offer any analysis on those who did not attempt the test (n=1,102), Gnatt et al (2008) concluded that BMI was the single most important factor in predicting PRT failure. Furthermore, this study suggested that 80% of the failing scores were attributable to overweight and obese personnel. In the current study the results would suggest a similar value of 76% (failures attributable to either overweight or obese personnel). The finer detail indicates that 3 and 4 in every 10 obese male and female soldiers respectively fail the test compared to 4 in every 100 BMI defined 'healthy' soldiers. Whilst the PFA cannot be viewed as an occupational assessment of physical readiness (MATT 2012), the results in respect of the impact of weight status have occupational and financial implications. In another assessment of military physical fitness based on Finish soldiers, Kyrolainen et al (2008) concluded that high BMI was associated with poor test outcomes for aerobic and muscle endurance events. The author also suggested that these 'high BMI' individuals demonstrated the longest bouts of sickness absence (Kyrolainen et al 2008).

In respect of age, Gnatt et al (2008) indicated the average age of those who failed the PFA was significantly lower than the average age in the other PRT score categories. The current study supported this conclusion, however, data suggest this is a direct reflection of the low attendance rates of this group, as only 41% male and 23% female soldiers categorised as obese and ≥ 30 years attempted the test (compared with 54% and 47% obese and <30 years, male and female respective study participants). Similar patterns are observed for the risk of obesity related ill-health, suggesting those categorised as increased risk fail more readily, and while the older soldiers return better pass rates, the younger soldiers are more likely to attempt the test regardless of risk category.

This is the first time data pertaining to those who do not attempt military physical tests has been presented. In the chapter document I allude to the issue, and suggest fear of failure or failure avoidance may motivate older de-conditioned soldiers to not attempt physical fitness tests (PFA and AFT). Studies on the US Military have suggested that, as individuals near retirement from the military, they admit to, and undertake more poor health habits (Parker at al 2001). However, this ‘fear of failure’ in older obese personnel could be due to a lack of physical preparation owing to physical impairment caused by injury (Ward et al 1997), or reduced physical capacity due to injury recovery (Anandacoomarasamy, Fransen and March 2009). This hypothesis is given some credence in the data presented in Chapter 6, as injury was positively correlated with age, obesity and the risk of obesity related ill-health. Parker et al (2001) also suggest that reaction to significant life events (like major injury), lack of time, priority and competence in gymnasium facilities may hamper exercise intentions, and could, therefore, influence attendance and ability to pass physical fitness tests. While the conclusions of Parker et al (2001) were supported by Sigrist, Anderson and Auld (2005), indeed these factors may be influential. However, it may be the motivation to exercise and more specifically the type of motivation to exercise that is the vital component to influence attendance, and enduring commitment to occupational readiness (Dystad 2007).

As the AFT is the occupational test of the British Army, failure to pass and attempt has more implications. While it is encouraging that the number of male soldiers who failed the test is relatively small, obese male soldiers fail more readily than non-obese soldiers; this relationship is underlined to a greater extent within the female population. However, and of more consequence, when the risk of obesity related ill-health is assessed, those categorised as having ‘extreme risk’ displayed the highest levels of test failure. Only 1% of males categorised as no risk failed the test compared to 3% defined as having some risk of obesity related ill-health. For the female study participants the level of failure is higher for both groups 7% and 17% respectively (no risk and some risk). The results suggest that female British Army soldier’s do not achieve the same level of success in the AFT compared to male British Army soldier’s, moreover, bodyweight and abdominal obesity have further detrimental effects on successful completion and attendance.

Whereas females cannot be employed in ground close-combat roles (Household Cavalry, Royal Armoured Corps and Infantry) (MoD 2010), vast arrays of military trades are still open to both men and women. Some of these trades have high strength and endurance performance requirements (QinetiQ 2011), certainly some female soldiers will be required to carry the same or similar weights to those male soldiers employed in ground close-combat roles. Studies have suggested that on average women have 25-60% lower muscle mass, strength, power and muscle endurance than the average man, and while these differences are more profound in the upper-body musculature, they all decline with age (Knapik et al 2009, NATO 2009).

Physical performance in the military is an occupational requirement (Rona et al 2010) and fat-free mass, which is highly associated with BMI, is also highly associated with maximal performance (Fitzgerald et al 1986, Harman and Frykman 1992). Specifically for load carriage, research has suggested that body composition rather than body weight is more closely associated with the metabolic demands of heavy load carriage tasks as undertaken by the military (Lyons, Allsop and Bilzon 2001). It could be hypothesised due to sexual dimorphism female soldiers differ in their reaction to strength specific stressors (Friedl 2004), in essence the body composition of male and female soldiers could be different even if the physiological stressors are the same (Knapik et al 2007). Given that body fat has been described as a 'dead-weight', impairing performance during load-carriage tasks (Haisman 1988) and the physiological considerations, it is not surprising that over fat females fail the AFT more readily.

For those soldiers categorised as obese or (more importantly) as having an increased risk of obesity related ill-health, the metabolic changes that can reduce muscle function, oxidative capacity and motor unit activity (Waring et al 2006, Newcomer et al 2001), may have diminished their performance capacity. For a reducing British Army it is vital that all soldiers attend and pass mandatory fitness tests. It is clear from the information presented that an increase risk of obesity related ill-health is linked to increases failure rate and decreases attendance. Furthermore, data presented in Chapter 5 suggests that when controlling for all other variables (most notably age and medical status) failure of the PFA and AFT are two of the main predictors of obesity and increased risk of obesity related ill-health in the British Army.

Thesis Objective 4: To clarify through a large sample the predictors of obesity in the British Army.

In reference to obesity, the UK Foresight report (Butland et al 2007) suggested that energy balance was determined by a complex multifaceted system, where no single influence was observed to dominate. Obesity prevention therefore, must understand and attempt to alter the relevant physical, social, and economic environments and policies that structure these environments (Kumanyika and Brownson 2007). The military environment and occupational requirements differ from the civilian norm (IOM 2004); hence an understanding of the social, behavioural and environmental factors that differ from the civilian population may help identify the significant predictors of obesity. This process should help identify the significant levers (Rutter 2011) to shape obesity prevention and obesity treatment intervention.

Building on the initial work presented in Chapter 3, which identified the socio-demographic correlates (age, rank, marital status and employment), Chapter 5 sought to investigate the remaining data available (physical test outcome, medical status, years in the Army and geographical location of unit) to ascertain the probable predictors of obesity in the British Army. This investigation used secondary analysis on the existing data set (DASA 2011) as described in Chapter 3. Most of the observations will cover the addition of the new variables, and any major changes to the predictive nature of the existing socio-demographic elements.

Data suggests that the main predictors of obesity and obesity related ill-health in the British Army are failure of mandatory fitness tests, being older (≥35 years), reduced medical capability and enlisted status. In addition, for male participants, years served (≥12), being married, employment category and geographical location unit were also indicative of increased risk of obesity related ill-health.

While the relationship between weight status and physical test outcome was considered as an individual investigation in Chapter 4, the impact of physical test outcome has not been discussed as a predictive element. It has been reported that high cardiorespiratory fitness (CRF) can attenuate much of the health risk attributed to abdominal obesity (Lee, Blair and Jackson 1998, Ross and Katzmarzyk 2003).

Nevertheless, as aerobic capacity considered in terms of body weight reduces with increasing fatness (Friedl 2004), there is good reason to assess both physical and occupational fitness (Kyrolainen et al 2008). However, physically fit obese men can have a lower risk of mortality than physically unfit lean men (Wei et al 1999). Many military specific tasks involve lifting and carrying that favour big (and perhaps over fat) individuals, however, these individuals may not present the ideal military image and more importantly may be at higher risk of NCD's (Friedl 2004).

