Food and beverage consumption of Canadian Forces soldiers in an operational setting: Is their nutrient intake adequate?

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2 Abstract

Food and beverage consumption of Canadian Forces soldiers in an operational setting: Is their nutrient intake adequate?

Introduction

Despite increased metabolic demands, infantry soldiers are known to not eat enough during military manoeuvres. We undertook this study to examine food provided and consumed by male soldiers in the Canadian Forces in operational environments to examine and potentially improve their nutrition.

Methods

Subjects recorded their food intakes using dietary questionnaires during two exercises. The adequacy of dietary intake and the nutrient value of foods offered were assessed against Dietary Reference Intakes (DRI).

Results

Soldiers did not consume enough energy, carbohydrate, fibre, folate, vitamin C, potassium and calcium compared to operational requirements. The combat rations provided less than the recommended DRI for some nutrients. Food sources of nutrients were examined.

Discussion

We recommend increasing the quantity of easy-to-eat nutrient-dense foods while decreasing sodium content. To optimize nutrition and combat readiness,

new products rich in carbohydrate, potassium, folate and calcium need to be added.

3 Abregé

L'apport nutritif des aliments et des boissons consommés est-il suffisant ?

Introduction

Malgré des besoins accrus du métabolisme, on sait que les fantassins ne mangent pas suffisamment durant les manœuvres militaires. Nous avons entrepris cette étude afin d'évaluer la nourriture consommée au cours des opérations par les soldats de sexe masculin des Forces canadiennes dans le but, éventuellement, d'améliorer l'alimentation.

Méthodes

Au cours de deux exercices, les sujets ont consigné leur consommation quotidienne d'aliments à l'aide des questionnaires. La suffisance de l'apport alimentaire et la valeur nutritive des aliments distribués ont été étudiées d'après les rapports nutritionnels de référence (ANREF)

Résultats

Comparativement aux besoins en contexte opérationnel, l'apport en énergie, glucides, fibres, folate, vitamine C, potassium et calcium était insuffisant. Certains des éléments nutritifs fournis par les rations de combat étaient deçà de qui est recommandé en fonction des ANREF. Les sources nutritives alimentaires ont été examinées.

Discussion

Nous recommandons d'augmenter la quantité d'aliments faciles à manger et riches en nutriments tout en réduisant la quantité de sodium. Afin d'optimiser la nutrition et la préparation au combat, il faut ajouter de nouveaux produits riches en glucides, potassium, folate et calcium.

4 Introduction and background

On operations, the Department of National Defence (DND)/ Canadian Forces is responsible for providing nutritious and wholesome food services to meet the nutritional needs of healthy military men and women.

As few or no commercial food outlets are usually available to Canadian Forces members while on exercise or deployed missions, it is important that the Canadian Forces provide palatable nutritious food accepted by Canadian tastes and culture in order to promote adequate intake of energy and nutrients. Sustaining health in severe and stressful environments requires adequate intake of macro and micronutrients to maintain stamina for combat and to fuel the brain for cognitive performance.

Combat rations are intended to be nutritionally adequate for a period of up to 30 days, but whether they will sustain the soldier indefinitely is questionable. For a long time, it was assumed that a soldier would eat an entire combat ration even under adverse conditions – especially if he was hungry. However, if soldiers reach the point of desperation where they will eat anything, it "may be assumed that the stage of optimum nutrition has been left far behind" (Nindl, Friedl et al. 1997). Devising combat rations for soldiers must consider both current and future operations with nutrition designed to optimize operational capability. The development of a combat ration must consider the increased metabolic demands associated with extreme environmental conditions and heavy physical and psychological activity (Booth, Coad et al. 2003). Regardless of combat ration formulation, "a ration is no good if it is not eaten" (Nindl, Friedl et al. 1997).

4.1 Combat Ration Program

Canadian combat rations are shelf-stable foods designed and developed to meet military members' physical and dietary requirements, while incorporating Canadian cultural food preferences as well as common preferences of the military members. As a primary alternative to a freshly prepared meal, combat rations are used when it is not feasible or practical to serve fresh rations. Specific training or exercise purposes, rapid-response emergency situations and when over-riding practical considerations preclude the use of fresh food necessitate using combat rations. Combat rations are designed for healthy Canadians who do not require special therapeutic dietary needs and are not subject to food allergies, food intolerance or food sensitivity. The meal components offer common foods based on Canadian eating patterns (DND, 2002).

The food components of the Combat Ration Program include Individual Meal Packs, Light Meal Combat, arctic and tropical supplements and survival packets. The Individual Meal Pack (IMP) is shelf-stable for three years and identified by meal (breakfast, lunch and supper) (Figure 1). The intent of the IMP is to provide a nutritionally adequate diet, including sufficient energy and other nutrients for up to 30 days without supplementation with fresh rations. All components of the IMP are prepared or require limited food preparation or reconstitution. The retort pouch packaging of the main entrée allows eating the contents unheated or heated in boiling water or by body heat. Eating the entire three meals per day provides between 3600 to 4100 kcal. Macronutrient composition ranges between 35-65 g of protein, 188-282 g of carbohydrate and 18 to 62 g of fat per complete meal (DND 2002). .

The Light Meal Combat (LMC) component supplements IMPs when arduous activity or severe weather conditions warrant extra energy intake. The LMCs can also substitute for IMPs for a maximum of 48 hours when the situation precludes carrying, preparing or disposing of IMP components. The LMC menus range between 1300 to1471 kcal with 25 to 33 g of protein, 25 to 39 g of fat and 213 to 256 g of carbohydrate per package (DND 2002).

In extreme climatic conditions, the arctic supplement or the (tropical) ration supplement can provide additional nutrients, energy and fluids (DND

2002). The starch jelly composition of the basic survival packet provides emergency sustenance for two days. The air survival food ration consists of the basic survival food packet and hot beverages for a period of three days. The Maritime survival ration includes two jelly food packets and a fresh water ration providing emergency sustenance for five days (DND 2002). See Figure 2 for a conceptual image of the Combat Ration Program.

5 Literature review

Canadian Forces soldiers endure a wide range of sustained physical activities; forced marches, running, carrying heavy loads, crossing rugged terrain, in combination with stressors such as sleep deprivation, high altitude-induced hypoxia, extreme ambient temperatures, and restricted food and water availability during operational missions (Friedl and Hoyt 1997). Military manoeuvres induce negative energy balance because energy intake is lower than expenditure (Ainslie, Campbell et al. 2003). With these contributing factors, the Canadian Forces require a feeding regimen that will accommodate combat soldiers and remain suitable for soldiers in less rigorous conditions.

Long periods of physical activity deplete muscle glycogen (Jentjens, van Loon et al. 2001) compounding the problem of under consumption of food by military personnel in field environments (Jones, Jacobs et al. 1993; Nindl, Friedl et al. 1997; Westerterp-Plantenga, Westerterp et al. 1999; Friedl, Moore et al. 2000; Kramer, Lesher et al. 2001; Booth, Coad et al. 2003; Montain and Young 2003). Thus, military forces require a practical solution encouraging adequate consumption to optimize cognitive and physical performance.

5.1 Energy balance – the risk of underconsumption

The energy expenditure of soldiers is comparable to the energy outlay of endurance athletes. However, the military nature of the tasks creates a unique set of circumstances that may extend well beyond the total activity time of an athlete (Jacobs, van Loon et al. 1989). The athlete normally knows how long and when his or her event will be held, but for the soldier, the duration of activity is unpredictable. The negative energy intake of soldiers on operations may harm health indicators such as the immune system, sex hormones and bone mineralization, where even short-term fasting can reduce physical performance (Ainslie, Campbell et al. 2003).

Other military studies support the negative effect of underconsumption on performance. In a review of studies with military personnel or subjects undergoing high energy expenditures, nearly every field training study demonstrates inadequate energy intakes that are below a North Atlantic Treaty Organization (NATO) panel recommendation of at least 450 g of carbohydrate/day (Jacobs, Anderberg et al. 1983; Jacobs, van Loon et al. 1989; Jones, Jacobs et al. 1993; Nindl, Friedl et al. 1997; Westerterp-Plantenga, Westerterp et al. 1999; Friedl, Moore et al. 2000; Kramer, Lesher et al. 2001; Booth, Coad et al. 2003; Montain and Young 2003). See Appendix 1 for review. The insufficient carbohydrate intake is hypothesized to be due to inadequate overall food intake coupled with high-energy requirements.

Multiple and interrelated factors and stresses contribute to the underconsumption of food in the field directly affecting soldiers' nutritional status. Stress is complicated and perceived differently by individuals; some stressors are more "universal", affecting all individuals to a greater extent, whereas some stressors are more individually perceived. Eating is a personal act with the perception of various stressors influencing an individual's intake and may cumulatively impact the entire group. There is no test or any training devised that helps a soldier achieve the self-knowledge of his strengths and weaknesses (Friedl, Moore et al. 2000). Knowledgeable and experienced leadership invigilating an appropriate eating discipline reduces potential underconsumption.

The combination of various stresses affects the food consumption of soldiers. The many reasons contributing to underconsumption of combat rations range from the organoleptic qualities of the food, psychological factors and lack of time. Factors such as menu boredom, inability to work on a full stomach, lack of water, lack of scheduled meals or time to prepare meals, anxiety and intentional dieting play a role in reduced intake (Friedl and Hoyt 1997). Soldiers consider ration offering, ease of preparation, taste and perceived food value in determining what they will carry (Booth, Coad et al. 2003). Reduced food consumption can be also attributed to operational anorexia as a generalized stress response to a severe environment, thermal strain, hypohydration, anxiety, fatigue, aches and pain (Booth, Coad et al. 2003).

Motivation fluctuates amongst soldiers during underfeeding to an extent that may negatively affect military performance (Montain and Young 2003). Underfeeding also decreases vigour and increases feelings of confusion (Booth, Coad et al. 2003) leading to detrimental effects on morale ultimately impairing concentration and the perseverance for group functioning (Montain and Young 2003).

Long-term underfeeding has a detrimental effect on soldiers' physical performance capability (Montain and Young 2003). Soldiers' physical performance capability as indicated by decreased muscle strength, power and altered sex hormones is seen in long-term negative energy balance when accompanied with weight loss (Friedl, Moore et al. 2000; Montain and Young 2003). Underconsumption reduces thermal balance, possibly due to limited availability of an energy substrate and loss of insulation from body fat, thus allowing more heat loss (Young, Castellani et al. 1998; Ainslie, Campbell et al. 2003). Low energy consumption – especially low carbohydrate intake – can lead to quicker fatigue time, potentially increasing the risk of injury (Ainslie, Campbell et al. 2003). Meeting the energy requirements for military personnel is obviously important in achieving the aim of a mission.

5.2 Carbohydrate and performance

Since soldiers work at various exercise intensities, the metabolism of their energy source determines the most appropriate fuel for task performance. During exercise, glucose is the main source for energy where muscle relies almost entirely on oxidative metabolism. Carbohydrate is used as the primary fuel at intensities of more than 65% $VO_{2\ max}$[1], but is used about equally with fat at about 60-65% $VO_{2\ max.}$ (Maughan 2003). Fat from intramuscular triacylglycerol, blood-borne free fatty acids from adipose tissue, and glucose from liver, blood glucose and muscle glycogen provide fuel during prolonged exercise at intensities of less than 50% $VO_{2\ max}$ (Maughan 2003). Protein is used when other free fatty acids and glucose are unavailable (Maughan 2003). Restoring depleted muscle glycogen between periods of activity maintains performance levels (Bell, McLellan et al. 2002) and is facilitated by the increased cell membrane permeability to glucose post exercise (Jentjens, van Loon et al. 2001).

A timely high carbohydrate intake improves or maintains performance in a number of studies involving military personnel and athletes (Jacobs, Anderberg et al. 1983; Jacobs, van Loon et al. 1989; Montain, Shippee et al. 1997; Bell, McLellan et al. 2002; Booth 2003). Unlike fat, carbohydrate spares protein and does not increase urine volume or accelerate dehydration seen in protein utilization during early starvation (Phillips 1994). Unlike body fat, body carbohydrate stores are limited. Adequate dietary carbohydrate intake is crucial in maintaining a soldier's capacity to sustain heavy exercise (Friedl and Hoyt 1997). The joint position of the American College of Sports Medicine, American Dietetic Association and Dietitians of Canada recommends that 7-8 g carbohydrate/kg/day (for 70 kg athlete) will maintain muscle glycogen and follow the Nutrition Recommendations for Canadians(ACSM 2000).

Consuming sufficient and successive amounts of carbohydrate and minerals to support metabolism during prolonged work minimizes the diuresis associated with semi-starvation diets and maintains physical performance during several days of underfeeding (Friedl, Moore et al. 2000; Bell, McLellan et

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[1]$VO_{2\ max}$ The maximum amount of oxygen that an individual can utilize in a set period of time (generally expressed as a volume ie L/min). It is a measurement of the upper limit of aerobic muscle cell metabolism and is dependent on both the maximal cardiac output and the maximal arterial-venous oxygen difference at the muscle or tissue level.

al. 2002) . The depletion of intramuscular glycogen stores during 4.5 days of military manoeuvres and a low carbohydrate diet can be prevented with an intake of 3700 kcal with 64% carbohydrate (580g) (Jacobs, Anderberg et al. 1983). Endurance-exercise performance improves significantly when extra carbohydrate is consumed at mealtime, with a pronounced effect when carbohydrate is consumed during exercise (Friedl and Hoyt 1997). Soldiers using a carbohydrate-electrolyte drink during extensive exercise delay fatigue. (Chryssanthopoulos, Williams et al. 2002). Providing a carbohydrate source late in exercise - when muscle glycogen is low - postpones fatigue associated with low plasma glucose and is more apparent when carbohydrate is provided early during activity (Coggan and Coyle 1987). These positive performance results suggest that carbohydrate is easily tolerated and can be applied in an operational setting without generating negative side effects.