It could be that the two primary outcomes of the physical tests identify associated PA levels. In that those who failed the physical test were less physically active than those who passed; as obesity is more common in physically inactive people than their physically active counterparts (Ross, Freeman and Jansen 2000, DiPietro 1999), this would not be an unreasonable hypothesis. Conversely, rather than lower physical activity levels influencing BMI, it could also be possible that obese individuals select / undertake less active jobs and leisure pursuits (King et al 2001).
The military has a broad range of jobs, many of which demand the worker to sit for long periods of time, with little opportunity for physical activity (Allman-Farinelli et al 2010). Thus the high OPA associated with the military may not be homogeneous across all trade groups. Studies have suggested that those workers who are highly active in their primary employment have a 42% reduced likelihood of being obese (King et al 2001); King et al (2001) also indicated that high levels of leisure-time PA (LTPA) were associated with highly active occupations. Supporting the notion that those who are already at a reduced risk of obesity related diseases (through their highly active occupation) gain additional risk reduction through their interaction with LTPA. For the military, those obese personnel who fail, or avoid mandatory tests may be primarily sedentary and lack any enduring commitment to mandatory physical training or volitional LTPA. While the AFT and PFA are measurements of occupational and physical performance, these occur at a single point in time. A measure of exercise commitment and motivation-type, over career will gain more precise information as to the risk of obesity related ill-health. As the health benefits of exercise only appear to be long-term if they are enduring (Paffenbarger 1986).

It could also be that obese personnel do engage in PA, but the frequency, intensity and volume of their exercise are not supportive of performance enhancement and therefore successful completion of the mandatory tests. Specifically high frequency, low intensity exercise motivated by interest or preserving health and fitness has been shown to increase performance and self reported quality of life (Wilson, Markey and Markey 2012). Lack of time, and low priority, have been alluded to earlier in this discussion as reasons for lack of PA involvement (Parker et al 2001, Sigrist, Anderson and Auld 2005). However, the results of the HBQ outlined in Chapter 6 imply that type of motivation towards exercise may be influential. The data suggests those autonomously motivated towards exercise are significantly less likely to be at risk of obesity related diseases. In the exercise domain, autonomous motivation has been linked to exercise bout duration (Wilson et al 2004), persistence (Ryan et al 1997) and frequency (Wilson et al 2004). The results of the HBQ also suggested that those motivated through external contingencies for exercise were more likely to be at risk of obesity related diseases. This result is of importance to the military, as the mandatory PT that supports the physical conditioning for the AFT and PFA is externally motivated (and therefore part of the controlling motivation spectrum). Studies have repeatedly demonstrated the negative association between the more controlling types of behavioural regulation and exercise bout duration (Duncan et al 2010), intensity (Wilson et al 2004) and prolonged persistence (Duncan et al 2010, Williams et al 1998).

While the results of the logistic regression support failure of the PFA and to a lesser extent the AFT as predictors of obesity related ill-health is clear, the reasons why obese personnel fail may be a more complex issue.

As poor occupational fitness has been linked with obesity (Knapik et al 2007, Taanila et al 2011), and poor fitness has been cited as a strong predictor of injury (Ross et al 1994, Cowan et al 2011) and since obesity is linked to injury and musculoskeletal disorders in military and civilian populations (Murphy, Connolly and Beynnon 2011, Anandacoomarasamy et al 2009). It may not be surprising that medical deployment category was identified as a significant predictor of obesity and obesity related ill-health.

While data were not available as to the actual conditions relating to the specific medical grading, the British Army utilizes a system to assess the medical needs of the individuals set against the often austere military operational environment. This grading categorises soldiers as medically fit deployable (MFD), medically limited deployable (MLD) or medically non deployable (MND). From the medical grading, one could hypothesis that those in the MFD are free of medical complications and those in the MND have the most medical complications.

For medical category the results suggest those MLD participants were significantly more likely to be at some-risk (as opposed to no-risk) of obesity related ill health. Of note the soldiers in the MLD category were twice as likely, than personnel in the MFD category to be at some-risk of obesity related ill-health. In a study on the UK Royal Navy, Kilminster, Roiz de sa and Bridger (2008) have also concluded that obesity was significantly associated with medical category. Obesity as measured by BMI, has been associated with overuse syndromes, osteoarthritis and various other musculoskeletal disorders (Niebuhr et al 2008). While a systematic review into the effect of weight reduction in obese patients suggested that, obesity was central to any discussions concerning bone and joint health (Christensen et al 2007). In addition, the analysis suggested that those male soldiers defined as MND were also more likely to be at increased risk of obesity related ill-health compared to the MFD cohort, but less likely than the MLD cohort. This relationship was not expected, as the MND personnel are those with the most medical restrictions. One possible explanation is that the MND personnel may have more chronic conditions. Within the British Army, the Defence Medical Rehabilitation Programme places individuals with chronic conditions onto MSK rehabilitation courses, with an associated educational component (DMRP 2010). It is possible that some individuals regulate their calorific intake in reaction to the nutritional information they receive on these residential courses.

Some civilian studies have suggested that obesity increases the risk of occupational injuries by some 25% (Lin, Verma and Courtney 2013). Sharp et al (1994) found that injury rates were directly correlated to percentage of body fat. While Cowan et al (2011) observed that overuse injuries were 47% more likely to occur in those individuals classified as 'over fat' compared to those within 'acceptable' ranges. Due to the significant predictive ability allied to medical status in respect of obesity related ill-health, there are real capability issues for the military as 14% of male and 20% of the female study population were categorised as MLD. Injury prevention through an enduring commitment to physical conditioning may reduce the incidence of MSK injury, however, education may need to be offered to all those who suffer from injury as to the nutritional adjustments and requirements of injury rehabilitation.

Independent of age, the years served in the Army was a predictor of obesity related ill-health in male soldiers. Specifically those male soldiers who had served 13-24 years and 25-36 years were nearly one and half times more likely to be at increased risk (of obesity related ill-heath) than those who had served <13 years. The relationship between years served in the military and obesity has not been the focus of any (known) investigations. It is recognised, as soldiers progress in their careers into more administrative and managerial roles that OPA is likely to decline (IOM 2004), even if they maintain voluntary fitness habits (Friedl 2004). There is some support for these statements in the HBQ results in Chapter 6, as the correlations suggest that years in the British Army are positively correlated with LTPA, but negatively correlated with group physical training. Moreover, this study also found that years in the army was positively correlated with BMI, risk of obesity related ill-health and injury. Therefore, it could be hypothesised that soldiers, who have spent more than 12 years in the British Army, may undertake volitional PA; however, this may not be at the correct frequency and intensity to ameliorate their transition into sedentary roles. The lack of total PA may influence their ability to withstand injury and body fat accumulation.

Thesis Objective 5: To gain a broader understanding of the health behaviours and physical characteristics and specific motivations linked to BMI and the risk of obesity related ill-health.

People’s health and well being are profoundly affected by lifestyle factors such as alcohol consumption, diet, physical activity, sedentary behaviour, all of which involve behaviours that are potentially controllable by the individual (Ryan et al 2008). Obesity has been termed complex, as opposed to complicated due to multifaceted systems that are not linear, indeed some have suggested that it is better to view the concept of obesity as a family of obesities (Butland et al 2007). However, central to this understanding is an appreciation of how some health behaviours interrelate and which behaviours predominate. For the military this is vital, as personnel who undertake poor health behaviours compromise their own health and reduce the operational effectiveness of their unit (Bray et al 2006).

The data presented in Chapter 6, reflects a questionnaire-based study that aimed to gain a broader understanding of multiple health behaviours in relation to weight status. This study utilised self-report data from (n=1124) British Army personnel (91% male and 9% female). These personnel were recruited from 31 units across the UK and were part of the UK 3rd Division. For context the UK 3rd Division is the deployable component of the British Army's UK based forces. Due to this fact the physical fitness (readiness) would be generally higher than those soldiers in the non-deployable units. This fact is highlighted by the levels of obesity observed in this 'higher readiness' population (11%), compared to the 12% observed in the population that involved 'all readiness states', outlined in Chapter 3.