Feeding a 12% carbohydrate supplement to soldiers during arduous training improves their vigilance and mood and decreases confusion (Lieberman, Falco et al. 2002). It is suggested that carbohydrate supplementation increases plasma glucose levels available to the brain, thus increasing brain activity and memory and that increased brain serotonin contributes to regulating fatigue (Lieberman, Falco et al. 2002). Studies on the somnolent effects of serotonin are controversial and it is hypothesized that carbohydrate can improve centrally mediated fatigue in exercising individuals (Lieberman, Falco et al. 2002). These studies demonstrate that carbohydrate maintains physical performance; it also plays a role in delaying fatigue and contributes to positive cognitive functioning.

Dehydration and low endogenous carbohydrate independently impair endurance exercise performance and marksmanship (Tharion 1993; Montain and Young 2003). Maintaining hydration appears to have a significant positive impact on performance, despite expending extra energy carrying the extra water weight (Bell, McLellan et al. 2002). Studies at Defence Research and

Development Canada (DRDC) demonstrated that commercial sport drinks (CSD) provide a readily available source of energy and fluid to supplement the current Light Meal Combats (LMC), providing both fluid and energy (Bell, McLellan et al. 2002). The high proportion of carbohydrate and added electrolytes in a commercial sports drink could be more advantageous in certain circumstances than the LMC because the metabolism of carbohydrate is more important than fat at higher exercise intensities (Bell, McLellan et al. 2002) . There are no disadvantages to drinking 4 to 8% carbohydrate solution in hot weather and it may increase voluntary fluid intake (Burke 2001). After heavy exercise, individuals are more likely to replenish energy by drinking fluids than by eating solids and in a combat situation, soldiers consume whatever is easiest to carry, prepare and ingest (Bell, McLellan et al. 2002). The evidence suggests that mixed meals supplemented with carbohydrate drinks or foods are important for long-term and overall glycogen status.

5.3 Adding protein to increase glycogen synthesis

Would the addition of protein to recovery drinks improve glycogen synthesis and improve performance and recovery? Testing a carbohydrate and protein supplement (CHO+pro) during exercise trials indicates a higher insulin response compared to the control but is not significant at 60 minutes post exercise and does not affect the rate of muscle glycogen synthesis during the early post-exercise recovery period (Jentjens, van Loon et al. 2001). Nor is there a significant difference in plasma or muscle glucose concentrations (Jentjens, van Loon et al. 2001). There is no increase in the rate of glycogen synthesis with a CHO + protein recovery drink, therefore excluding insulin as a limiting factor for glycogen synthesis (Jentjens, van Loon et al. 2001). Ingesting 1.2 g/kg/hour of glucose post exercise significantly maximizes muscle glycogen synthesis (Jentjens, van Loon et al. 2001). Adding protein to a beverage decreases the practical application for soldiers, since more GI discomfort is noticed with the CHO + protein drink (Jentjens, van Loon et al. 2001). Avoiding unnecessary protein intake makes it easier to remain adequately hydrated in cold environments (Friedl and Hoyt 1997). The insignificance of altered glycogen synthesis, the GI discomfort and hydration factors make additional protein an unsuitable supplement in a recovery drink – but may be beneficial as a meal enhancer.

5.4 Using fat to spare muscle glycogen

As described, lower exercise intensity uses more fat than carbohydrate as the preferred energy substrate and potentially decreases endogenous carbohydrate requirements, resulting in muscle glycogen sparing and postponing muscle fatigue (Vogt, Puntschart et al. 2003). Burke et al. investigated whether enhanced rates of fat oxidation during sub-maximal exercise after a 5-day high fat diet persisted with high carbohydrate availability. Despite more fat oxidation, it fails to offer a performance advantage in 30-minute time trials (Burke, Hawley et al. 2002). Commencing exercise reverts insulin concentrations to fasting levels and remains at low levels during trials (Burke, Hawley et al. 2002). As no performance benefit is seen for a short-term high fat diet, the practice of fat-adaptation strategies by endurance athletes competing in events of 2 to 3-hour duration is not supported (Burke, Hawley et al. 2002). All subjects reported headaches, lethargy and increased fatigue during the high-fat treatment compared to the high carbohydrate diet (Burke, Hawley et al. 2002).

Vogt et al. evaluated a long-term (5 weeks) high fat (53% fat) and a low-fat (17% fat) diet on substrate stores in skeletal muscle, substrate selection and performance capacity in trained endurance athletes. Hypothetically, the mechanism of action for the observed increased fat oxidation appears to be due to an increase in activity of carnitine acyltransferase without changes in citrate synthase and 3-hydroxyacyl-coenzyme A dehydrogenase activities resulting in a qualitative change in mitochondrial composition (Vogt, Puntschart et al. 2003). The increased oxidation could also be from a mass action effect by the increased intramyocellular lipid content of the muscle (Vogt, Puntschart et al.

2003). Subjects' performance results remained the same under both diet regimens of all tested exercise intensities despite increased lipid oxidation (Vogt, Puntschart et al. 2003).

The results of various trials confirm that muscle adapts to increase its capacity to oxidize fat in trained subjects (Burke, Hawley et al. 2002). Increased fat oxidation alone can not sustain intense training and leads to decreased performance (Maughan 2003). Fat oxidation and blood glucose oxidation are unable to support the energy requirements of moderate intensity exercise, which requires available glycogen, thus the individual must consume adequate carbohydrate (Maughan 2003). Body fat reserves are readily available to meet shortfalls in dietary fat intake, whereas limited body carbohydrate stores make adequate carbohydrate intake more critical to sustain a soldier's capacity for continual heavy work (Friedl and Hoyt 1997). Military studies show that the additional energy intake from fat has no significant effect on carbohydrate balance, nitrogen balance or water intake and does not increase fat oxidation. Supplementing rations with fat does not offer a performance advantage (Montain and Young 2003).

5.5 What are the challenges of getting the soldier to eat?

Getting the soldier to eat adequately, especially enough carbohydrate, can be challenging. Despite the obvious differences, energy requirements do not vary greatly when comparing extreme heat or cold environments. The same difficulty of getting enough food into a soldier is encountered in both climates. Energy requirements do not decline in the heat, and sweating may increase requirements over those of thermoneutral environments (Friedl and Hoyt 1997). It is important to counter heat-induced anorexic effects by increasing soldiers' energy intakes in hot environments (Friedl and Hoyt 1997). Energy requirements are estimated to be 4300 kcal/day in the arctic, (Jones, Jacobs et al. 1993) but decreased fluid water availability decreases total food energy eaten. Decreased physical performance occurs even with short-term fasting in both hot and cold climes (Edwards and Roberts 1991; Ainslie, Campbell et al. 2003), thus presenting another factor to overcome.

Measuring combat ration adequacy in the past was based on whether or not it maintained body weight (Friedl and Hoyt 1997). Now, militaries are asking for a performance edge and to get the best value for the unit energy provided. The reasons contributing to underconsumption include monotony and repetition of the ration itself (Kramer, Lesher et al. 2001). The environmental temperature, meal schedules, biological rhythm and the eating situation (Shukitt-Hale, Askew et al. 1997) are also difficult aspects to control in field settings, but must be considered when examining overall consumption and nutritional status.

Military leaders must emphasize the total performance and nutritional significance attributed to ration consumption by reflecting this in military feeding policy and attitudes. Commanders need to understand that operational anorexia or reduced consumption can be a stress response to an extreme environment, hypohydration, anxiety, fatigue or climatic adaptation (Booth, Coad et al. 2003). With improved feeding policies, doctrine and nutrition education, commanders and personnel can improve their understanding for carbohydrate requirements before and during deployment. Soldiers who consciously eat all their food – thus practicing good food discipline - are more likely to sustain physical performance than those eating only a portion of their food (Bell, McLellan et al. 2002).

5.6 Food Intake Survey Techniques

Food intake methodology has many limitations partly, due to logistics in an operational environment. Dietary intake determination is challenging, and no "ideal" methods have been reported. A method providing the most accuracy given the constraints of an operational environment is best. The practical burden on the respondent and resources for analyses, validity and reliability of the methodology are key factors for choosing the most appropriate method (Woteki 1992). Possible methods for estimating group intakes include the food frequency questionnaire, 24-hour dietary recall, retrospective diet histories, food intake diaries, direct observation and weighed records (Hill and Davies 2001). The food frequency questionnaire lacks accuracy because it is limited in its ability to provide quantitative data for nutrient intake (Chu, Kolonel et al. 1984). For groups, the 24-hour recall method is accurate and reproducible but requires multiple-day information to determine usual individual intake (Woteki 1992; Hill and Davies 2001) . Repeating the recalls augments precision, however, the risk of error due to over- or under-reporting by the subjects remains (Bingham 1991). In studies with military personnel, soldiers tend to under-report energy intake when fresh food is extra to combat rations. There does not appear to be under-reporting if there are limited rations (i.e. as much as a soldier can carry including personal food) (Hill and Davies 2001). False conclusions may be based on inaccurate reporting, so recommendations must be approached with caution. Including methods such as direct observation and recording food weights can provide more accuracy than from recalls alone (Barrett-Connor 1991).

Doubly (isotopically) labelled water experiments are considered a reliable method to validate the energy component of dietary assessment (Bingham 1991). It assesses energy expenditure and if body fat does not change then this serves as an indicator for energy intake. Jones et al. confirmed under-reporting of energy intake with doubly labelled water with Canadian Forces soldiers in the arctic when supplemented with fresh rations (Jones, Jacobs et al. 1993). Other studies with controlled rations reported good agreement between energy intake and energy expenditure (Forbes-Ewan, Morrissey et al. 1989; Hoyt, Jones et al. 1991). Jacobs et al. used a weighed waste bag method to determine food intake. This modified "tray-return" method accounts for food consumption by having soldiers dispose of all uneaten food and packaging in a coded bag and then weighed (Jacobs, van Loon et al. 1989). The energy intake results compared favourably to estimates of energy expenditure by direct measure of O_2 consumption. An Australian 12-day jungle study also used the waste bag method and corroborated results with energy expenditure determined by doubly labelled water (Booth, Coad et al. 2003).

Using pre-coded, self-reported questionnaires to determine intake of combat rations is considered to be a "reasonably accurate method of collecting intake data because military ration items are individually packaged, single serving-sized pouches or bars" (Marriott 1995). The data collected from specific days of combat ration consumption reflect the exact nature and quantity of individual foods consumed but do not account for intra-individual variations due to day of week or season (Marriott 1995). This is likely not problematic, as the working days of operational soldiers eating combat rations are not punctuated with weekend routines and expanded menu offerings. In studies done in the United States, researchers recommended that soldiers should be eating combat rations for 10 days before evaluating if they will eat more of one type of combat ration than another (Marriott 1995) .

5.7 *Nutrient intake assessment of groups*

To determine the nutrient adequacy, nutrient intakes are compared with dietary guidelines. The Dietary Reference Intakes (DRI) are used to assess dietary adequacy of healthy groups by the probability approach or the Estimated Average Requirement (EAR) cut-point method (Institute of Medicine 2000a) . The EAR is defined as "the average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and gender group" (Institute of Medicine 2000a). This study uses the EAR values for carbohydrate, protein, iron, vitamin A, vitamin C and folate. AI values are used for fibre, calcium and potassium. Mean intakes of groups are compared to the Adequate Intake (AI) defined as "a recommended intake value based on observed or experimentally determined approximations or estimates of nutrient intake by a group of apparently healthy people that are assumed to be adequate – used when a (Recommended Daily Allowance) RDA cannot be determined" (Institute of Medicine 2000a). If the mean intake of the healthy group is greater than the AI, then the assumption of low prevalence of inadequacy can be made. If the mean intake is lower than the AI value, it is not appropriate to assume the extent of intake inadequacy (Institute of Medicine 2000a). The US Department of Defence uses dietary reference standards to plan menus and assess whether provision of "fortified foods, nutrient supplement, or special food products are needed in operational conditions" to emphasize performance enhancement rather than to prevent deficiencies (Institute of Medicine 2000a).

The tolerable upper intake level (UL) is the highest level of chronic daily nutrient intake unlikely to cause a risk of adverse health effect to almost all individuals which can be tolerated biologically (Institute of Medicine 2003). When planning diets, the UL should not be exceeded in order to minimize adverse effects. By planning a menu with a nutrient density that is adequate for a sub-group with the highest needs – such as the infantry - it is possible that a substantial proportion of some of the other subgroups will consume diets that exceed the UL (Institute of Medicine 2003). Knowing how much of the offered food is actually consumed, and the resulting distribution of nutrient intakes, allows planning for desired distribution of usual intake (Institute of Medicine 2003). The strenuous nature of soldiers' work makes sodium most relevant in this study.

5.8 The way ahead

Canadian Forces personnel require adequate nutrients plus an efficient and reliable energy source for optimal military performance during extreme conditions and high exercise intensity. In the literature reviewed, adding protein or consuming a high fat diet has not demonstrated any performance, physiological or psychological advantages. Complaints of gastrointestinal upset, mood disturbance and general unease have been reported with increased proportions of protein and fat. In the absence of positive effects, increasing protein and fat intake is not warranted in military operations.

The evidence presented indicates that a diet high in carbohydrate is best able to meet the demands for blood glucose and muscle glycogen replenishment, as meals and as carbohydrate supplementation with food and drinks. A high carbohydrate diet for a soldier comprises 50 to 60% of an estimated energy requirement of 4000 kcal, as carbohydrate is 500 g to 600 g and meets the minimum recommended carbohydrate intake of 450 g (Nindl, Friedl et al. 1997). It also agrees with other suggested intakes of 7 to 8 g carbohydrate/kg body weight/day and Jacobs findings of 580 g carbohydrate/day (Jacobs, Anderberg et al. 1983; ACSM 2000). Based on this research, soldiers undergoing strenuous activity need to consume approximately 500 g of carbohydrate/day as a minimal threshold amount to maintain blood glucose levels. Ideally, this is coupled with consuming ~4000+ kcal of energy a day.