Thus far, the majority of evidence amassed in this thesis, is based on objectively measured data (specifically Chapters 3, 4 and 5) and is reflective of one extensive data set used for secondary analysis. It was therefore, seen as strength to add additional data, from a different study population. Furthermore, understanding the restrictions of time and the large geographical footprint of the study, self-report was viewed as the most efficacious method of data collection. Self-report weight and height and PA data has been widely used in epidemiological studies, whilst some have shown considerable reporting bias (Taylor et al 2006, Yun et al 2006, Rzewnicki, Auweele and Bourdeaudhuij 2003), many have suggested satisfactory agreement between self-report and objective data (Avila-Funes, Gutierrez-Robledo and Ponce De Leon Rosales 2004, Kuczmarski, Kuczmarski and Najjar 2001, Craig et al 2003). The validity and reliability of self-report have, 'in-part' being blamed on the cognitive complexity of recall in respect to unfamiliar / vague terms and estimations of time in relation to health behaviours (Slattery and Jacobs 1995, Blair et al 1991, Baranowski 1988, Schuna, Johnson and Tudor-Locke 2013).

In regards to PA, self-report questionnaires are useful in gaining an insight into the PA of large populations, however, they have the capacity to over or underestimate energy expenditure and rates of inactivity (Prince et al 2008). It is acknowledged that a reliance on self-report could lead to misclassification of PA levels, weight and height (Shephard 2003, Larsen et al 2007). In turn this misclassification could induce bias that could lead to type 1 error (Hardman & Stensel 2009).

Larsen et al (2007) suggested that within industrialised societies the stigma attached to being overweight might influence overweight individuals to under report their weight and overestimate their height. This conclusion is broadly supported in adult (Taylor et al 2006), and late adolescents (Brener et al 2003) populations. With heavier individuals (McCabe et al 2001), restrained eaters (Shapiro & Anderson 2003) and women (Jacobson & DeBock 2001) having a greater tendency to under report weight. Although self-report measures tend to underestimate the prevalence of overweight and obesity, numerous epidemiologic studies have demonstrated that self-reported BMI and waist circumference are robust and strong predictors of biomarkers of adiposity, incidence of chronic disease and premature mortality. Nevertheless, there is a distinct possibility that the HBQ surveyed population could have underestimated their PA and weight, and overestimated their height. However, the ability to employ a pilot study allowed me to assure the specific population understood the terminology used. Furthermore , previously validated questionnaires were employed in the main elements of the questionnaire (IPAQ, TSRQ, DEBQ-Restrained eating). In addition soldiers are required to have their height and weight measured on a regular basis therefore they would have recent knowledge of the objectively measured results. Moreover, the similar results obtained through objective measurement in Chapters 3 and 5 give credibility to self-reported height, waist and weight findings reported in Chapter 6.

The HBQ represented an extensive investigation into health behaviours that may influence obesity and more importantly an increased risk of obesity related ill-health. Whilst the classification of singular health behaviours are of use, it was decided that the inter-relationships of health behaviours and the identification of the predominant factors represented the most beneficial investigatory pathway. This discussion element will focus on this specific outcome and the implications of the HBQ results for the previous chapters. Moreover, within this study, an investigation of data relation to BMI and NICE defined risk category of obesity related ill-health highlighted certain disparities between the two indices (Table 6.18). This information suggests that 12% of male and 23% of female study participants would be classified differently and possibly incorrectly. Corroborating evidence was presented by Shaw et al (2013) who observed that 11% of male and 24% of female navy personnel were misclassified. I have made many comments on the restrictions of BMI within this specific population and I am not alone in these concerns (Heinrich et al 2008, Shaw et al 2013, Friedl 2004, McLaughlin and Wittert 2009). While BMI is commonly used in population studies, numerous investigations have questioned its validity in athletic and military populations (Prentice & Jebb 2001, Poston & Foreyt 2002)

In essence many soldiers could be identified as overweight and even obese without having an unhealthy excess of body fat, which could increase the risk of medical illness and premature mortality (Villareal et al 2005). Indeed, misclassification of some individuals could be due to excess lean mass (Janssen et al 2004), which is ideal for many occupational and operational military tasks (Friedl 2004). Misclassification could penalise those very soldiers who are most active and specific in their conditioning regimens, more worryingly it could support disordered eating habits that impair rather than promote physical and medical health (Friedl 2002). Additionally, reliance on BMI may not assess individuals with excess fat, but not excess weight as obese (Heinrich et al 2008). Studies have also demonstrated that the rate of false negatives increases with age, as older individuals tend to have higher body fat than younger individuals with the same BMI (Gallagher et al 1996, Movsesyan et al 2003). BMI may also underestimate body fat levels in those who are suffering from infirmity or disease and overestimate certain ethnic groups with relative high levels of muscularity, such as Pacific Islanders (Kumanyika & Brownson 2007). There is also consistent evidence that the percent body fat is higher in Asians than whites with the same BMI (Deurenberg & Deurenberg-Yap 1998).

Whereas waist circumference can adequately measure abdominal adiposity and some visceral fat, subcutaneous fat and internal visceral fat cannot be accessed via waist circumference measurement (Kumanyika & Brownson 2007). However, waist circumference can provide an independent prediction of obesity related co-morbidity risk beyond that obtained by BMI alone (Hope et al 2005). The current combination of both indices may represent the most pragmatic solution as other methods such as bioelectrical impedance (BIA), ultrasound, computerised tomography (CT), hydrodensitometry and dual emission x-ray absorptiometry (DEXA) increase the complexity, cost, risk and expense of body fat measurement (Roche, Heymsfield & Lohman 1996) and would not be practicable across the military population. However, as mentioned earlier in the limitations of Chapters 2-5 and in the study by Shaw et al (2013) there are certain practical implications in respect of measurement quality that may require further training to ensure that misclassification is not due to initial measurement error.

Due to the measurement processes involves and reported within this thesis, there remains a possibility that some individuals may have been misclassified due to the measurement process selected, or the skills of those taking the measurements. However, the ability to interrogate objective and subjective data across two different contextualised study populations should help reduce the risk of measurement error. Therefore, any conclusions drawn from this thesis should be made understanding the possibility of measurement and classification error. Furthermore, should individuals be deemed obese or at increased risk of obesity related ill-health, this categorisation should be qualified by a suitable measure of body fat before any intervention or administrative action is undertaken.

While Chapter 6 reflects the full results, this discursive element will only cover the results in respect to the increased risk to obesity related ill-health (BMI and waist circumference combined).

The final logistic regression produced a significant predictive model that accounted for 21% of the variance. This analysis suggested that for this specific study population, restrained eating, LTPA engagement, food preparation in the working week, injury status, age, sedentary behaviour and type of motivation for exercise were the most influential factors of increased risk to obesity related ill-health. Within this model each variable was controlled for each other, however LTPA engagement and restrictive eating were the dominating factors.

For LTPA engagement a linear relationship was observed. As those who had engaged with LTPA beyond six months were least likely to be at some risk of obesity related ill-health and those who did not engage and did not intend to undertake LPTA

were most likely to be at some risk of obesity related ill health (odds ratio suggested these individuals were seven times more likely to be at some risk). Studies have suggested that individuals who do not participate in LTPA have a higher unadjusted BMI (Allman-Fairnelli et al 2010). For those individuals undertaking high levels of occupational PA and mandatory PT, the lack of LTPA may not be of significant importance, as OPA alone can confer some protection to many NCD's including obesity (Probert, Tremblay and Connor-Gorber 2008). Nevertheless, the greatest health benefits are observed with a combination of OPA and LTPA (Hu et al 2004).
For the final analysis, only LTPA engagement was included, as LTPA total MET was not retained as a significant predictor. Much of the engagement question refers to exercise intentions and sustained involvement in LTPA, one could hypothesis that (for this study population) the commitment to LTPA is actually more important than the accumulated metabolic equivalent outcome. Wilson, Markey and Markey (2012) suggested that some individuals may engage in exercise due to obligation, and that these individuals may not reap the same health benefits as those who undertake exercise for purely volitional reasons. In this study into obligatory versus intrinsic motivation, Wilson, Markey and Markey (2012) indicated that some military personnel may just "go through the motions" when exercising. Proposing the frequency of exercise may be correct, however, the intensity may be insufficient to support health and prevent body fat accumulation (Hausenblas and Fallon 2006, Stroth et al 2009). This could offer some insight to why older soldiers (and soldiers in an extended career) who meet PA guidelines and have a positive relationship with LTPA, are still more likely to be at risk of obesity related ill-health.