Carbohydrate supplementation is suitable for high intensity exercise with no disadvantage at lower intensities. Maintaining adequate blood glucose levels demonstrates positive physical and cognitive performance advantages. In addition, accepted foods supplemented with a commercial sports drink can meet practical applications.

6 Rationale

6.1 Research rationale

The energy expenditure of an operational soldier compares to an endurance athlete, so maintaining muscle glycogen and appropriate blood glucose levels to optimize military relevant tasks is important. Underconsumption in the field compounds this problem and creates a greater challenge of finding practical and convenient ways to encourage adequate energy intakes.

There are multiple risks - such as decreased performance, thermal balance deregulation, fatigue and impaired vigilance - when soldiers do not eat enough. Therefore, optimizing carbohydrate as a fuel choice provides the best metabolic insurance in maintaining glucose availability to active muscles and the capability of enduring sustained operations. Carbohydrate's protein-sparing ability decreases muscle breakdown and allows ingested protein to be used for muscle growth and repair (Phillips 1994). Ensuring adequate and regular access to high carbohydrate foods provides a reliable energy source to carry out the soldiers' mission.

The fast changing geopolitical situation may increasingly require the Canadian Forces to react and deploy quickly with a greater reliance on the full range of combat rations to deliver food services to our troops (DND 2003). To meet the operational requirements and stressors, soldiers need access to adequate nutrition. The Canadian Forces requires Canadian-specific data to validate the composition and consumption of combat rations. There are no known military studies that compare dietary intake with menu offerings.

6.2 Specific aim

The purpose of the study is to determine the intakes of macronutrients and micronutrients of Canadian Forces soldiers when consuming combat rations on operations. The study is designed to compare combat ration intake of soldiers against combat ration menu offerings and Dietary Reference Intakes (DRIs) to determine nutritional adequacy.

6.3 Research objectives

The purposes of the study are to:

a. determine what food, beverages and supplements Canadian Forces members are consuming on exercise or deployed operations;
b. analyze the intakes of macro- and micronutrients of Canadian Forces soldiers when consuming combat rations;
c. analyze the macro- and micronutrients of the foods discarded before subjects go on operations;
d. compare food, beverage and personal food intake against combat ration menu offerings provided by DND;
e. compare nutrient intake between subjects who consume personal foods and those who do not;
f. compare intake of macro- and micronutrients to recommended nutrient intakes for operational environments;
g. validate food consumption survey data with sub-study of "waste-bag" method; and,
h. report pre-manoeuvre body weights, heights and waist circumference.

In addition the study will:

a. identify foods that are accepted, rejected and preferred, and
b. identify foods that are brought from "home" as personal foods.

6.4 Significance

The findings will be a basis on which to recommend food service policy and menu standard changes in the Canadian Forces to promote the most nutritious intake of combat rations for operational performance. Optimized consumption may result in better nutrition for soldiers, thus increasing their mission readiness.

7 Subjects and methods

7.1 Ethics

Approval of ethics by boards from McGill University and the Department of National Defence were received prior to starting the study. It is recognized that the military is a captive audience and special efforts to disassociate soldiers' participation from their duty requirements were made very clear. Written consent from all subjects was obtained (Appendix 2 and 3). McGill University Ethic's form is found in Appendix 4. The Department of National Defence's ethics approval is found in Appendix 5.

7.2 Subject recruitment

Soldiers and officers (of 2 Royal Canadian Regiment and 3 Princess Patricia Light Infantry) were briefed about the study and provided detailed instructions on how to participate. The soldiers' military status and active duty dictates their participation on a training exercise or operation. Military personnel were asked to participate in the study; however, it was made very clear that there was no institutional pressure to participate.

<u>Inclusion criteria</u>: Male soldiers who were operational, eating combat rations and taking part in operational rotations during the study period were included as potential subjects. Soldiers who are medically unfit were not permitted to deploy to the field, therefore enabling eligibility of all operational soldiers.

<u>Exclusion criteria</u>: Female soldiers were not included in this study since the low numbers in the CF (12.1%) and even lower numbers in combat arms units (1-8% depending on military occupation code) do not allow a significant representation with enough statistical power (DND 2004). One female infantry soldier participated in Exercise Narwhal but she was not included in the study.

7.3 Study design

This study was done in two parts – first, a pre-test in Wainright, Alberta and second, the larger study as part of Exercise Narwhal in Pangnirtung Nunavut. In both scenarios, male infantry soldiers were part of a military exercise during the data collection

The protocol included;

a. a pre-test during a military exercise;

b. evaluating 24 hr food records;

c. observing food waste in a stationary setting (base camp);

d. recording discarded food prior to exercise activity; and

e. calculating nutrient intake from food records.

In both settings, military subjects were surveyed about the foods, beverages and supplements they consumed during an operational setting. Feeding was provided from combat rations. A food intake questionnaire (Appendix 6) was used to record food consumption over the evaluation periods.

7.3.1 Pre-test setting

The pre-test was performed from 7 to 11 June 2004 in the Canadian Forces training area of Wainright, Alberta. The military exercise involved section attacks and field craft training. The weather was mild and sunny with temperatures around 20° C for 7 to 9 June and rainy with temperatures around 10C for 10 and 11 June. Soldiers lived in austere conditions, sleeping outdoors without tents and travelling on foot. All the soldiers' essential equipment for survival and performance of military tasks were carried in rucksacks weighing between 32 and 62 kg.

7.3.2 Pre-test design

The pre-test validated the study protocol and the reliability of self-reporting of a food intake questionnaire. Feasibility of the study was determined by evaluating logistical aspects, volunteer rates and time estimations. Two validation exercises to determine reliability and variability were completed and are explained below. The pre-test ensured completeness and ease of use for the self-reported questionnaire. Completed questionnaires were quantified for dietary intake and calculated for nutrients. A food intake questionnaire recorded either one or two 24-hr periods of food consumption.

Soldiers (n=72) were assigned to one of three groups depending on their Company/Platoon.

1. All subjects from A Company (n= 46) were to eat only the combat rations and not to supplement with other foods brought from home. This main group was subdivided into 2 groups to:
   a. determine within person variability: A Company 3 Platoon (n=26) was given (2) 24-hour self-reported food intake questionnaires for a total 2-day intake survey; and
   b. validate self-reported intakes: A Company, Platoons 1 and 2 (n=20) disposed of all their uneaten food and packaging waste in labelled bags for comparison to their 24-hour self-reported intakes.
2. The 26 subjects from C Company were given a 24-hour food intake questionnaire. This group was permitted to eat personal foods (Figure 3).

7.3.3 Waste bag measurement

To determine the validity of the self-reporting, researchers matched items in the labelled garbage bags with the responses in the questionnaire. Uneaten food from combat rations was weighed using a "Mettler" PE 6000 digital scale. The scale was calibrated with 3 kg of known weights from Quality Engineering and Test Equipment (QETE) and certified for limited use to ±0.2 g. (Appendix 7)

Reported intakes in the questionnaires were verified for agreement by using a chi-square test. There was no significant difference between reported food intakes and waste bag records (Appendix 5).

7.3.4 Exercise Narwhal setting

To situate the environment, Exercise Narwhal was a joint sovereignty exercise including the Army, Air Force and Navy and took place in Pangnirtung, Nunavut from 17-28 August 2004. As part of the scenario, troops searched for and collected fake debris from a failed foreign satellite launch, as well as escorted a fictional unauthorized foreign vessel from Canada's northern waters.

Over 250 military personnel, civilian researchers and media lived in the local elementary school for the exercise. For the purposes of the combat ration study, only personnel attached to the Army were included.

The food intake evaluation period was from 25 to 28 August 2004. The infantry performed operational rotations with full rucksacks and weapons. This essential gear weighed between 32 and 62 kg. Soldiers were on foot in the tundra with limited support from all-terrain vehicles operated by Canadian Forces Rangers. Foot travel was estimated at 5 to10 km in the mountainous region. The weather was cold and snowy in the mountains on 25 August with a low of –8°C and a high of 5°C. The 26-28 August period was cool and clear with temperatures from just under freezing to a high of 7°C. Soldiers slept on the tundra in bivy bags. As part of the exercise, some soldiers were required to board the HMCS Montreal on (Friday 27 Aug 04) and did consume fresh rations for one meal.

7.3.5 Main study - Exercise Narwhal

Military subjects (n=72) were surveyed about the foods, beverages and personal foods they consumed while deployed to the field. Subjects were assigned study numbers and were given two 24-hour food intake questionnaires to complete (for a total two-day intake survey). The 24-hour period was determined to start with the first meal the soldier ate while out in the field. Subjects were free to supplement with foods outside the combat rations provisions if they wished. They were instructed to include them in their consumption reporting. During the evaluation period no additional fresh supplementation was brought in. At this time, soldiers did not have access to the local economy of Pangnirtung.

7.3.6 Discarding combat rations

Soldiers were given 48 hours of combat rations the night prior to deploying to the field. The practice of "stripping rations" or discarding combat rations before packing them into rucksacks is done to lighten the infantryman's load and to exclude foods that he does not think he needs or will eat. The subjects put their discarded "stripped rations" into labelled bags so that "potential nutrients" not taken with them could be calculated. Researchers counted and logged the items by study number for input into CANDAT for nutrient analysis.

When a discarded main course or dessert was not recorded by type or name when logging information, the default was *Meatballs in Gravy* and *Strawberry Rhubarb Compote*. These selections were chosen because they represent the closest selection of a mean nutrient value for a combat ration menu choice. This occurred in 8 instances for the main meal and 90 times for the fruit desserts.

7.4 Anthropometric measurements

Anthropometric measurements included height, weight and waist circumference. The anthropometric measurements were used to assess Body Mass Index (BMI) and provide a value from which to estimate energy needs. All soldiers were measured in sock feet, T-shirt and combat pants.

In the pre-test, measurements were taken one day prior to the exercise in accordance with weight and height measurement protocol (Appendix 9) by a trained CF medical assistant using a Health-o-Meter balance beam scale, stadiometer (Boca Raton, Florida) and a non-stretch tape measure.

For Exercise Narwhal, the measurements were taken upon return from the exercise. The measures were done in accordance with weight and height measurement protocol by a trained Canadian Forces medical assistant and two dietitians using a wall measure for height with a removable headpiece, a SECA 812 digital scale (Hamburg, Germany) and a non-stretch tape measure. The scale was verified to manufacturer's tolerance against known weights at the CF Quality Engineering and Test Establishment (QETE).

Because the exercises were of a short duration, there likely was no fat or fat free-mass loss and any weight loss could be attributed to a change in hydration status. Thus, weighing subjects before or after the exercise would not make a difference in their normal body weights. It was not possible to obtain weight measures just before and just after the exercise in either setting.

7.5 Dietary intake measurement methods

The survey tool was a self-reported questionnaire with close-ended direct questions based upon menu items. Open-ended entries for additional foods, beverages and foods brought from home or outside of the combat ration provision (i.e. granola and energy bars, protein powders, sports drinks, vitamins) and water were included. Figure 4 provides an example of a page in the questionnaire.

All items in the combat rations are packaged with determined weights. This approximates weighed food records and "provides a solid basis for nutrient assessments" (Institute of Medicine 2000a). Subjects were instructed to complete the food intake questionnaire with respect to the type and to estimate the percentage quantity of combat rations items they consumed and to record all food eaten during the 24-hour periods.

7.6 ***Quantification of dietary intake***

The survey tool was a self-reported questionnaire with close-ended direct questions based upon menu items. Open-ended entries for additional foods, beverage and supplements brought from home or outside of the combat ration provision (i.e. granola and energy bars, protein powders, sports drinks, vitamins) and water were included. All foods included in the combat ration packs were coded and entered in S.I. measurements (metric weights) into the CANDAT v.5 nutrient analysis program (*Godin London Inc 1985-2000)*. Dietary analysis was performed using the CANDAT database. The nutrient analysis of foods specific to combat rations was added to the CANDAT database. The nutrient analyses of these combat ration-specific foods were either laboratory analyses for chemical composition or nutrient calculations the manufacturer provided. Where nutrients were missing, such as for folate, inferences were made using the Canadian Nutrient File. Commercially or commonly available foods were analyzed using the Canadian Nutrient File. When the actual main course meal was not indicated, in 2 cases in the questionnaire, and 8 cases in the discarded or "stripped" items, a default mean of *Meatballs and Gravy* was used as this meal was closest to the average nutrient values of the main meals offered. *Strawberry Rhubarb Compote* was used as the default dessert in 1 instance when dessert was not indicated in the questionnaire. This fruit dessert was used 90 times as the default dessert in the discarded rations, as the name of the dessert was not recorded in the logging.

Some conversions were required in order to compare vitamin A intakes to DRI requirements. Current nutrition labels still contain international units (IU) rather than being harmonized with the DRI measurement of retinol activity equivalents (RAE). To determine the RAE content of foods, IUs were converted as follows. First, the vitamin A source was determined to be of vegetable or animal origin. If the vitamin A source was of vegetable origin, the IU was divided by 20 to convert to RAE mcg. Animal origin vitamin A activity is contributed by retinol; therefore the RAE mcg is calculated by dividing the IU by 3.3. For mixed sources of vitamin A, the ratio of animal and vegetable source was determined, the RAE calculated for each source and then added together (USDA 2004).

DND provided a nutrient analysis of the combat rations for whole meals (Appendix 10). These tables were not used, as they do not list individual food composition. They use complete meals (everything in the package), which are homogenized and subsequently analyzed as one unit offering. The CANDAT database using the Canadian Nutrient file was used for comparison to soldier intake, because it was necessary to have data on individual foods and not whole meals as some soldiers only ate a portion of the complete meal.

7.6.1 Measurements

We calculated the nutrient intake per day for the following nutrients:

a. energy kcal;
b. protein g;
c. fat g;
d. carbohydrate g;
e. fibre g;
f. vitamin A RAE mcg;
g. vitamin C mg;
h. calcium mg;
i. iron mg; and
j. folate /DFE mcg.

7.6.2 Energy requirements

Using activity recalls estimating metabolic equivalents (METs) in order to convert to a physical activity level (PAL) in the total energy expenditure (TEE) equation resulted in implausible energy requirements. The TEE equation used by the Institute of Medicine is not compatible in estimating metabolic equivalents (METs) and converting to a PAL in active soldiers. The estimated energy requirements for this study were derived from the mean of doubly labelled water studies with particular attention given to the Canadian Forces arctic study by Hoyt and Jones (Hoyt, Jones et al. 1991). (See Appendix 1 as described in Literature Review).

7.6.3 Nutrient requirements and adequacy

The DRI values were used to assess adequacy of various intakes. Using the Estimated Energy Requirement (EER) of 4400 kcal/day/soldier, the macronutrient recommendations were based on the DRIs Acceptable Macronutrient Distribution Range (AMDR). The Acceptable Macronutrient Distribution Ranges (AMDRs) for adults are 45 to 65% carbohydrate, 10 to 35% protein and 20 to 35% fat (Institute of Medicine 2002) (Institute of Medicine 2003). The reference weight of 80 kg for a soldier established requirements for iron.

Estimated average requirement (EAR)s for carbohydrate, protein, iron, vitamin A, vitamin C and folate were used to establish cut-points and determine the percentage of subjects at risk for inadequate intake. The AI levels were used for fibre, calcium and potassium to assess the risk on inadequacy where possible. The UL was used to determine the risk of overconsumption for sodium. All the reference values are listed in Tables 1, 2 and 3.

7.7 Statistical analysis

CANDAT files and food intake questionnaire results were exported to the SAS Statistical Analysis v 8.02, 2001 program (*Cary NC)* via Microsoft Excel (Program). Descriptive statistics include means, medians and standard deviations. Student's t-tests were used to compare mean intakes between the combat ration only group and the combat ration and personal foods group. Significance was set at $p<0.05$.

To evaluate the adequacy of the diet using the cut-point method with EARs, statistical adjustments were performed to estimate the distribution of usual intakes after eliminating the effect of within-subject variability. The nutrient intake data were transformed, adjusted and then back-transformed on SAS v. 8.2 to estimate the between-person and within-person and total standard deviations for the group data. The adjusted distribution of intakes was then used to analyze and compare nutrient intakes at the group level to the Dietary Reference Intakes (DRI) (Institute of Medicine 2003). A chi-square test was used to determine agreement between waste-bag findings and reported questionnaire dietary intakes.

8 Results

The results section will highlight response rates, anthropometric data, and macronutrient and vitamin and mineral intakes of the two study groups. Two similar study sites were chosen; the first in Wainright, Alberta and the second in Pangringtung, Nunavut.

The main study, Exercise Narwhal, was a large-scale sovereignty exercise in Canada's arctic during the summer. Because of the remote location of the main study, difficult logistics and a compressed time line, the researchers wanted to ensure that all methodology and logistics had been carefully considered. Therefore, a pre-test was first conducted to validate methods and to ensure reliability and consistency in patterns. The sites were similar because they involved infantry training exercises where the subjects lived outdoors in temperate weather and were on foot.

At the first site in Wainright, subjects ate combat rations during the pre-test. They ate the Individual Meal Packs (IMP) and did not have access to the Light Meal Combat (LMC). Subjects, in A Company, were instructed not to bring any personal food with them. At the second site, Exercise Narwhal, subjects ate IMPs and LMCs and were free to consume personal foods.

Exercise Narwhal's results are examined. Then, a comparison between Exercise Narwhal and the pre-test are reviewed. Finally, the two studies are combined and discussed.

8.1 Respondents

The subjects were all healthy active male soldiers who ranged in age from 18 to 42 with a mean age of 26 years. The response rates of the pre-test and Exercise Narwhal are described below in Figures 5 and 6. Both the pre-test studies and Exercise Narwhal had final response rates of 69 and 92% respectively, with few dropouts.

8.1.1 Pre-test response rates

In Wainright, 72 soldiers initially participated in the pre-test study resulting in a volunteer rate of 95%. Questionnaires from 50 participants were collected for a completion rate of 69%. Even though there were no dropouts, 22 questionnaires were not retrieved due to the intense operations at the end of the exercise. The weather had turned rainy and cold and the pace of final operations was rapid and demanding. As a result, some questionnaires were lost (Figure 5).

8.1.2 Respondents Exercise Narwhal

In Pangringtung, 78 soldiers initially participated in the study for a volunteer rate of 63%. Questionnaires from 72 subjects were collected for a response rate of 92%. There were 3 dropouts in the study as the participants cited they did not think they were appropriate subjects since they remained in garrison (base camp) during the study and would not be as active. Three other questionnaires were not returned, as the participants were only accessible by helicopter (Figure 6).

8.2 Anthropometric data

Anthropometric data, such as height, weight and waist circumference can be used as a starting point for general standards and specific requirements, such as determining estimated energy requirements or body fatness. Subjects' measurements for height, weight and waist circumference were examined.

Body mass index (BMI=body weight in kg/height in m^2) and waist circumference are good indicators for health risks due to overweight and obesity in a normal population. The physical demands of a soldier make them akin to athletes with greater muscle mass and their BMI may be high even though body fat is not excessive (Witt and Bush 2005). The anthropometric characteristics from the 50 pre-test subjects (Table 4) and 72 Exercise Narwhal subjects (Table 5) were similar for age, height, weight, waist circumference and BMI. These subjects were healthy, robust young men.

The combination of a BMI ≥25 and abdominal circumferences ≥ 94 cm (in men) is associated with being overweight and poses greater risk for adverse health (WHO 2000; Zhu, Wang et al. 2002) . The above criteria from the World Health Organization indicate that 20% of Exercise Narwhal subjects were overweight even though 61% of Exercise Narwhal's subjects had a BMI≥ 25. Only 8% of the pre-test subjects fit the criteria of an abdominal circumference ≥94 cm and BMI ≥25. Using Canadian references for body weight classification indicates that 5.5% of Exercise Narwhal and 6% of the Pre-test subjects had waist circumferences >102cm and a BMI >30 (Health Canada. 2003) (Table 60). For future studies, other clinical measures such as skin fold tests or bioelectric impedance measurements may help in identifying the prevalence of excess body fat and whether overweight is a problem with infantry soldiers.

8.3 Exercise Narwhal nutrient intakes

Sixty-six percent of subjects included personal foods in their dietary intake during Exercise Narwhal and 24% did not. Table 1 describes the nutrient intakes of those two subgroups of subjects during Exercise Narwhal. The first group (n=48) of subjects ate combat rations and personal foods (CR+PF group). The combat rations consisted of Individual Meal Packs (IMP) and the Light Meal Combat (LMC). Personal foods could include any foods outside the combat menu offerings, such as snack items from home or foods bought on the local economy. All subjects were free to bring personal foods. The intake of nutrients derived from personal foods, combat rations and then totals of the two are separately categorized on the left side of Table 1.

The second subgroup (CR group) of subjects (n=24) ate only combat rations and chose not to consume any personal foods even though they were free do so. The midsection of Table 1 details the nutrient intakes.

The dietary reference intakes (DRI), energy estimates and nutrient composition of the total menu offerings are listed on the far right of Table 1.

8.3.1 Macronutrients

Soldiers involved in Exercise Narwhal performed operational rotations on foot with full rucksacks and weapons, resulting in an estimated energy expenditure of about 4400 kcal. Energy intake for both the combat ration and personal food (CR+PF) group and combat ration (CR) group were too low to meet the energy needs for activity performed. This corroborates earlier military studies that show soldiers do not eat enough. The mean macronutrient intakes for the CR+PF and CR groups respectively were 47% and 51% carbohydrate, 16% and 14% protein, 38% and 35% fat.

Fat. As a percentage of energy intake, mean fat intakes were higher than recommended for adult men and this may be a result of the high overall energy intake coming from solid food. Most diets include beverages containing carbohydrates, but participants' diets differed as they consumed few carbohydrate rich drinks (Gray-Donald, Jacobs-Starkey et al. 2000). When carbohydrate rich beverages like sports drinks or juice are consumed in a normal diet, it increases the proportion of carbohydrate represented as energy intake and reallocates the macronutrient distribution. (i.e. Drinks reduce the ratio of energy from fat and increase the percentage of energy from carbohydrate).

Carbohydrate. Personal foods contributed almost half of the carbohydrates to the CR+PF group's total intake. Despite that, the CR+PF group consumed a mean intake of 414 g carbohydrate, almost 100g carbohydrate /d more than the

CR only group, however, this difference was not statistically significant owing to the variability in individual diets.

Protein. All subjects exceeded the Estimated Average Requirement (EAR) of 0.66g/kg/d for protein. While both groups consumed adequate protein, those eating personal foods consumed a mean intake of 140 g protein, an average of 48 g more. Although this difference is statistically significant (t=0.010), there are no real nutritional benefits to consuming this higher protein diet. The fact that only half of the protein the CR+PF group consumed came from combat rations shows that protein rich personal foods such as energy bars, nuts/seeds, tuna and meat jerky are used to supplement combat rations (Table 1).

Fibre. Since fibre offerings in the IMPs and LMCs total 36 g, it would be difficult to meet the adequate intake (AI) level of 38 g fibre/d without eating all foods offered or with supplementation from personal foods. The mean total fibre intakes for both groups did not meet the AI levels. The soldiers consumed 20 g and 16.5 g fibre respectively. Because there are not many fruit and vegetable portions or other high fibre foods in the current IMP and LMC formulation, makes it difficult to consume the recommended amount of fibre.

8.3.2 Vitamins and minerals

Potassium. Both groups consumed potassium levels below the AI level of 4700 mg. Despite the CR+PF group consuming approximately 66% of their potassium intakes from personal foods, the total mean intake for this group was 3985 mg and still below the AI. Those consuming only combat rations had an intake significantly lower with an average of 1800 mg potassium (t=0.002). Since both groups mean consumption intakes were below the AI levels, no evaluation of the adequacy of intake for the groups can be made (Institute of Medicine 2000). For those nutrients with only AI levels provided, one can only be sure there is a low probability of deficiency if the mean value for the group is above the AI.

Sodium. Sodium intake for virtually all subjects was high. Sodium intakes for 64 of the 72 Exercise Narwhal subjects exceeded the tolerable upper limit (UL) of 2300 mg with the majority of sodium coming from combat rations. The UL is the highest level of continuing daily nutrient intake that is likely to pose no risk of adverse health effect (Institute of Medicine 2003) . There is great variability in the salt from sweat of individuals, making it difficult to set precise quantities of sodium required to replace lost electrolytes yet not exceed the needs for all military personnel (Consolazio, Matoush et al. 1963; Verde, Shephard et al. 1982; Sawka and Montain 2000; Noakes 2004). The literature is not definitive on the amount of sodium highly active people should consume, but it is known that for less active people, consuming above the UL increases adverse health risks (Institute of Medicine 2004).

Calcium. Both groups had mean calcium intakes below the AI value of 1000 mg, whether or not they supplemented with personal foods. Consuming less than 1000 mg of calcium does not necessarily indicate inadequacy as explained previously (Institute of Medicine 1997). The CR+PF group consumed significantly more - with a total of 849 mg ($p > 0.033$) calcium - than the CR group who consumed 579 mg of calcium. (Table 1) About 350 mg of calcium came from their personal foods in the CR+PF group.

Iron. Only 2 of the 72 subjects did not meet the estimated average requirement (EAR) of 7.8 mg for iron. The CR+ PF group consumed significantly more iron than the CR group, but both groups had high intakes of iron so this is not a factor for concern.

Vitamin A. Intakes for vitamin A could not be statistically adjusted to estimate the distribution of usual intakes from observed intakes for the two groups, owing to its very skewed distribution of intake; therefore, no comment can be made on the cut-point EAR of 625 mcg vitamin A RAE or the AI of 900 mcg vitamin A RAE. The raw means of the CR+PF group consumed 338 mcg vitamin A RAE, or about 100 mcg vitamin A RAE more than the CR only group, but this was not statistically significant. Vitamin A sources are derived from fruit, vegetables, and animal foods such as liver and egg yolk. Since it would be difficult to bring these fresh foods into the field, it is unlikely that soldiers would improve their vitamin A intake from personal foods. However, personal foods contribute almost half of the vitamin A intake, mostly coming from fortified sources like energy bars.

Vitamin C. Overall, vitamin C consumption was inadequate. Despite a high mean intake of vitamin C, 44% of the CR+PF group and 50% of the CR group did not meet the estimated average requirement (EAR) of 75 mg for vitamin C. As with the vitamin A, if there are no fresh fruits or vegetables available, it is difficult to consume adequate vitamin C – other than with the vitamin C fortified drink crystals.

Folate. The EAR of 320 mcg/d for dietary folate equivalent (DFE) was not met by 33% of the CR+PF group or by 48% of the CR group.

Overall, when the subjects consumed only combat rations their intakes met the EAR for protein and iron, but a large percentage of subjects did not meet the EAR for vitamin C and folate or the AIs for fibre, calcium and potassium. Virtually all subjects exceeded the UL for sodium.