Type of motivation to support exercise emerged as a significant predictor of risk to obesity related ill health. Specifically those who were controlled in their motivation towards exercise were more likely to be at increase risk and those autonomous in their motivation towards exercise were significantly less likely to be at risk. Whilst these results were consistent with previous research (Wynd and Ryan-Wenger 2004, Williams, Freedman and Deci 1998), they may be of more concern in a setting where fitness training is mandatory or externally imposed (Wilson, Markey and Markey 2012). For many soldiers, undertaking exercise will be a purely externally motivated process and is open to lack of intention to perform, reduced intensity, relapse and in all probability exercise cessation (Ryan and Deci 2000). While controlling motivations can thrive in structured environments (such as the military) (Deci and Ryan 2002), once the external contingency is removed the behavioural change is liable to relapse (Thorgersen-Ntoumani and Ntoumanis 2006). This point has real context for the military, as significant amounts of time is spent away from unit bases, thus removing many of the external mechanisms in-place. It also poses a concern for UK public health, as once these individuals exit from the military it may increase the public health burden. Alternatively, autonomous exercise intentions are linked to exercise across lifespan (Brunet and Sabiston 2010). It could be that if soldiers experience intrinsic and autonomous motivation towards exercise early in their career that both mandatory PT sessions will be more appealing and volitional PA sessions will be more enjoyable and beneficial towards health. Certainly one study on the exercise training volumes of soldiers on a peacekeeping mission, concluded that those with high internal motivation had higher training volumes than those who were externally motivated (Dyrstad 2007). Moreover, the author indicated that some externally motivated soldiers abandoned exercise entirely.

A reduction in occupational fitness, through insufficient conditioning may lead to injury (Kyrolainen et al 2008). Within the current study 23% of all study participants indicated that they were currently injured, moreover, 41% of personnel categorised as having some risk of obesity related ill-heath were injured (as opposed to 17% of those categorised as being at no risk). Final analysis of the HBQ indicates that injury is a significant predictor of obesity related ill-health. Injury shares many similar correlation relationships as increased risk of obesity related ill-health (age, years in the army, reduced physical training, reduced total LTPA METS, low LTPA engagement and high levels of restrictive eating). The US DoD view MSK injuries as one of the most significant health problems currently facing their armed services, specifically when MSK conditions result in permanent disability (Bell et al 2008). For the UK military and in direct relation to obesity, a study on Royal Navy personnel suggested that medical capability was a significant predictor of obesity (Kilminster, Roiz De Sa and Bridger 2008).

A review of general characteristics of the study participants listed at Table 6.4 is suggestive of a population with high levels of smoking and alcohol consumption, with low fruit and vegetable intake. In addition over 40% of the study population consumed high-fat foods on most or every day. Whilst attenuated by high levels of total PA, the general picture is one of generally poor health behaviours. The combined detrimental effect of poor health behaviours on 'all cause mortality' is substantial (Khaw et al 2008, Kvaavik et al 2010). However, the point of real concern may be the amount of occupational injury and the correlations between injury and reduced PT and LTPA; as should injury occur, the risk reduction offered by total PA would be reduced, if not totally removed. This hypothetical situation has further complexities, given the correlations between low PA and high level of sedentary behaviour.

In previous conclusions I have hypothesised that sedentary behaviour could be an influential factor in the prediction of obesity related ill-heath. The final analysis supports this assertion, as those soldiers sitting for more than 9.5 hours on a daily basis were significantly more likely to be at risk of obesity related ill-health. Moreover, a positive correlation with reduced total PA (physical training plus leisure-time physical activity), suggests that these individuals do not seek to ameliorate their high sedentary behaviour with appropriate levels of PA. Beyond the decline of individual and collective fitness, these results have broad health implication, as sedentary behaviour is independently associated with a number of adverse health outcomes including mortality (Dunstan et al 2005, Ford et al 2005). It is noted that sedentary behaviour was correlated with both LTPA MET and LTPA interaction, however, as suggested in Chapter 6 this may not be at the sufficient frequency and intensity to maintain health and body composition. Some research into sedentary behaviour has suggested in very basic terms that 'too much sitting' is a distinct health hazard (Hamilton et al 2008). While some research has indicated that breaks in sedentary time (activities as light as standing from sitting) have shown to be beneficial to the metabolic biomarkers that support obesity (fasting plasma glucose, triglycerides and high density lipoprotein) (Healy et al 2008). This is an environmental intervention that should be employed for individuals who are occupationally directed or personally driven towards protracted periods of sitting. However, the independent nature of sedentary behaviour, as a risk factor of metabolic syndrome and abdominal obesity (Healy et al 2008), indicates there are real physiological consequences of being highly sedentary (Bey and Hamiliton 2003). Of further concern, is the proposition that these physiological changes are amplified by age (Hamilton et al 2001), and has occupational resonance for the British Army, where age generally signals a move to sedentary duties and a reduction of OPA. The relationship between sedentary behaviour, decreased occupational fitness, and increased health risk is an area deserving of further investigation and proactive intervention.

The oscillation between un-successful dieting (disinhibited eating) and over eating (binge eating) has been termed with restrictive eating (Heatherton et al 1988, Herman, Polivy and Leone 2005). Due to the association between restrictive eating and obesity (Robbins and Fray 1980), a measure of restrictive eating was included into the HBQ. A correlation was observed between high levels of restrictive eating and risk of obesity related ill-health. This could suggest those soldiers who frequently vary between over-eating and dieting are more likely to be at increased risk of obesity related ill-health. It was also observed that as the level of restriction increased, the odds of being at some risk (as opposed to no risk) increased. Research into eating behaviour indicates that attitudes and environment play a large role in determining whether people eat, what people eat and how much people eat (Meiselman et al 1999). In particular, the environment contributes to social, economic and physical factors (Meiselman 1996, Bell and Meiselman 1995, Rozin and Tuorila 1993). When the structure of an individual’s immediate environment is altered due to factors like military service, or in reaction to significant life events (i.e. long-term injury), the environment may contrive to change eating habits, and therefore, attitudes to food may change (Meiselman et al 1999). Consequentially, a positive relationship between dietary restraint and a higher level of risk of obesity related ill-health could be normal reaction of a healthy individual adjusting his or her energy intake to the broad calorific requirements of military specific environments. Indeed, Tharion et al (2005), has reported daily energy requirements for military tasks ranging from 2332 kcal for administration to 6678 kcal for operational training. Conversely, and in keeping with the general consensus (Herman and Mack 1975, Rotenberg and Flood 2000), the results of the current study may suggest frequent oscillations between restrained and un-restrained eating, are the actions of over fat individuals reacting to internal and external stimuli. In a study involving 3030 employees from a large banking corporation, higher BMI scores and less time undertaking PA and sports were linked to higher levels of dietary restraint and absenteeism (van Strien and Koenders 2010). It is therefore, of note that in the current study high levels of restrictive eating were also correlated with age, years served and injury. Although in their study, van Strien and Koenders (2010) did not disclose a reason for the absenteeism, MSK injury and the loss of productivity through absenteeism, is a recognised relationship (Anandacoomarasamy et al 2008), and has health and financial implications for the armed services (McLaughlin and Wittert 2009, Kyrolainen et al 2008). It has been proposed that an inability to regulate energy intake to match the reduction in PA may be a dominating factor in the promotion of obesity (Moore 2000). Nevertheless, it could be hypothesised that older individuals occupying more sedentary roles, (due to their extended career) may not seek to regulate their energy intake in reaction to reduced OPA, or injury. This scenario supports a possible outcome of positive energy balance, due to failure to adjust energy intake (Murgatroyd et al 1999, Stubbs et al 2004).

Although data for marital status was available, subsequent analysis did not detect a significant relationship, however, the location of food preparation and consumption was observed to be a significant factor in the final analysis. Odds ratio suggested that compared to eating in the centralised eating facilities offered by the individual units, those who frequently used fast food outlets were nearly 5 times more likely to be at increased risk of obesity related ill-health.