8.4 Pre-test nutrient intakes compared to Exercise Narwhal nutrient intakes

Table 2 describes nutrient intakes during the pre-test. In Wainright, the combat rations for the pre-test consisted only of the Individual Meal Packs (IMPs) and did not include the Light Meal Combat (LMCs). The CR+PF group (n=10) ate combat rations and personal foods.

The CR group (n=40) ate only combat rations, as they had been instructed not to consume any personal foods. The following section serves to address the macronutrient, and vitamin and mineral intakes of the two groups. Table 2 mirrors Exercise Narwhal's format in Table 1, sequentially listing nutrient intakes from the CR+PF and CR groups with the DRIs and total nutrient availability from the combat menu offerings.

8.4.1 Macronutrients

As with Exercise Narwhal, the pre-test groups' energy intakes were found to be low for the level of activity, and the macronutrient distributions for both groups were almost identical (Table 2). Similar to Exercise Narwhal, the percentage of energy from fat in the pre-test was high at 35%. Fibre intake for both groups was also relatively low and did not meet the AI. The similarity in nutrient intakes in Exercise Narwhal and the pre-test demonstrate consistency in eating patterns when comparable groups are in different training situations.

8.4.2 Vitamins and minerals

Potassium and sodium. Potassium and sodium intakes for both the pre-test group and Exercise Narwhal group were similar. Virtually all subjects were above the UL for sodium, which is believed to be a level at which the normal population starts to have risks associated with overconsumption, but the UL is not based on highly active people and thus may not be accurate for soldiers engaged in exercises. Most of the sodium was derived from combat rations but the addition of personal foods increased total sodium intake. For the pre-test, the difference in sodium intake between the CR+PF and CR groups was not significantly different (p=0.051).

Calcium. Without a good source of calcium in the combat rations, pre-test group means were below the AI level and, as expected, not different to Exercise Narwhal.

Iron. Personal foods contributed to increased iron intake (Table 2) but this difference was not statistically significant (p=0.053).

Vitamins A and C and folate. As with Exercise Narwhal, personal foods contributed to total vitamin A intake. Despite means that appear adequate for vitamin C, 20% of CR+PF group and 35% of the CR group did not meet the EAR of 75 mg vitamin C after adjusting for normal distribution. The EAR is not used as an individual intake goal but as a cut-point method to assess the dietary adequacy of a healthy group. For individuals, usual intake at this level is associated with a 50% risk of inadequacy. Folate DFE intake was higher for the pre-test groups than Exercise Narwhal. Even so, the adjusted means for the pre-test study show that 20% of CR+PF group and 18% of CR group did not meet the EAR of 320 mcg for folate (Table 2).

8.5 Combined research site data

With similar nutrient intake data, anthropometry and austere training situations, Exercise Narwhal and the pre-test data were pooled to increase the sample size and statistical power. The t-test comparing the pooled CR+PF and CR groups indicates that the differences in nutrient intake are statistically significant for all but fibre and vitamin C (Table 3). The data show that personal foods supplemented the combat rations offerings and provided extra energy, protein, fat, calcium, iron, potassium, sodium, folate and vitamin A. The increased consumption of ~800 kcal of energy in the CR+PF group appears to be derived from foods high in protein and fat, as those nutrients are also significantly higher. Almost half of the protein and fat intake was derived from personal foods in the CR+PF group. As vitamin C rich products are found in fresh fruits and vegetables and would be difficult to include with personal foods, intake is not significantly higher in the CR+PF group. Subjects who ate personal foods in addition to the combat rations consumed more nutrients overall.

8.6 The top ten foods contributing to nutrient intake

To define the individual food sources of nutrients in the diet, an analysis was done to rank the foods in terms of quantity of nutrients consumed for the two groups: Exercise Narwhal and the pre-test (Table 8). Both study groups obtained the bulk of their nutrients from similar food sources. To show where the greatest proportions of nutrients come from, the top ten foods are ranked for each nutrient category (i.e. Calcium, with the top ten foods providing that nutrient). The left-hand column lists the food rank according to nutrient consumption during Exercise Narwhal with the food in the adjacent column. The "per subject" heading in column 2 is the value obtained by dividing the total nutrient amount consumed by all 72 subjects to determine an average nutrient amount consumed per subject. Under the heading "Pre-test rank", is listed the ranking of that food compared to where it ranked in the pre-test. The most right-hand column lists the food item and rank within the pre-test.

The contribution of food to nutrient intake at the group level is related to the frequency and portion size of the foods. If a food is eaten in smaller portions or infrequently, the food contribution to that nutrient and to the total diet may be minimal, despite the food being a good source of the nutrient. For example, *Crunchy Cereal Type 3* offers 176 mg calcium per 50 g serving but only supplies an average of 32 mg/subj/d (Table 8) because only a fraction of the soldiers ate this food during the study. In contrast, food consumed in large quantity and frequency may be an important source of a nutrient, despite having a small amount of that nutrient in a food – example, candy bars. Chocolate/Candy bars are eaten frequently and therefore provide considerable amounts of energy, carbohydrate and fat – nutrients expected from a candy bar. However, because of the quantity of candy bars consumed, they also provide significant calcium, folate and fibre – nutrients not normally associated with candy bars. When examining the food list and corresponding nutrient contribution, it shows that some foods which are not well recognised sources of a particular nutrient may provide a considerable amount of some nutrients such as the chocolate/ candy bars providing calcium and folate or peanut butter providing fibre.

Chocolate/candy bars are frequently listed as one of the top ten foods providing a significant proportion of the diet's energy, carbohydrates, calcium, folate, fat, fibre, potassium and vitamin A. All foods eaten were analyzed individually and not grouped by like item. However, if the individual types of candy bars were grouped under one heading, the impact would appear even greater. The high frequency of menu exposure and consumption make chocolate/candy bars, normally thought of as a nutrient-poor food, a popular food and results in significant food value to the combat rations. The chocolate/candy bars do not offer major nutrient contributions for iron, sodium and vitamin C. Another food that offers nutritional impact to the soldiers' diets is peanut butter, as it provides significant food value and is listed in the top ten for energy, protein, fat, fibre, folate, iron and potassium.

Most subjects consumed bread. Bread appears in the top ten lists of nutrients for providing energy, protein, fat, fibre, sodium and iron on a per subject/d basis. The folate-enriched bread provides between 112.8 and 216.4 mcg dietary folate equivalents (DFE) per subject. The pre-test group consumed more bread per subject than the Exercise Narwhal group, explaining the greater percentage of folate contribution from bread. Despite bread ranking in the top for providing carbohydrate, it averages between 16 and 30 g carbohydrate/d/subject – a small contribution when the aim is to consume ~500+g carbohydrate /d. Main meals were the largest contributors to sodium in the diet. The foods providing the most sodium were pepperoni, macaroni and cheese, spaghetti, turkey stew, cheese tortellini, beef jerky and *Ritz Bits* crackers. The high-sodium instant soup mixes are absent from the list because they were rarely consumed. Overall, the foods frequently listed in the top ten items of various nutrients offer more nutrient density to the diet. Replacing or enhancing foods frequently eaten with a higher level of nutrient density can improve overall nutrient intake.

8.7 Discarded rations

Before soldiers head to the field, they will discard or "strip" combat rations they believe are not beneficial to them – this can be food and packaging considered too heavy, unpalatable foods, foods that are time-consuming to prepare or to eat. During Exercise Narwhal, soldiers stripped 1017 g ±463 of combat rations, lightening their food load by about 500 g/d (not including packaging). By analyzing the food that was left behind, it is estimated that soldiers do not have access to many nutrients such as an extra 1367 kcal/d of energy or 245 g/d of carbohydrate. In other words, if food is stripped from their rucksacks before leaving for the field, they cannot eat it. The nutrient analysis of the stripped foods for a day per subject is summarized in Table 10.

The most commonly stripped foods – whether ranked by frequency, energy or carbohydrate content - were foods in small packages containing simple sugars such as jams, honey, sugar and condiments. None of the condiments offered any significant food value. Subjects complained the condiments were fiddly and weighed too much. The frequencies that the items were discarded are listed in Table 9.

Drink crystals were discarded 49 times and hot chocolate 41 times. This contributes to a loss of potential nutrients, as drink crystals and hot chocolate were ranked high for providing energy and carbohydrates. They would have ranked higher had people wanted to use them. Bread was discarded 37 times, yet bread was a major contributor of energy, carbohydrates, fat, protein, fibre, folate, potassium and iron in the diet (Table 9). This suggests that there is more bread in the combat rations than a soldier will eat. Foods requiring preparation time such as rice, potatoes and pudding were also discarded frequently (33, 38, 34 times respectively) even though they were less frequently provided in menu offerings. It is difficult to determine exactly how many times each soldier would have been offered the specific food item, but the side dishes of rice and potatoes are offered a total of 7 times in 17 menus and pudding is offered only twice. Soldiers complained the small and clumsy packaging such as with the rice, potatoes and pudding were annoying to prepare, generated too much garbage and took too long to be ready.

8.8 Nutritional adequacy of combat rations (as provided) versus recommended intakes

The following addresses the overall adequacy of the combat rations compared with recommended intakes. The nutrient requirements were determined in several of ways. Estimated energy expenditure of 4400 kcal is derived from the literature, with the acceptable macronutrient distribution ranges (AMDR) calculated from this figure. Based on the Institute of Medicine's Dietary Reference Intakes, the estimated average requirement (EAR) for iron (adjusted for athletes), vitamin A, vitamin C and folate were set as target nutrient intakes. When EARs were unavailable, adequate intake (AI) levels were used to assess nutrient sufficiency for calcium, fibre, potassium and sodium. The upper tolerable limit (UL) was also used as a cut-off for sodium. The target nutrient intake amounts are located in the mid column of Tables 1 and 2. The nutrient analysis of the combat rations are listed on the rightmost columns of Tables 1 and 2 – where the Individual Meal Packs (IMP) and Light Meal Combat (LMC) are listed separately and then combined for a total.

When the IMPs and LMCs are offered together, the total nutrient profile of the combat rations improves and is adequate for most nutrients but too high in sodium. The potential energy offering increased to 5571 kcal and the macronutrient distribution for protein, fat and carbohydrates is 12%, 31% and 61% respectively. The total fibre offering increases to 36g and vitamin A to 475 mcg vitamin A RAE. The IMP and LMC combination increases the potassium offerings and puts the potassium to sodium ratio to 1:1.77 which is still below the recommended ratio of 1:1 (Institute of Medicine 2004).

However, when only IMPs are offered, as in the case of the pre-test, the IMPs alone do not meet the estimated energy requirement of 4400 kcal by ~360 kcal. IMPs, independently, do not provide sufficient fibre at 28 g/d. The DRI AI of 38 g fibre/d is based on 14g fibre/1000 kcal/d with for a reference 2700 kcal diet (Institute of Medicine 2002). Using a target energy intake of ~4000 kcal/d for soldiers corresponds to 56+g of fibre/d. Extrapolating the DRI recommendations for fibre to extremely high-energy intakes would result in amounts of fibre that would be difficult to consume in an omnivorous diet and impracticable in situations where access to water may be limited. With only 814 mg/d of calcium and 4021 mg of potassium potentially available in the IMP, individuals would likely not meet AI levels even by consuming the entire IMP but would exceed the UL for sodium by over 5000 mg. However the DRIs for sodium are set to a sedentary population and not for situations of heat acclimatization, heavy workloads and high sweat rates where extra sodium may be tolerated (Institute of Medicine 2004). If the IMPs are to be used without LMC supplementation during operations, the nutrient profile needs to be enhanced to include more fibre, calcium and potassium to improve the probability of consuming the necessary quantities of these nutrients with less food. Although the nutrients are present when both IMPs and LMCs are offered, they are not consumed in their entirety, putting soldiers at nutritional risk if these rations are eaten on a continual basis.

9 Discussion

Combat rations feed military personnel when fresh food is unavailable or impractical. This study is aimed at determining the intake of food, beverages and supplements in an operational environment and comparing this to combat ration menu offerings and nutrient recommendations. Through the analysis of dietary intake questionnaires, the nutrient intake of soldiers was measured.

Anthropometric measurements as assessed by BMI and waist circumference indicate an adequately nourished group with lower prevalence of overweight than the general Canadian male population. Seven percent of Exercise Narwhal and 6% of the Pre-test subjects' had a BMI>30 combined with a waist circumference >102 cm compared to 10.9% and 24.2% of Canadian men aged 20 to 24 years and 25 to 34 years respectively who were obese (BMI≥30) (Statistics Canada 2005). Being below the national average for overweight is likely due to the physical nature of a soldier's work and having more muscle mass. Obesity is a known risk factor for a number of serious diseases such as cardiovascular diseases, hypertension, type 2 diabetes, dyslipidemia and gallbladder disease (Birmingham, Muller et al. 1999). While the Canadian Forces study population is leaner than the Canadian population, there is still risk associated with obesity and feeding plans must consider this.

9.1 Assuring accurate dietary evaluation

Estimating dietary intake can be done in numerous ways although accurate reporting of food intake is disputed in nutrition research (Westerterp and Goris 2002). The research design in this study minimized errors for estimating energy and nutrient intake (Hulley 2001). We reduced errors in nutrient intake estimation by validating a dietary intake questionnaire, using standardized food package weights, and comparing package waste with intake questionnaires.

Reported food intake was validated for agreement with the waste bag (modified "tray-return") method (Forbes-Ewan, Morrissey et al. 1989) in the pre-test to reduce the error of under- or over-reporting (Beaton 1994; Westerterp and Goris 2002). Soldiers recorded the food they consumed in the questionnaires and then deposited all packaging and any leftover food into bags labelled with their study numbers. Each waste bag was compared to the intake questionnaire and any food waste was weighed. Examining the completed questionnaires with packaging and food waste showed good agreement with chi-square tests and provided confidence in the accuracy of the reporting.

Subjects recorded 2 days of food intake with known portion weights, reducing the sources of error and bias and maintaining between-subject variation (Nelson, Black et al. 1989; Tarasuk and Beaton 1991; Beaton 1994). As questionnaires included all combat menu choices, any misinterpretation of food items or portions eaten was minimized.

The similar intakes from both the Exercise Narwhal and the pre-test groups suggest homogeneity and consistency in patterns, thus strengthening the argument for adjusting the combat ration formulation to meet the needs of the infantry soldier.

In order to have the most appropriate nutrient composition data, we examined data provided by the Department of National Defence (DND). A homogenized whole meal laboratory nutrient analysis was performed for DND but it indicated higher values than CANDAT nutrient analysis for most nutrients other than iron, potassium, sodium and vitamins A and C. There were discrepant values between calcium and fibre in comparison with the nutrient analysis by CANDAT. Considering that the laboratory analysis was done using a homogenized whole meal, this information could not be attributed to individual foods and was of little value in a comparison with the foods the subjects ate.

Since this information was of little practical significance, all foods including those specially packaged for DND and those commercially available were separately entered into the CANDAT database. The nutrient analysis for foods specially packaged for DND was either provided by the manufacturing company's laboratory analysis or their calculated nutrient composition. Missing values for folate DFE were calculated based on the Canadian Nutrient File. Some manufacturers' reports still used the International Unit for vitamin A; therefore converting to the currently used standard of measuring vitamin A in retinol activity equivalents (RAE) was required. Using the United States Department of Agriculture's (USDA) protocol for determining animal and vegetable sources of vitamin A, IU was transformed to RAE. Using the Canadian Nutrient File for commercially available foods and laboratory nutrient analysis for retort pouches packaged for DND provided the best food composition database available to estimate nutrient intake and reduce bias (Beaton 1994).

9.2 *Inadequacies and suggested areas of improvement*

Adequate food intake during military operations is important for operational performance. Optimized consumption of combat rations may result in better nutrition for soldiers thus increasing their combat readiness (Jacobs , van Loon et al. 1989).

The subjects' intake means were statistically adjusted to estimate the distribution of usual intakes after eliminating the effect of within-subject variability. Transforming, adjusting and back-transforming the nutrient intake data allowed estimating the between-person, within-person and total standard deviations for the group data. Using the adjusted distribution of intakes permitted analyzing and comparing nutrient intakes at the group level to the Dietary Reference Intakes.

As assessed from the dietary intake questionnaires, the estimated intakes of protein, fat and iron were adequate as compared to the dietary reference intakes (DRI) (Institute of Medicine 2002). Intakes for energy, carbohydrate, fibre, potassium, vitamin C and folate were below the DRIs suggested for healthy populations. Subjects may not be consuming adequate amounts of calcium and vitamin A because combat rations do not offer nutrient levels that provide for a secure level of intake. Intake for sodium was well above the UL– a level suggested for healthy people rather than a level to sustain the high sweat rates from strenuous work that military manoeuvres can generate, especially in hot climates (Forbes-Ewan, Morrissey et al. 1989).

A deficit in energy intake by soldiers generally has negative effects on lean body mass, physical performance, and defence against infection (Marriott 1995). Despite the subjects bringing personal foods, their energy intake was still below the estimated expenditure of ~4300 kcal/day in the arctic (Jones, Jacobs et al. 1993). The arctic compounds the underconsumption challenge, as decreased availability of fluid water leads to decreased total food consumption (Edwards and Roberts 1991). In contrast, heat and sweating may increase nutritional requirements compared to thermoneutral environments and require measures to counter heat-induced anorexic effects (Friedl and Hoyt 1997). A review of studies with military subjects shows remarkable similarity in estimating a mean energy requirement of ~4300 kcal/day. As described in the Literature Review, see Appendix 1 for full synthesis of the studies.

Optimizing carbohydrate as a fuel choice provides the best metabolic insurance to maintain muscle glycogen stores and the capability to endure sustained operations. The dietary reference intakes (DRI) acceptable macronutrient distribution ranges (AMDR) of 45% to 65% of energy as carbohydrate translates to 495 to 715 g/carbohydrate/day for an EER of 4400 kcal, and compares with Jacobs recommendations of 580g carbohydrate/day for soldiers and 7-8g carbohydrate/kg/day (Jacobs, van Loon et al. 1989; ACSM

2000; Institute of Medicine 2002). When extra carbohydrate is consumed at mealtime and better yet during exercise, endurance-exercise performance improves (Friedl and Hoyt 1997). For the military, applying these feeding practices can delay fatigue after eating a mixed meal or using a carbohydrate-electrolyte drink during extensive labour (Chryssanthopoulos, Williams et al. 2002).

Increasing total energy and carbohydrate intake with a carbohydrate beverage supplement such a "power shake or instant breakfast" type drink may achieve a performance edge and provide best value for energy (kcal) (Friedl and Hoyt 1997; Bell, McLellan et al. 2002). Since the carbohydrate-rich potatoes, rice and puddings are frequently discarded, a large and palatable baked product such as crackers, banana bread, cereal bar or trail mix would satisfy soldiers' requests for foods that are easier to consume.

Modifying dietary offerings to increase the availability of nutrients such as fibre, potassium, calcium and vitamin A to meet or exceed the AI levels increases the probability of consuming adequate nutrients. The difficulty of defining individual requirements and usual intakes does not allow us to estimate individual level inadequacies (Institute of Medicine 2000a) and therefore dietary intake planning must be executed at the group level (Institute of Medicine 2003).

Fibre is a nutrient inadequately represented in the combat rations. For example, the recommendations for dietary planning would provide at least 38 g of fibre within the combat ration menu. Fibre delays gastric emptying and possibly reduces post-prandial blood glucose concentration (Holt, Brand et al. 1992; Jenkins, Vuksan et al. 1998; Institute of Medicine 2002) and could help maintain stable blood glucose levels and thus delay fatigue (Coggan and Coyle 1987; Bell, McLellan et al. 2002). With soldiers consuming a relatively higher fat diet, fibre's benefits of interfering in the absorption of dietary cholesterol and the enterohepatic re-circulation of bile acids may lower blood cholesterol concentrations (Institute of Medicine 2002). In an environment of increased stress, altered hormones can increase the risk of cardiovascular disease (Friedl, Moore et al. 2000) and compound the long-term effects of a diet high in fat (Institute of Medicine 2002). Despite the suggested safety of diets in excess of 10-12 g/day/1000 kcal of dietary fibre (Institute of Medicine 2002) high fibre intake could interfere with tactical mobility of soldiers in situations where water availability is limited and frequent bowel movements are undesirable.

More fruit and vegetable sources could increase the potassium offerings from ~4000 mg in the Individual Meal Packs (IMP) to at least meet the AI of 4700 mg. The bicarbonate-yielding organic anions found in fruit and vegetables neutralize diet-derived non-carbonic acids, which are generated from sulphur containing amino acids found in meats and other high protein foods. When potassium is added in processed foods, the conjugated anion is typically chloride, which cannot act as a buffer (Institute of Medicine 2004). Moderate potassium deficiency is characterized by increased blood pressure (Khaw and Barrett-Connor 1990), salt sensitivity (Morris, Sebastian et al. 1999), bone cell turnover (Tucker, Hannan et al. 1999; Maurer, Riesen et al. 2003) and increased risk of kidney stones and cardiovascular disease, especially stroke (Khaw and Barrett-Connor 1987; Tanaka, Schmidlin et al. 1997).

Combining the IMPs and Light Meal Combat (LMC) improves the potassium to sodium ratio to 1:1.77, but the increased risk of kidney stones related to the urinary sodium to potassium ratio remains (Cirillo, Laurenzi et al. 1994). High sweat rates in hot climates can also increase potassium losses and therefore increase the requirements (Institute of Medicine 2004). Increased potassium intake can blunt the increased blood pressure effect from sodium (Whelton, He et al. 1997), however, data are unavailable to set recommended potassium intakes in accordance with sodium intakes.

Since vitamin A intake distributions could not be normalized to compare to the estimated average requirement (EAR) of 625 mcg vitamin A RAE, a cut-point to assess risk of deficiency was not possible. As IMPs do not provide vitamin A in levels to reach the EAR nor the adequate intake (AI), it is suggested that many individuals may not be meeting requirements. When vitamin A intakes of soldiers eating combat rations are below the AI levels of 900 mcg vitamin A RAE, we cannot assume or conclude adequate or inadequate intakes as found in normal free-living dietary patterns (Institute of Medicine 2001).

There is great variability in the development of the deficient state since liver stores of vitamin A are dependent of the subject's diet (Wolf 2002) and the vitamin A deficient state rarely occurs in developed countries (Tanumihardjo 2004). There is a protection against a vitamin A deficiency for approximately 4 months while the person consumes a vitamin A-deficient diet (Institute of Medicine 2001) . Subclinical deficiency can show impaired retinal function (Smith and Steinemann 2000) and may be exhibited at serum retinal levels of 20 to 29 mcg/dL (Gibson 1990). An EAR of 300 RAE mcg/d has been used to correct dark adaptation (Institute of Medicine 2001). Night blindness is the first ocular symptom to be expressed with vitamin A deficiency (Harris, Loewenstein et al. 1998) which could be disadvantageous in performing military night operations. Adequate intake of vitamin A is required for normal vision, gene expression and immune function (Institute of Medicine 2001). By increasing dairy products and fruit and vegetables, the sources of vitamin A could increase to meet the EAR levels. The level of adequate vitamin A intake could not be estimated because subjects' intake means could not be normalized with statistical methods in order to compare mean dietary intakes.

If subjects ate everything in the IMPs, total calcium intake would be 800 mg and would not likely meet the AI levels of 1000 mg unless supplemented with personal foods. Reduced bone mass and osteoporosis are the effects of chronic calcium deficiency resulting from inadequate intake (Murray 1996). If inadequacies at the individual level are unknown (Institute of Medicine 1997), then planning for a secure level of at least 1200 mg of calcium ensures better access to the AI level. Increasing the relative portion size of calcium-rich products and dispersing more calcium sources throughout IMP food choices would improve the possibility of adequate intake.

The EAR cut-point method allows one to examine the probability and the risk of not obtaining adequate amounts of nutrients (Institute of Medicine 2000). Increasing the mean intake of vitamin C and folate requires broadening the distribution of foods containing those nutrients The DRIs suggest moving the usual intakes distribution curve so that only 3% of the group would be at risk for inadequacy. Since the IMP vitamin C-fortified drink crystals are the principal source of vitamin C, soldiers are likely not getting adequate intake if they are not using the crystals. Vitamin C functions physiologically as a water-soluble antioxidant by virtue of its high reducing power and as it is not produced in the human body (Institute of Medicine 2000), a broader range of vitamin C sources in the IMPs are required to plan for an assured level of intake.

Considering that folate intake sources seen in the study are primarily from folic acid enriched flour in the bread, spreading out folate sources by increasing fruit and vegetables and baked products may increase overall folate intake. Moderately elevated homocysteine concentrations may be the first biochemical marker of insufficient intracellular folate (Booth, Coad et al. 2003). Homocysteine is identified as an independent risk factor for cardiovascular disease and is inversely related to folate status (Boushey, Beresford et al. 1995; Selhub, Jacques et al. 1995).

In light of the unexpected high macronutrient distribution of fat in the subjects' intake, capturing the type of fat consumed would have been beneficial for future menu planning and risk assessment.

9.3 Recommendations for adequacy

The nutrient density of IMPs needs to be increased, to ensure that all dietary reference intakes (DRI) can be met. Too often, foods contributing significant nutrients are not necessarily identified as high nutrient sources as seen in the "top ten foods" table (Table 8). By offering the IMPs and LMCs together, the total nutrient profile of the combat rations improves with potential energy at ~5500 kcal, fibre at 36 g and potassium at ~5000 mg. As seen with the extent of discarded or "stripped" foods before going to the field, simply increasing the quantity of menu offerings does not translate to consuming enough food. Individuals choose what they think they need and do not necessarily make appropriate choices. As a result, a majority (78%) of Exercise Narwhal subjects did not meet the target amount of ~580 g carbohydrate/day for military manoeuvres (Jacobs, Anderberg et al. 1983; Jacobs, van Loon et al. 1989). The reality of soldiers discarding or "stripping" rations needs addressing. Since many potential nutrients are thrown out, such as the rarely consumed potatoes, rice and puddings, these nutrients need replacing with foods that soldiers will eat under operational requirements.

Increasing the nutrient density of the combat rations must be done without increasing weight or awkward packaging. LMCs should provide supplementary energy, carbohydrate and other nutrients above the DRI rather than their current use of "making up the difference" for the deficiencies in the IMPs. By providing adequate levels of potential intake, the IMPs could be a stand-alone item.

Further research is required to determine appropriate levels of sodium intake for soldiers – especially with varying levels of physical output. The risks such as hypertension, stroke and coronary artery disease, calcium excretion, kidney stones and gastric cancer associated with consuming above the UL are set out for a normal or even sedentary population (Institute of Medicine 2004). Research has focused on sodium and fluid replacement in athletes during exercise (Brouns 1991; Noakes 2004) and encourages athletes to consume sports drinks when exercising for long periods of time and in hot weather (ACSM 2000; Burke 2001). Sweat sodium losses are dependent on the rates of sweating, and sodium intake (Allsopp, Sutherland et al. 1998) and lessen with heat acclimatization (Sawka and Montain 2000). A practical military application would provide vitamin C fortified sports-type beverages to supplement carbohydrate and sodium intakes when labouring in hot climates – thus creating a self-adjusting type model. The greater palatability of sports beverages compared to plain water increases overall fluid (Burke 2001; Bell, McLellan et al. 2002) which may help avoid hyponatremia (ACSM 2000). It is theorized that hyponatremia occurs when either there is a salt depletion with dehydration or there is a fluid overload and dis-equilibrium with sodium in a "third space" such as intestinal lumen (Speedy, Noakes et al. 2001). There is a risk of hyponatremia when soldiers are working and acclimatizing in tropical weather or on long route marches (Montain 2001; Speedy, Noakes et al. 2001). There is unresolved controversy in the literature concerning the definite quantities of fluid and sodium required by persons exercising or labouring in hot or cool climates (ACSM 2000; Noakes 2004).