More than 15 years ago, the World Health Organisation (WHO 1997) suggested the worldwide increase in food prepared outside the home (FPOH) was a major factor in the rise of obesity. Studies have indicated that lack of cooking skills have resulted in a dependency on fast food outlets and restaurants (Haines et al 1992). Moreover and based on a large US National survey, data has found a significant relationship between fast food consumption and body mass index (BMI) in men and women (Binkley, Eales and Jekanowski 2000). More recently, and in a UK Military population, Shaw et al (2013) reported that eating in a food outlet was significantly associated with obesity risk within the UK Royal Navy. While other military studies have suggested that individuals may, through perceived lack of time, cooking skills or enjoyment rely upon fast food or prepared food (Sigrist, Anderson and Auld 2005, Hyland 2006).

The current study also suggested that soldiers who personally prepared their own food were more likely to be at some risk (as opposed to no risk) than those who ate in the centralised eating facilities. Many factors are known to influence dietary behaviour at the household level, including disposable income, gender; the knowledge and skills of those purchasing, preparing, storing and serving food; influences such as advertising; and practical constraints such as the availability and adequacy of facilities for preparation, cooking and storage (Anderson and Hunt 1992, White and Raybould 1997, Pollard, Steptoe and Wardle 1998, Brug, Lechner and de Vries 1995). Diet quality is an important issue for the military, as correct nutrition prevents illness, improves health (WHO 2003), and optimizes emotional, cognitive, and physical capabilities (Arija et al 2006, Rodriguez et al 2009). However, a review into US Military physical readiness, Jonas et al (2010) suggested soldiers might come to rely upon the comfort foods that are freely available when on operational duty, and undertaking high levels of OPA. Yet they may seek to continue these habits on return to peacetime activities that have a reduced OPA component (Jonas et al 2010). Worryingly research into the UK Navy indicates that health is not an important factor in determining food choice in military personnel (Shaw et al 2013). Moreover, it was observed that navy personnel with a very high waist circumference consumed more unhealthy foods (than those with a waist circumference within the healthy range) and stated convenience as a main factor influencing food choice. While some attempts have been made by the UK Military to increase nutritional knowledge though educational lectures and guides (Casey and Wood 2006, Messer, Owen and Casey 2002), these have lacked any measure of efficacy (Fallowfield et al 2010).

From an environmental standpoint, the military may be ideally situated to influence nutritional habits, as an amount of control can be exerted over the immediate working setting. Nevertheless, it would appear that the opinions of peer group may be more influential in an institutional environment where many food choices are externally directed and autonomy is diminished (Bingham et al 2012).

Whilst not the primary aim of the HBQ, 11% of the study population were defined as obese, of more importance high levels of risk to obesity related ill-health were observed for male (23%) and female (32%) study participants. In this specific study population, restrained eating, food preparation in the working week, injury status, age, sedentary behaviour, LTPA engagement and type of motivation for exercise were the most influential predictors of the risk to obesity related ill-health.

These findings have broad and complex implications for the military due to the potential detrimental effects on health, retention, and individual and collective capability.

<u>General Conclusions and Research Priorities</u>

This thesis has highlighted a lack of available information as to the probable correlates of and treatment of obesity in military personnel. Where papers are available most suffer from lack of quality, follow-up and generalisability. However, if treatment interventions are to be employed, they should be follow a multi-component approach that is theoretically driven, supported by suitably trained professionals. Treatment interventions should employ ecological models that are specifically multilevel in their approach, reflecting the intrapersonal, interpersonal and behavioural components, whilst remaining cognisant of the physical environment and policy requirements. Prevention should be processed as part of institutional policy. However, if treatment and prevention strategies are to be successful they will require support at the various levels of local and corporate leadership.

For the British Army the main socio-demographic correlates of obesity are age, marital status, rank and employment. Further analysis suggested that physical test outcome and medical status were also significantly influential. The ability to pass and attend British Army physical tests is negatively affected by BMI and a large waist circumference, and while older personnel fail less they also attempt less. The results of the HBQ suggest reduced LTPA engagement and high levels of restrictive eating to be significant predictors of increased risk of obesity related ill-heath. In this final analysis age, injury status, sedentary behaviour, location of food preparation and type of motivation were also significant in their predictive ability.

For an occupation whose criterion for selection is based on medical fitness and physical potential, obesity is primarily a reversible illness resulting from personal choice. Based on the findings of the thesis, I offer the following recommendations and research priorities.

Recommendations

- The dearth of information and involvement in most areas suggests ambivalence in regards to the issue of obese soldiers, commanders at all levels should be aware of the complex interrelating health, economic and occupational issues regarding obesity.
- The British Army should not use BMI in isolation to define body composition.
- The British Army should use environmental strategies to aid obesity prevention, and these strategies should permeate through all locations where British Army soldiers are located.
- The British Army should develop an obesity treatment intervention utilising a multi-disciplinary approach within an ecological theoretical framework, using resistance training as part of the PA construct.
- Due to the physiological, motivational and occupational issues regarding age and extended military careers. Therefore the British Army require specific conditioning regimes that enhance total PA output, reduce the impact of sedentary behaviour, and offer an amount of injury and health protection.
- The British Army should place more emphasis on mandatory test specific conditioning and attendance. Specifically, it should be a function of leadership to ensure personal and occupational fitness, through personal example and consistency of message. It should be a function of doctrine to ensure that occupational physical fitness is a requirement of employment.
- In the event of MSK injury that enforces cessation or reduced OPA and PA, British Army personnel should be made aware of the nutritional adjustments required for rehabilitation and to combat positive energy accumulation.
- Due to the relationship between medical deployment category and weight status, all British Army MLD and MND personnel should be monitored in regards to body composition.
- To facilitate a move away from purely externally motivated PT, the British Army should seek to enhance soldier ownership for health, personal and occupational fitness at point of entry and throughout career. If young soldiers

experience competence and autonomy towards PA and PT early in their career, occupational fitness may be retained throughout career, and is supportive of risk reduction to many NCD's (including obesity).

- Nutritional knowledge and cooking skills should be offered to all serving British Army personnel and their spouses. These interventions should highlight nutritional need in respect of calorific requirement for regular, training and operational tasks. In addition interventions should underpin the economic and health implications of high-calorie, convenience and fast foods.

<u>Research Priorities</u>

As with any pioneering work this thesis has identified several areas of potential research.

- Development and evaluation of an obesity treatment intervention utilising a multi-disciplinary approach within an ecological theoretical framework, incorporating resistance training as part of the PA construct.
- Examine the occupational utility of BMI and waist circumference in comparison to an objective measure of body fat (e.g. DEXA).
- Investigate current BMI cut-off points employed to define overweight, within the context of personal and occupational health and fitness.
- Examine the impact of dietary habits and PA on body composition, and the behavioural attributes that inform these decisions.
- Examine the impact of injury on body composition. This should be a prospective study of all individuals entering the British Army.
- Evaluate economic impact of obesity in the British Army in relation to medical and non-medical costs (loss of productivity through absenteeism).
- Evaluate the impact of the specific military environment on body composition, this investigation should seek to assess the physical, socio-cultural and economic environmental factors that may facilitate / deter obesity.
- Examine the motivational components and type of motivation that support or deter mandatory and volitional PA.
- Examine the metabolic needs of load carriage in relation to gender and body composition.

- Due to the hypothesised link between sedentary behaviour, years in the army and total PA. An investigation should attempt to clarify the impact of sedentary behaviour in relation to total PA and body composition in the British Army.
- Examine the relationship between soldiers who have spent more than 12 years in the British Army and LTPA uptake (engagement, frequency and intensity).
- Investigate soldiers eating behaviours, specifically, if the amount of oscillation between over-eating and dieting is due to environmental constraints or individual choice.
- Investigate the influence of location of food consumption on body composition.
- A prospective cohort study should seek to discern the impact to body composition, fitness and injury in relation to the extended BMI tolerance for recruits (32 kg/m^2).

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Appendix 1 Data Extraction Form

This form was used to extract the relevant information for the systematic review process. The system employed followed the guidelines articulated in the National Institute of Clinical Excellence (NICE) (NICE 2009) and the National Health Service (NHS) Centre for Reviews and Dissemination (CRD) guidance (NHS 2001). In addition the study selection in/out form is also attached.

THE ARMY OBESITY STUDY - DATA EXTRACTION FORM

Version Draft 1 19,06,2009

	FREE TEXT FIELDS	KEY FIELDS	NOTES
Abbreviations	*CT: can't tell; NA: not applicable; NR: not reported*		
1. BASIC DATA			
Full citation from RefMan			
Reference Manager record number			RefMan number
First author			Surname
Year of publication			Year
Short name of Intervention			Short name
Country of Origin			
First reviewer			Initials
Date of first review			Date
Checked by second reviewer			Initials
Date of second review			Date
SUBJECT OF THE STUDY / DOCUMENT			
	Causes / Determinants		
	Prevention		
	Treatment		
	Combination		
DOCUMENT SOURCE			
	Civilian Journal		
	Civilian Journal with Military Author		
	Military Journal with Civilian Author		
	Military Journal with Military Author		
	Military Document		
	Other		
DATA COLLECTION METHOD			
	Self Report		
	Researcher Report / Measure		
	Direct Observation		

GENDER DATA			
	Mixed		
	Male		
	Female		
RANK RANGE			
	Soldiers Only		
	Officers Only		
	Soldiers and Officers		
	Not Specified		

2. STUDY METHODS

Objective of the **study**	To discuss and evaluate a weight-loss programme for active duty military personnel		
Study Type	Systematic review (including at least one RCT)		Mark (Y) one only
	Systematic review of experimental studies		
Complete section 3 below	Systematic review of observational studies		
	Randomised controlled trial: Individual		
	Randomised controlled trial: Cluster		
	Controlled non-randomised trial		
Complete section 4 AND 5 below	Controlled before-and-after		
	Interrupted time series		
	Before and after study		
	Intervention with post-only data		
	Non-analytic study		
Complete section 6 AND 7 below	Audit/Evaluation		
	Case study		
	Local practice report		
	Qualitative study		
	Other (please state)		

3. IF THE STUDY IS A REVIEW…

Describe the search method	
Databases/sources searched	
Years searched	
Search terms	
Study inclusion criteria	
Study exclusion criteria	
Number of studies included	
What data were extracted?	
Was there heterogeneity across studies?	
Describe the method of analysis (meta-analysis/narrative synthesis etc):	

Summarise main findings, including study conclusions	
Will this review provide useful context for the NICE report?	
Will this review provide primary studies that should be followed up for review?	
Other comments	

4. IF THE STUDY IS AN INTERVENTION…

Purpose or objective of the **intervention**			
Target population			
Setting (Unit etc)			
Geographical location			
Age of participants (at baseline)			
Duration of intervention			
Length of follow up			
Content and mode of delivery			Broad category eg Unit based, Hospital

Additional information if reported

Theoretical basis	
Implementation and integrity (training, exposure,	

adherence etc)		
Year study commenced		
For randomised studies only		
Method of randomisation		
Allocation concealment		
Intervention group or population		
Definition		
Number of participants (at outset)		
How participants were selected		
Response rate or consent rate to participate		%, NR or NA
Are the individuals selected to participate in the study likely to be representative of the target population?		Very, Somewhat or Not
Control group or population		
Definition		
Number of participants (at outset)		
How participants were selected		
Response rate or consent rate to participate		
Exposure		
Is it likely that subjects received an unintended intervention (co-intervention or contamination) that may influence the results?		Y, N or CT
Analysis		
Unit of allocation		
Unit of analysis		
If different, was this taken into account in analysis?		
Was the analysis performed by intervention allocation status (intention-to-treat) rather than the actual intervention received?		
Was there a sample size or power calculation?		
Method(s) of analysis		
Were the statistical methods appropriate?		
Were tests of statistical significance reported?		
Prior to the intervention, were there between-group differences for important confounders reported in the paper?		Y, N or CT
If there were differences between groups for important confounders, were they adequately managed in the analysis?		Y, N or NA
Were there important confounders not reported in the paper?		Y or N

Other comments on the study methods			
5. INTERVENTION STUDY OUTCOMES			
Data sources used (e.g., participants, Physical Training Tests etc)			
Frequency and timing of data collection			
Duration of follow-up (from end of intervention)			
Percentage of participants completing the study			%, NR or NA
Number of participants in final analysis			
Primary outcome for this review			
Main physical activity / Weight measure(s)			
Type(s) of outcome measure	Self-reported		Mark (Y) all that apply
	"Objective" (pedometer, motion sensor etc)		
	Behavioural Change		
	Relapse		
	Other (describe below)		
Period over which physical activity assessed			days
Named data collection tool or device (if used)			Y or N
Were data collection tools shown or are they known to be valid?			Y, N or CT
Were data collection tools shown or are they known to be reliable?			Y, N or CT
Observed effect size			
Was there a statistically significant difference between groups?			
Was outcome assessment adjusted for baseline **PA / Weight / health related Knowledge**?			Y, N or CT
Secondary outcomes for this review			
Describe secondary outcomes			
Distribution of effect size between groups			
Effects on affective outcomes (e.g., intention & motivation), health (e.g., BMI, CHD risk factors, BMD, injury), psychological variables (e.g., anxiety, mental & emotional well-being),			
Were results reported by Gender; black and minority ethnic groups ; Lower socio-economic status			
Adverse effects			
Other comments on the outcomes			

6. OTHER STUDY TYPES

Geographical location			
Setting (Unit, Hospital etc)			
Description of study			
Context			
Theoretical basis			
Year study commenced			

7. OTHER STUDY TYPES OUTCOMES

Briefly describe the results for each of the main outcomes			
Primary outcome for this review			
Main physical activity / Weight Related(s)			
Type(s) of measure	Self-reported		Mark (Y) all that apply
	"Objective" (pedometer, motion sensor etc)		
	Behavioural Change		
	Relapse		
	Other (describe below)		
Period over which physical activity assessed			days
Named data collection tool or device (if used)			Y or N
Were data collection tools shown or are they known to be valid?			Y, N or CT
Were data collection tools shown or are they known to be reliable?			Y, N or CT
Observed effect size			
Secondary outcomes for this review			
Describe secondary outcomes			
Distribution of effect size between groups			
Effects on affective outcomes (e.g., intention & motivation), health (e.g., BMI, CHD risk factors, BMD, injury), psychological variables (e.g., anxiety, mental & emotional well-being), educational outcomes (e.g., exam results), sedentary behaviours			
Were results reported by Gender; black and minority ethnic groups ; Lower socio-economic status			

Adverse effects			
Other comments on the outcomes			
8. CONCLUSIONS (all study types)			
Did **authors** conclude intervention was effective in increasing **physical activity, decreasing Body weight / body fat?**			Y, N, NR or NA
Did **reviewer** conclude intervention was effective in increasing **p physical activity, decreasing Body weight / body fat?**			Y, N, NR or NA
Did **author** make other conclusions about relationships between physical activity and the reduction of **Body weight / body fat?**			Y, N or CT
Did **reviewer** agree with these findings?			
Are the findings of this study likely in principle to be replicable elsewhere?			Very, Somewhat or Not
9. FINAL CHECKS			
Do the authors reference **any other studies** which should be followed up?			Y or N
Are there any significant discrepancies between reviewers?			Y or N
Is the RefMan citation correct? If not enter it here			
Should this reference be passed on to the reviewer for any of the following reviews?			
	Background		**Y or N**
	Causes		
	Determinants		

IF NECESSARY, PASTE IN HERE ANY KEY EXTRACTS ESPECIALLY OUTCOME DATA

The Correlates and Treatment of Obesity in the Army - In/Out Form								
Title: ***A Comprehensive Weight-Loss Program for Soldiers***								Year:
Author and Year		**Gender**	Male		Female		Mixed	
Today's Date		**Age Range**	18-30		31-40		41-50	Other: 19-38
Study ID Number		**Rank Range**						
Country		**Sample Size**						
Service Type		**Design**						
Where the Document was sourced		**Outcome**	Causes		Prevention		Treatment	
Military or Civilian Domain		**Data**	Qualitative		Quantitative			
Journal Title / Document Affiliation			Other		Rems:			
Reviewer								

Question	Yes	Not Clear	No	Further Information
Does the study refer to a military or civil force population?				
Is the outcome physical activity, weight or health related?				
English Language				
1990 Onwards				
Economically and Military developed country (i.e. UK, Europe, USA, Can, Aus)				
Obesity Intervention, health promotion				
Weight Reduction Surgery				
Health Edn that does not include obesity				
Clinical Therapy				
Conscription Service (Treatment)				

IF THE ANSWER TO ANY OF THE STATEMENTS RESIDES IN THE SHADED BOX, EXCLUDE THE STUDY (FROM THE INITIAL SCREENING)

The study is:	Included		Excluded		Not sure		
	Details:						

Remarks:

Appendix 2 HBQ – Socio-demographics

The following questions were posed to ascertain information relating to socio-demographics, habitation status, location of food preparation, self reported height and weight, self reported waist circumference, education attainment, diet, smoking status, alcohol consumption and injury status.