As combat rations are shelf stable for three years and meant to be used worldwide – from the arctic to the tropics – determining an appropriate level of sodium not associated with the adverse risks of exceeding the UL is required for maximum versatility. Usually, increased food and energy intake corresponds with increased and compensatory sodium intake but this inference may not be true as appetite can decrease when working in the heat. Apportioning sodium to drinks consumed more readily in hot environments with high rates of sweating could decrease the risk of excess sodium consumption by a group that is less active in cooler climes. Unlike the recommendations to disperse the nutrient distribution throughout the menu offerings, sodium should be concentrated in foods or drinks that will be consumed only when there is a high rate of sweating or acclimatizing to heat. Reducing overall sodium in the IMPs and supplementing sodium with a vitamin C fortified sports-like drink when there is heavy physical output would likely reduce the risk for less active soldiers and provide for heavy labour and heat acclimatization.

10 Conclusions

The purpose of the study was to assess dietary intakes of male infantry using 24-hour food questionnaires. The study examined the relationship between dietary intake of combat rations and requirements and investigated which foods provide specific nutrients to their diets with a focus on nutrient dense foods. This is the first known study to compare soldiers' nutrient intake to what is offered in combat rations. Studying this disparity increases the understanding of what soldiers will consume and may help identify ways of increasing their total nutrient intake and improving operational effectiveness.

As a percentage of energy intakes, the macronutrient distribution was within the Acceptable Macronutrient Distribution Range (AMDR) for protein and carbohydrate but above the range for fat. The mean intakes of these men met or exceeded the Dietary Reference Intake (DRI) recommendations for protein, fat, iron. Sodium intakes were above the tolerable upper limit (UL). Target levels for energy and carbohydrate were not met. A significant percentage of subjects did not meet Estimated Average Requirement (EAR) for vitamin C or folate. As the mean intakes for calcium, fibre and potassium were below the AI levels, individual risk cannot be assessed. However, to provide for a secure level of intake, the diet needs to offer nutrient levels above the AI levels by dispersing the nutrients in various foods.

Subjects who brought personal foods consumed more nutrients overall. Thus, personal foods are supplementing and not replacing combat rations. The personal foods appeared to be high in energy, carbohydrate and fat and provided additional calcium, potassium and folate.

The diets' nutrient distribution showed that the main components of the combat ration – the main meals, fruit desserts, chocolate bars and crackers were consumed in high volume and frequency and provided the main source of energy, carbohydrate, fat and protein. Micronutrient intakes were generally poor and attributed to a lack of dairy, fruit and vegetable sources.

Overall, soldiers do not eat enough on operations. They do not consume enough carbohydrate for optimum performance. Soldiers need easy to-transport food higher in complex carbohydrates in the form of a very large bar (granola, energy etc), trail mix and more pasta choices. They do not want to be encumbered with lots of packaging or any preparation of food.

Soldiers' metabolic demands increase with the rigorous conditions of military operations and must be planned for when providing food. We recommend increasing the quantity of easy-to-eat foods high in energy, carbohydrate, calcium and potassium and moderate in fibre. Overall sodium content of the combat rations must be reduced. Foods need to be practical to promote eating them. This means they need to have minimal packaging, be easy to carry in a pocket and be of high nutrient density. Optimizing nutrition for combat readiness will depend on accepting and consuming convenient and portable foods.

11 Glossary

11.1 Abbreviations

AMDR Acceptable Macronutrient Distribution Range

AI Adequate intake

CF Canadian Forces

CR Combat ration

CR+PF Combat ration plus personal food

CRP Combat Ration Program

CSD commercial sports drink

DND Department of National Defence

DRDC Defence Research and Development Canada

DRI Dietary Reference Intakes

EAR Estimated Average Requirement

IMP Individual Meal Pack

LMC Light Meal Combat

PF Personal food

UL Tolerable Upper Intake Level

11.2 Definitions

<u>Acceptable Macronutrient Distribution Range</u>: The AMDR is defined as a range of intakes for a particular energy source that is associated with reduced risk of chronic disease while providing adequate levels of essential nutrients.

<u>Adequate Intake</u>: When scientific data are inadequate to identify an EAR (and therefore to set an RDA), an AI is set as a recommended intake. The AI is based on experimentally determined approximations or estimates of observed median intakes of a group or groups of healthy people. The AI is expected to meet or exceed the amount of a nutrient needed to maintain a defined

nutritional state in essentially all members of an apparently healthy population; it is therefore used as an intake goal for individuals.

Combat Ration Program: is the DND program under the Directorate Logistics Business Management/Food Services (DLBM/Food S) for the design, development, procurement and distribution of combat rations.

Combat ration: is a shelf-stable primary alternative to a freshly prepared meal and are used when it is not feasible or practical to feed fresh rations. Canadian Forces combat rations are shelf stable for three years.

Estimated Average Requirement (EAR): The EAR is the median requirement for a specified criterion of adequacy for members of a life stage/gender group. When usual intake is equal to the EAR, half the individuals in a life stage/gender group would meet their requirement and the other half would not. For this reason, the EAR is not used as an intake goal for individuals: usual intake at this level is associated with a 50% risk of inadequacy.

Individual Meal Pack (IMP): is a self-contained shelf-stable meal (breakfast, lunch and supper) and intended to provide a nutritionally adequate diet for up to 30 days without supplementation with fresh rations. IMPs contribute between 3600- 4100 kcal/day. The main entrée is packaged in a retort pouch.

Light Meal Combat (LMC): is used to supplement IMPs when extra caloric intake is warranted and can substitute the IMP for up to 48 hrs when the situation precludes carrying, preparing or disposing of IMP components.

Tolerable Upper Intake Level (UL): The UL is the highest level of daily usual nutrient intake that is likely to pose no risk of adverse health effects for almost all individuals in a life stage/gender group. As intake increases above the UL, the potential risk of adverse effects increases. The UL is not a recommended level: there are currently no established benefits for healthy individuals of consuming intakes above the RDA or AI. Instead, the UL is an intake that individuals should plan to remain below.

Underconsumption: "food intake that has been documented to provide fewer calories than required by energy expenditure on an individual or group basis. Use of the term underconsumption …assumes a longer-term risk of undernutrition if it persists over a longer period of time" Not eating enough (Marriott 1995)

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Figure 1 Picture Individual Meal Pack (IMP)

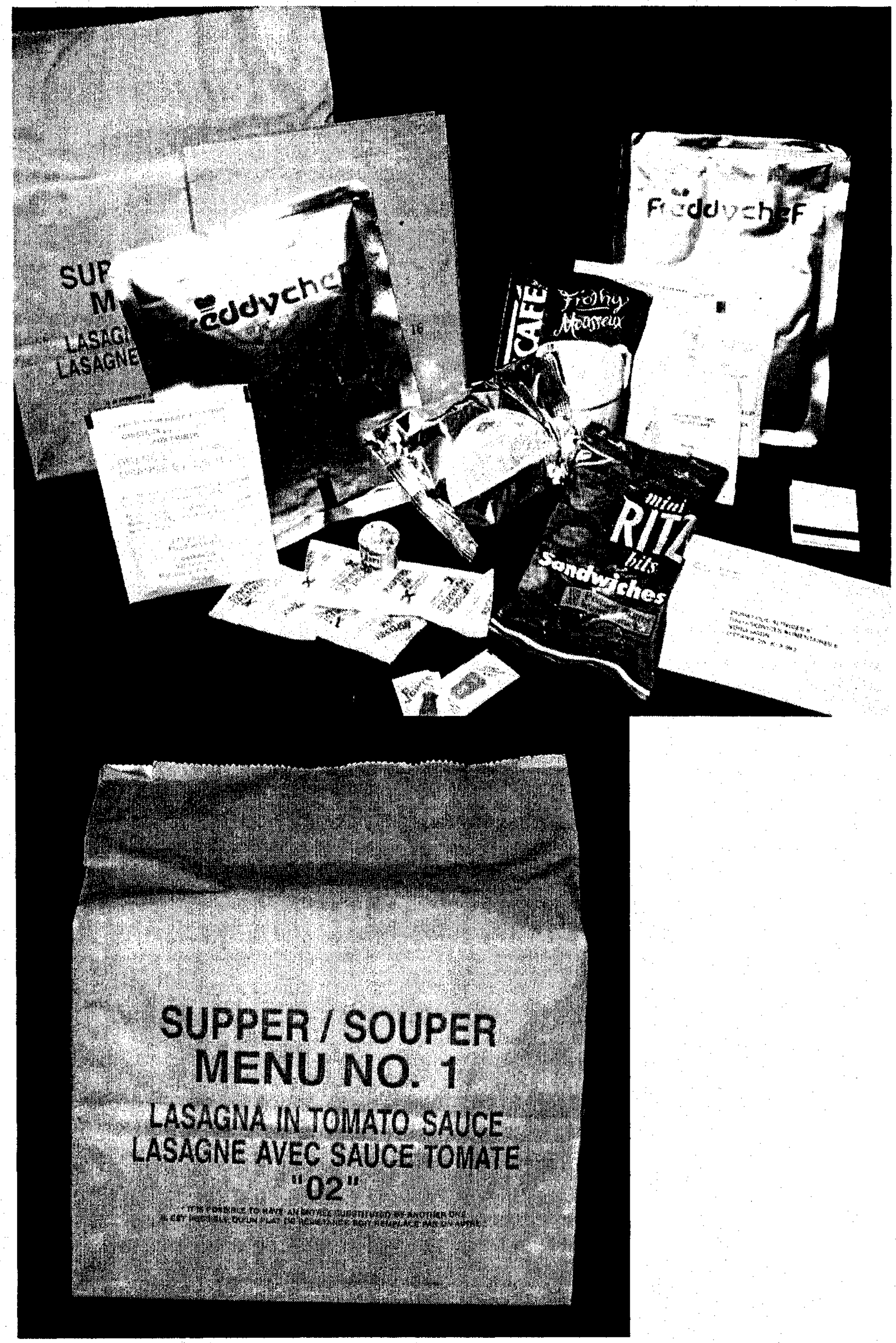

Figure 2 Combat Ration Program components

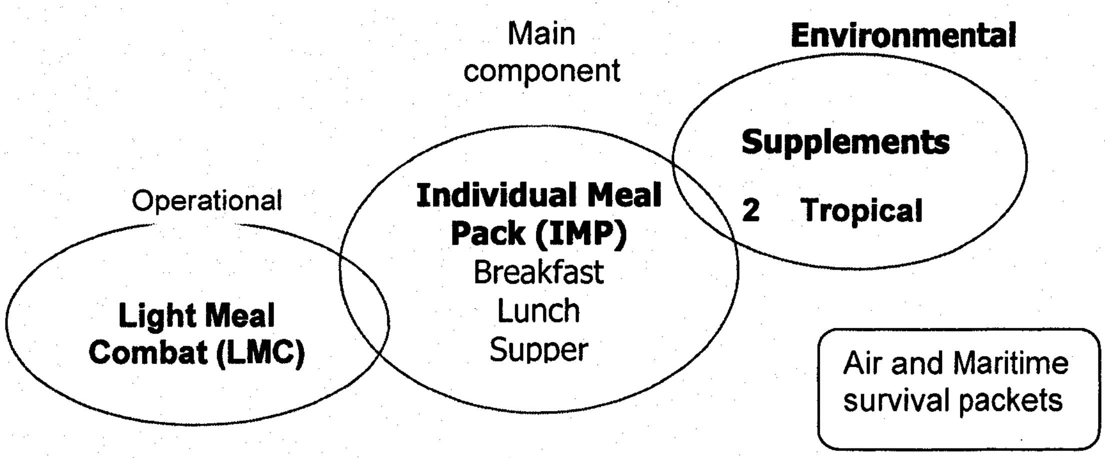

Figure 3 Subject assignment in pre-test

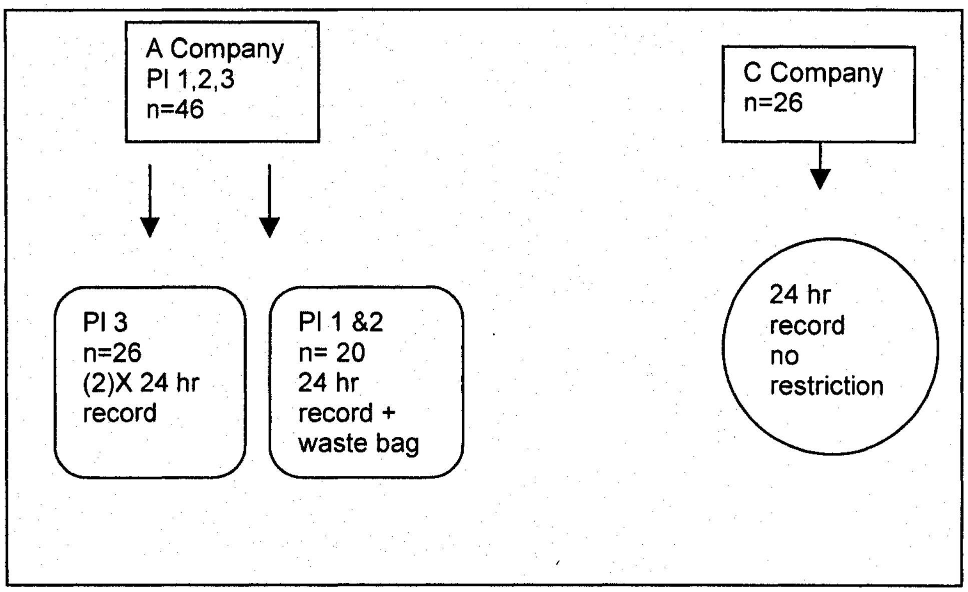

Figure 4 Sample of a page from dietary intake questionnaire

MEAL 2 TIME OF DAY: __________					
CHECK THE BOX TO INDICATE HOW MUCH OF THE PACKAGE YOU ATE	HOW MANY PKGS	100%	75%	50%	25%
Main entrée name:					
Main dessert name:					
BEVERAGES					
Beverage Crystals					
Coffee					
Flavoured Coffee					
Hot Chocolate					
Tea					
Water – approx number of canteens					
CEREAL					
Cereal Crunchie					
Oatmeal Cereal					
SOUP					
Cream of Celery Soup					
Cream of Tomato Soup					
Chicken Noodle Soup					
SIDE DISHES AND CRACKERS					
Bread					
Mashed Potatoes					
Crackers Mini Cheese Sandwich					
Rice					
CANDY					
Aero Chunky Bar					
Candy (Lifesavers, Caramel)					