Health Behaviour Questionnaire

ABOUT YOU

1 Age (in years) Y__________ (*Please state*).

2 Gender (*Please tick one*).

Male	
Female	

3 Ethnicity (*Please tick one*).

White	
Black Caribbean	
Black African	
Black Other	
Indian	
Pakistani	
Chinese	
Asian Other	
Other (please state)	

4 Arms & Service (*Please tick one*).

Inf	
AAC	
AMS	
AGC	
RA	
RAC	
RE	
REME	
RMP	
Int Corps	
RAPTC	
Other (Please state)	

5 Trade (*Please tick one*).

Infantry Soldier	
Administration (inc human resources)	
Information Technology	
Engineering and Mechanics	
Medical Nursing and Healthcare (inc dentistry, veterinary)	
PTI	
Technician	
Security (inc police and provost staff)	
Catering	
Other (Please state)	

6 Rank (*please tick one*).

Lt Col or Above	
Maj, Capt, Lt, 2Lt	
SNCO	
JNCO	
Pte	

7 How many years full-time Service have you completed? (please state)__________

8 Which Brigade do you belong to? (*Please tick one*)

145 (S)	
43 (Wx)	
2 (SE)	
49 (E)	
143 (Wm)	
160 (Wales)	
38 (Irish)	
42 (NW)	
51 (Scottish)	
Other (please state)	

9 What is your current personal status? (*Please tick one*)

Never married and never formed a civil partnership	
Living with someone in a long term or established relationship	
Married or in a civil partnership	
Separated, but still legally married or in a civil partnership	
Divorced or formerly in a civil partnership which is now legally dissolved	
Widowed or the surviving partner from a civil partnership	

10 During the working week are you living with a spouse/partner? (*Please tick one*)

Yes	
No	

11 At the weekend are you living with a spouse/partner? (*Please tick one*)

Yes	
No	

12 If you generally (working week) use the centralised feeding (cookhouse or mess), please indicate whether you are on the Pay as You Dine (PAYD) scheme. (*Please tick one*)

Yes	
No	

13 What is your current Height and Weight (Metric **or** Imperial?)

	Metric		Imperial			
Height	Centimetres		Feet		Inches	
Weight	Kilograms		Stone		Pounds	

14 During a typical working week who prepares your food? If more than one applies to you please state for your main meal (*Please tick one*).

Centralised feeding (cookhouse or mess)	
Food outlet	
You	
Your partner	
Other (please state)	

15 On a typical weekend who prepares your food? If more than one applies to you please state for your main meal (*Please tick one*).

Centralised feeding (cookhouse or mess)	
Food outlet	
You	
Your partner	
Other (please state)	

Please answer question Q16 if you are male (*If you are female, please go to question 17*):

16 For males only, what your current waist size? (*Please tick one*)

Less than 94 cm (Less than 37 inches, approx)	
Between 94 – 102 cm (Between 37 – 40 inches, approx)	
More than 102 cm (More than 40 inches, approx)	

Please only answer question Q17 if you are female:

17 For females only, what is your current waist size? (*Please tick one*)

Less than 80 cm (Less than 31.5 inches, approx)	
Between 80 – 88 cm (Between 31.5 – 34.5 inches, approx)	
More than 88 cm (Less than 34.5 inches, approx)	

18 What is your **highest** level of academic qualification? (*Please tick one*)

O levels/CSEs/GCSEs/School Certificate	
A levels/AS levels/Higher School Certificate	
Technical or Trade Certificate / Diploma	
First Degree (e.g. BA, BSc,)	
Higher Degree (e.g. MA, MSc, PGCE, PhD)	
None of the above academic qualifications	

DIET

19 How many portions of fruit and vegetables, **not** including potatoes, do you eat most days? (*Please tick one*). *A portion is roughly the size of a handful.*

0-1	☐
2-4	☐
5 or more	☐

20 In the average week how often do you eat high fat foods (hamburgers, chips, take-aways)? (*Please tick one*)

Every day	☐
Most days	☐
Rarely	☐
Never	☐

21 In the average week how often do you eat high fat or sweet snacks **between** meals (e.g. chocolate, crisps or cakes)? (*Please tick one*)

Every day	☐
Most days	☐
Twice a week	☐
Once a week	☐
Rarely	☐
Never	☐

SMOKING

In the following questions about cigarette smoking, please include roll-ups.

22 Are you a*….. (Please tick one)*

Regular cigarette smoker	☐
Social/occasional cigarette smoker	☐
Ex-cigarette smoker	☐
Never smoked cigarettes	☐

ALCOHOL

23 How often do you have a drink containing alcohol? (*Please tick one*)

Never	☐
Monthly or less	☐
2-4 times a **month**	☐
2-3 times a **week**	☐
4 or more times a **week**	☐

24 On the days you have a drink containing alcohol, how many drinks do you typically have? (*Please tick one*)

1-2	
3-4	
5-6	
7-9	
10 or more	

Injury Status

25 Do you have an injury or disability that limits the amount of physical activity you do? (*Please tick one*)

Yes	
No	

Physical Training (PT)

26 In the average week how many times do you do compulsory PT? (*Please tick one*)

None	
1-2	
3-4	
5-6	
7+	

Appendix 3 HBQ – International PA Questionnaire

The International physical activity questionnaire (IPAQ) was use to assess leisure-time physical activity (LTPA) (Craig et al 2003).

LEISURE-TIME PHYSICAL ACTIVITY

The following questionnaire is designed to assess the level of **leisure-time physical activity (LTPA)**. For this study, leisure-time physical activity includes all activities that have a physical element, this includes individual and team sports, circuit and weight training, outdoor pursuits (climbing, canoeing and mountain walking); strenuous activities such as cross country running and not so strenuous activities (jogging and recreational swimming) are all included. **LTPA refers to activities in your own time and not (PT) lessons or programmed fitness training or testing. Please be aware of the following point.**

1. If you are a physical training instructor (PTI), mandatory training refers to all the lessons you take and LTPA **refers to all physical activity that you do, that is of your own choice in your spare time (i.e. not programmed PT lessons).**

We are interested in finding out about the kinds of physical activities that people do as part of their leisure-time. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please think about the activities you do in your **spare time** for recreation, exercise or sport. Think *only* about those physical activities that you did for at least 10 minutes at a time.

27. During the **last 7 days**, on how many days did you do **vigorous** physical activities like running, football, aerobics, strenuous weight training or fast bicycling?

___ **days per week**

☐ No vigorous physical activities → ***Skip to question 29***

28. How much time did you usually spend doing **vigorous** physical activities on one of those days (if the amounts vary state the average amount)?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for <u>at least 10 minutes at a time</u>.

29. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, light weight training, jogging and recreational swimming ? <u>Do not include walking.</u>

____ **days per week**

☐ No moderate physical activities → ***Skip to question 31***

30. How much time did you usually spend doing **moderate** physical activities on one of those days (if the amounts vary state the average amount)?

____ **hours per day**

____ **minutes per day**

☐ Don't know/Not sure

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

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

_____ **days per week**

☐ No walking → ***Skip to question 33***

32. How much time did you usually spend **walking** on one of those days (if the amounts vary state the average amount)?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

33. During the last six months what is the length of time that you have regularly (**3 x per week or more of at least 10 minutes**) engaged in LTPA (**PLEASE TICK THE APPROPRIATE BOX**).

I have not engaged in regular **LTPA** and do not intend to.	
I have not engaged in regular **LTPA,** but intend to.	
I have engaged in some **LTPA** in the last six months but not enough to meet the description of regular **LTPA**.	
I have engaged in regular **LTPA FOR LESS THAN 6 MONTHS.**	
I have engaged in regular **LTPA FOR MORE THAN 6 MONTHS.**	

Appendix 4 HBQ – Sedentary Behaviour

The following questions are related to sitting (Marshall et al 2010). Participants were asked estimate how much time they spend sitting in several activities on their last working day and on their last non-working day (day off or weekend).

34.		Work day		Non-work day	
		Hours	Mins	Hours	Mins
A	For transport (car, bus, train)				
B	At work (e.g. using a computer)				
C	Watching television				
D	Using a computer at home / in your room (e.g. email)				
E	Other leisure activities (e.g. socialising, movies)				
		Work day		Non-work day	
Was this a usual working / non-working day? (please circle)		Yes	No	Yes	No

Appendix 5 HBQ – Treatment Self-Regulation Questionnaire

The following questions were posed to ascertain the type of motivation to support study participants exercise behaviours (Levesque et al 2007).

The reason I would do exercise regularly is: (Please circle the appropriate number on the scale provided indicating how true the statement is for you **(1) = Not true for me (5) Very true for me**						
35	Because I feel that I want to take responsibility for my own health.	1	2	3	4	5
36	Because I would feel guilty or ashamed if I did not exercise regularly.	1	2	3	4	5
37	Because I personally believe it is the best thing for my health.	1	2	3	4	5
38	Because others would be upset with me if I did not.	1	2	3	4	5
39	I really don't think about it.	1	2	3	4	5
40	Because I have carefully thought about it and believe it is very important for many aspects of my life.	1	2	3	4	5
41	Because I would feel bad about myself if I did not exercise regularly.	1	2	3	4	5
42	Because it is an important choice I really want to make.	1	2	3	4	5
43	Because I feel pressure from others to do so.	1	2	3	4	5
44	Because it is easier to do what I am told than think about it.	1	2	3	4	5
45	Because it is consistent with my life goals.	1	2	3	4	5
46	Because I want others to approve of me.	1	2	3	4	5
47	Because it is very important for being as healthy as possible.	1	2	3	4	5
48	Because I want others to see that I can do it.	1	2	3	4	5
49	I don't really know why.	1	2	3	4	5
50	Because I personally believe it is the best thing for my occupation	1	2	3	4	5
51	Because I feel that I want to take responsibility for my own occupational fitness.	1	2	3	4	5

Appendix 6 HBQ – Restrictive Eating

The restricted eating scale of the Dutch eating behaviour questionnaire was employed to assess how restrictive the study population was in their eating behaviour (van Strien et al 1986).

Please indicate your answer by circling the appropriate (**1= never, 2 = seldom, 3 = sometimes, 4 = often, 5 = very often)**						
52	If you have put on weight, do you eat less than you normally would do?	1	2	3	4	5
53	Do you try and eat les at mealtimes than you would like to do?	1	2	3	4	5
54	How often do you refuse food or drink offered because you are concerned about your weight?	1	2	3	4	5
55	Do you watch exactly what you eat?	1	2	3	4	5
56	Do you deliberately eat foods that are slimming?	1	2	3	4	5
57	When you have eaten too much, do you eat less than usual the following day?	1	2	3	4	5
58	Do you deliberately eat less in order not to become heavier?	1	2	3	4	5
59	How often do you try not to eat between meals because you are watching your weight?	1	2	3	4	5
60	How often in the evenings do you try not to eat because you are watching your weight?	1	2	3	4	5
61	Do you take into account your weight when you eat?	1	2	3	4	5

Appendix 7 HBQ – Participant information sheet

Participant Information Sheet – HBQ Main Study

Information for Participants

Study title

An investigation into the relationship between health behaviours and weight status in the British Army

Invitation to take part

You are invited to take part in a survey; your participation is valuable and will help in the understanding of health behaviours; specifically the causes, prevention and treatment of obesity. You should only participate if you want to; choosing not to take part will not disadvantage you in any way.

What is the purpose of the research?

The purpose of the research is to gather information relating to weight status and general health practises. This will enable the Army to understand why some soldiers become overweight and others do not. It will also offer valuable information to help in the prevention and treatment of excess weight.

Who is doing this research?

Maj Paul Sanderson is undertaking the research on behalf of the Royal Army Physical Training Corps and Army Health. He is financially supported in this venture by the Directorate of Personnel Strategy (DAPS) Science. He is academically supported and validated by Loughborough University.

Why have I been invited to take part?

You have been asked to take part because information is required to reflect the full age and rank range in the army. Additionally to fully understand the health behaviours related to weight status, it is important to gather information that covers all of the different weight categories.

Do I have to take part?

No you do not

What will I be asked to do?

You will be asked to answer 61 questions, in relation to general information (i.e. age, gender, job role) and health behaviours (i.e. how much exercise you undertake and how much alcohol you drink). It is important that you want to be a part of this study, if you do not please do not feel obliged to do so.

The questionnaire should take no longer than 30 minutes and is a collection of questions from several questionnaires.

Questions 1 – 18 are questions about you (Age, gender, trade and rank etc).
Questions 19 – 24 are about your eating, smoking and drinking habits.
Question 25 is about your injury status
Question 26 is a general question about physical training.

Questions 27 – 33 are about your leisure-time physical activity.
Question 34 is a question about the time you spend sitting.
Questions 35 – 51 are about the reasons you would do exercise.
Questions 52 – 61 are about eating behaviours.

What is the device or procedure that is being tested?

Whilst nothing is being tested, the survey and is designed collate information in regards to weight status and general health behaviours.

What are the benefits of taking part?

The aim of the survey is to help better understand some of the reasons why some individuals in the Army become overweight. This can only be achieved if the relationship between weight status and health behaviours is better understood. Therefore, by taking part you will be helping to shape future policy in regards to weight status and employment in the Army.

What are the possible disadvantages and risks of taking part?

There are no potential risks attached to participation in the study.

Can I withdraw from the research and what will happen if I don't want to carry on?

Yes you can.

Are there any expenses and payments which I will get?

No there are not.

Will my taking part or not taking part affect my Service career?

No it will not.

Whom do I contact if I have any questions or a complaint?

The lead investigator:
Maj (MAA) Paul Sanderson RAPTC
SO2 Physical Development
Headquarters 3 (UK) Division
Bulford Camp
Bulford
SALISBURY

Tel 01980 672269
E-mail Paul.Sanderson226@mod.uk

Primary Supervisor:
Professor Stuart J. H. Biddle
Loughborough University
School of Sport, Exercise and Health Sciences
Loughborough
Leicestershire LE11 3TU

Service Customer
Lt Col Alan Billings (SMAA) RAPTC
Headquarters Royal Army Physical Training Corps
Fox Lines
Queens Avenue
Aldershot
Hampshire GU11 2LB

or the MODREC secretary Marie Jones, Tel 01980 658301, MNJONES@mail.dstl.gov.uk.

What happens if I suffer any harm?

You will be cared for within the Army Medical chain

What will happen to any samples I give?

You will not be required to give any samples

Will my records be kept confidential?

Yes

Who is organising and funding the research?

HQ Royal Army Physical Training Corps (HQ RAPTC) and Army Health have both requested the research. The Directorate of Army Personnel Strategy (DAPS) Science is funding the research.

Who has reviewed the study?

A scientific protocol for this research has been approved by The Ministry of Defence Research Ethics Committee (MODREC).

Further information and contact details.

Major Paul Sanderson
Address above:

Compliance with the Declaration of Helsinki.

This study complies, and at all times will comply, with the Declaration of Helsinki[1] as adopted at the 52nd WMA General Assembly, Edinburgh, October 2000 and with the Additional Protocol to the Convention on Human Rights and Biomedicine, concerning Biomedical Research, (Strasbourg 25.1.2005). Please ask the Chief Investigator if you would like further details of the approval or to see a copy of the full protocol.

[1] World Medical Association (2000) Declaration of Helsinki. Ethical principles for medical research involving human subjects. 52nd World Medical Association General Assembly, Edinburgh, Scotland October 2000.