Figure 5 Response rate Pre-test

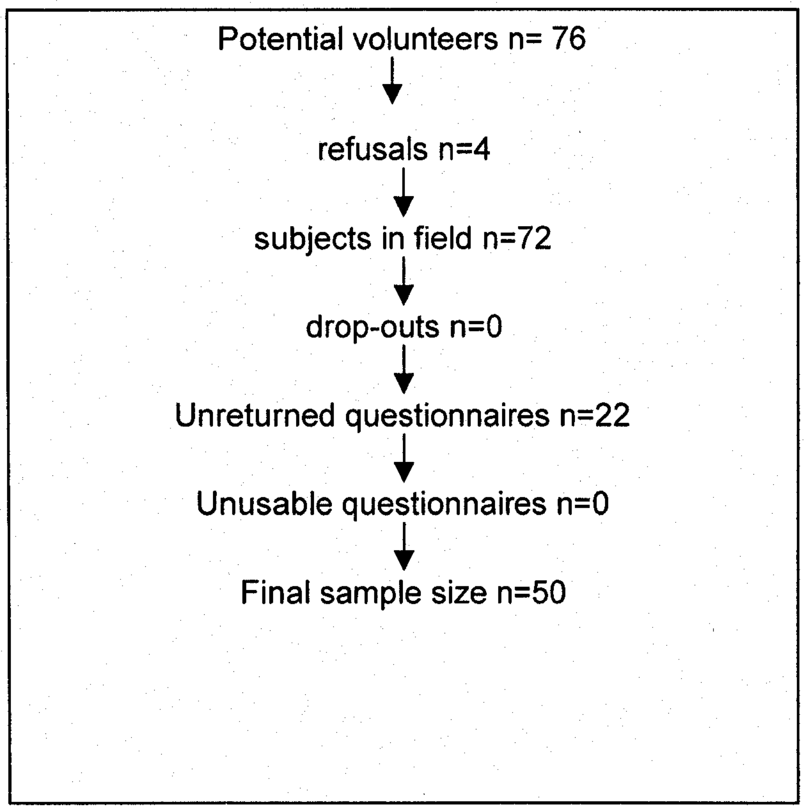

Figure 6 Response Rate Exercise Narwhal

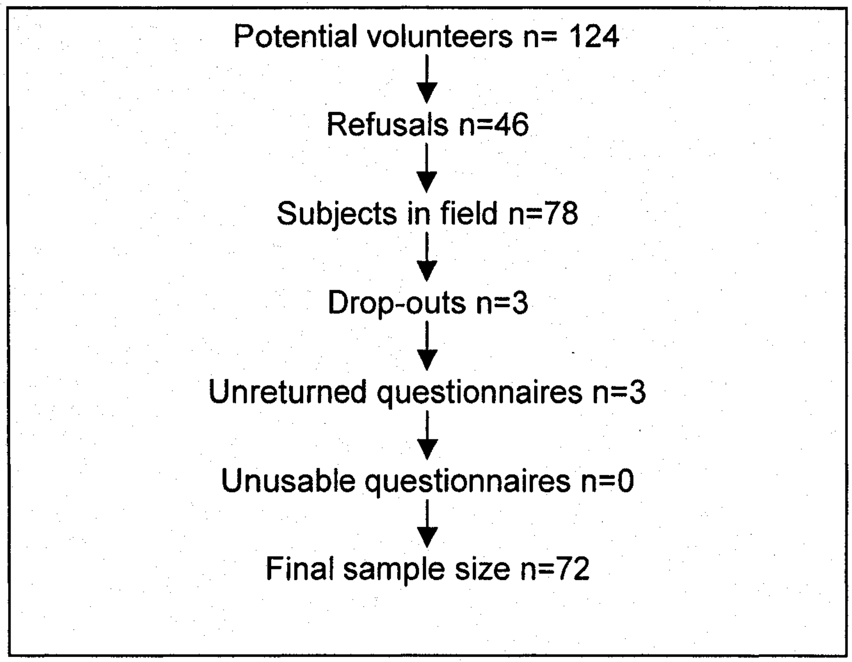

Table 1. Nutrient intake analysis of subjects eating combat rations and personal food (n=48) and combat rations only (n=24), compared to DRI and menu offerings- Exercise Narwhal

	CR+PF n=48							**CR** n=24					
Variable	Pers food Mean	±SD	Cmbt Rats Mean	±SD	Total Mean	±SD	t-test p>.05	Mean	±SD	Dietary Reference Intakes for 80kg male	IMP Mean	LMC Mean	total
energy (kcal)	1541	1558	1874	707	3415	1769	0.1400	2475	1182	EER=4400 kcal	4037	1270	5307
protein (g)	67	76	73	30	140	84	0.0104*	92	37	AMDR= 10-35% kcal[1]	133	34	166
fat (g)	66	79	82	32	148	87	0.0540*	101	44	AMDR=20-35% kcal[2]	137	50	187
CHO (g)	178	220	236	99	414	249	0.4086	328	187	AMDR=45-65% kcal[3]	595	210	805
fibre (g)	7.8	12.7	12.1	5.3	19.9	13.2	0.6103	16.5	8.4	AI=38 g [4]	28	8	36
calcium (mg)	355	312	494	241	849	417	0.0328*	579	331	AI=1000 mg/d	814	425	1239
iron (mg)	10.2	10.0	8.7	3.7	18.9	11.2	0.0090*	11.0	5.3	EAR=7.8 mg[5], UL= 45 mg/d	22	4	26
potassium (mg)	2356	2845	1628	655	3985	2907	0.0020*	2171	1161	AI=4700 mg/d	4021	1031	5052
sodium (mg)	2452	3626	3204	1337	5655	3863	0.2748	4262	2307	AI=1500mg, no EAR, UL=2300 mg	7681	1208	8889
vit A RAE (mcg)	150	178	188	111	338	225	0.0957	232	117	AI=900mcg EAR=625 mcg UL=3000mcg	268	207	475
vitC (mg)	53	90	78	70	131	114	0.4750	103	93	EAR=75mg,UL=2000mg	253	123	376
DFE (mcg)	246	295	238	151	484	327	0.2428	347	204	EAR=320 mcg, UL=1000 mcg	610	87	698

Note: CR+PF= combat rations and personal foods CR=combat rations only
[1] EAR=0.66g/k/d (52.8g) AMDR=(70.4-385 g) protein
[2] AMDR= (98-171 g) fat
[3] AMDR=(495-715 g) carbohydrate
[4] AI=14g/1000 kcal (61.6 g)
[5] EAR for athletes=6 mg/d+ 30% athletes

Table 1

Table 2. Nutrient intake analysis of subjects eating combat rations and personal foods (n=10) and combat rations only (n=40), compared to DRI and menu offerings- Pre-test Wainright

	CR+PF n=10							**CR** n=40			
Variable	Pers food Mean	±SD	Cbt Rats Mean	±SD	Total Mean	±SD	t-test p>.05	Cbt Rats Mean	±SD	DRI for 80kg male	IMP Mean
energy (kcal)	684	577	2832	1189	3516	1409	0.109	2714	591	EER=4400 kcal	4037
protein (g)	34	27	112	43	145	59	0.0786*	108	26	AMDR= 10-35% kcal[1]	133
fat (g)	26	36	112	55	138	72	0.221	108	30	AMDR=20-35% kcal[2]	137
CHO (g)	85	90	363	153	448	172	0.097	345	81	AMDR=45-65% kcal[3]	595
fibre (g)	3.9	4.4	22.4	10.6	26.3	11.7	0.248	21.6	6.6	AI=38 g [4]	28
calcium (mg)	305	601	636	403	941	649	0.156	620	187	AI=1000 mg/d	814
iron (mg)	6.7	6.3	14.8	6.2	21.6	9.9	0.0534*	14.6	5.0	EAR=7.8 mg[5], UL= 45 mg/d	22
potassium (mg)	994	855	2370	946	3363	1348	0.0513*	2396	572	AI=4700 mg/d	4021
sodium (mg)	1217	1274	4822	991	6040	1941	0.117	4945	1219	AI=1500mg, no EAR, UL=2300 mg	7681
vit A RAE (mcg)	168	434	243	142	411	478	0.204	204	82	AI=900mcg EAR=625 mcg UL=3000mcg	268
vitC (mg)	31	62	150	102	181	116	0.0574*	115	91	EAR=75mg,UL=2000mg	253
DFE (mcg)	152	145	489	293	641	349	0.133	455	169	EAR=320 mcg, UL=1000 mcg	610

Note: CR+PF= combat rations and personal foods CR=combat rations only
[1] EAR=0.66g/k/d (52.8g) AMDR=(70.4-385 g) protein
[2] AMDR= (98-171 g) fat
[3] AMDR=(495-715 g) carbohydrate
[4] AI=14g/1000 kcal (61.6 g)
[5] EAR for athletes=6 mg/d+ 30% athletes

Table 3. Nutrient intake analysis of subjects eating combat rations and personal food (n=58) and combat rations only (n=64), compared to DRI and menu offerings- Exercise Narwhal and Pre-test combined

	CR+PF n=58							**CR** n=64					
Variable	Pers food Mean	±SD	Cmbt Rats Mean	±SD	Total Mean	±SD	t-test p>.05	Mean	±SD	Dietary Reference Intakes for 80kg male	IMP Mean	LMC Mean	total
energy (kcal)	1393	1470	2039	877	3432	1702	0.0016*	2624	860	EER=4400 kcal	4037	1270	5307
protein (g)	61	71	80	35	141	80	0.0009*	102	32	AMDR= 10-35% kcal[1]	133	34	166
fat (g)	59	75	87	38	147	84	0.0009*	105	36	AMDR=20-35% kcal[2]	137	50	187
CHO (g)	162	206	258	119	420	237	0.0227	339	130	AMDR=45-65% kcal[3]	595	210	805
fibre (g)	7.1	11.7	13.9	7.5	21.0	13.1	0.5084	20	8	AI=38 g [4]	28	8	36
calcium (mg)	347	371	518	277	865	459	0.0002*	605	249	AI=1000 mg/d	814	425	1239
iron (mg)	9.6	9.5	9.8	4.8	19.4	11.0	0.0002*	13.2	5.3	EAR=7.8 mg[5], UL= 45 mg/d	22	4	26
potassium (mg)	2121	2657	1756	758	3878	2704	<0.0001*	2312	841	AI=4700 mg/d	4021	1031	5052
sodium (mg)	2239	3365	3483	1418	5722	3594	0.0500	4689	1724	AI=1500mg, no EAR, UL=2300 mg	7681	1208	8889
vit A RAE (mcg)	153	236	198	118	351	280	0.0008	214.3	96.8	AI=900mcg EAR=625 mcg UL=3000mcg	268	207	475
vit C (mg)	49	86	91	80	140	115	0.1180	111	91	EAR=75mg,UL=2000mg	253	123	376
DFE (mcg)	230	277	281	203	511	333	0.0565	415	189	EAR=320 mcg, UL=1000 mcg	610	87	698

Note: CR+PF= combat rations and personal foods CR=combat rations only
[1] EAR=0.66g/k/d (52.8g) AMDR=(70.4-385 g) protein
[2] AMDR= (98-171 g) fat
[3] AMDR=(495-715 g) carbohydrate
[4] AI=14g/1000 kcal (61.6 g)
[5] EAR for athletes=6 mg/d+ 30% athletes

Table 4 Height, weight, age, abdominal circumference and BMI of Pre-test subjects (n=50)

Subject	Wt kg	Ht cm	Abd cm	Age	BMI
Mean	81.8	179.9	86.2	26.2	25.3
SD±	9.6	6.4	7.3	5.5	2.5
Median	80.1	180.3	84.0	24.0	24.9
			n=5>94 cm		n=49>BMI 25
			n=3>102 cm		n= 1>BMI 30

Table 5 Height, weight, age, abdominal circumference and BMI of Exercise Narwhal subjects (n=72)

Subject	Wt lbs	Ht cm	Abd cm	Age	BMI
Mean	183.1	178.9	88.1	26.472	26.1
SD±	22.1	9.1	7.9	5.9905	3.2
Median	182.5	178.5	87.0	25	25.7
			n=15>94cm		n=72>BMI 25
			n=4>102 cm		n=8> BMI 30

Table 6. BMI and abdominal measurements (n=72) Exercise Narwhal

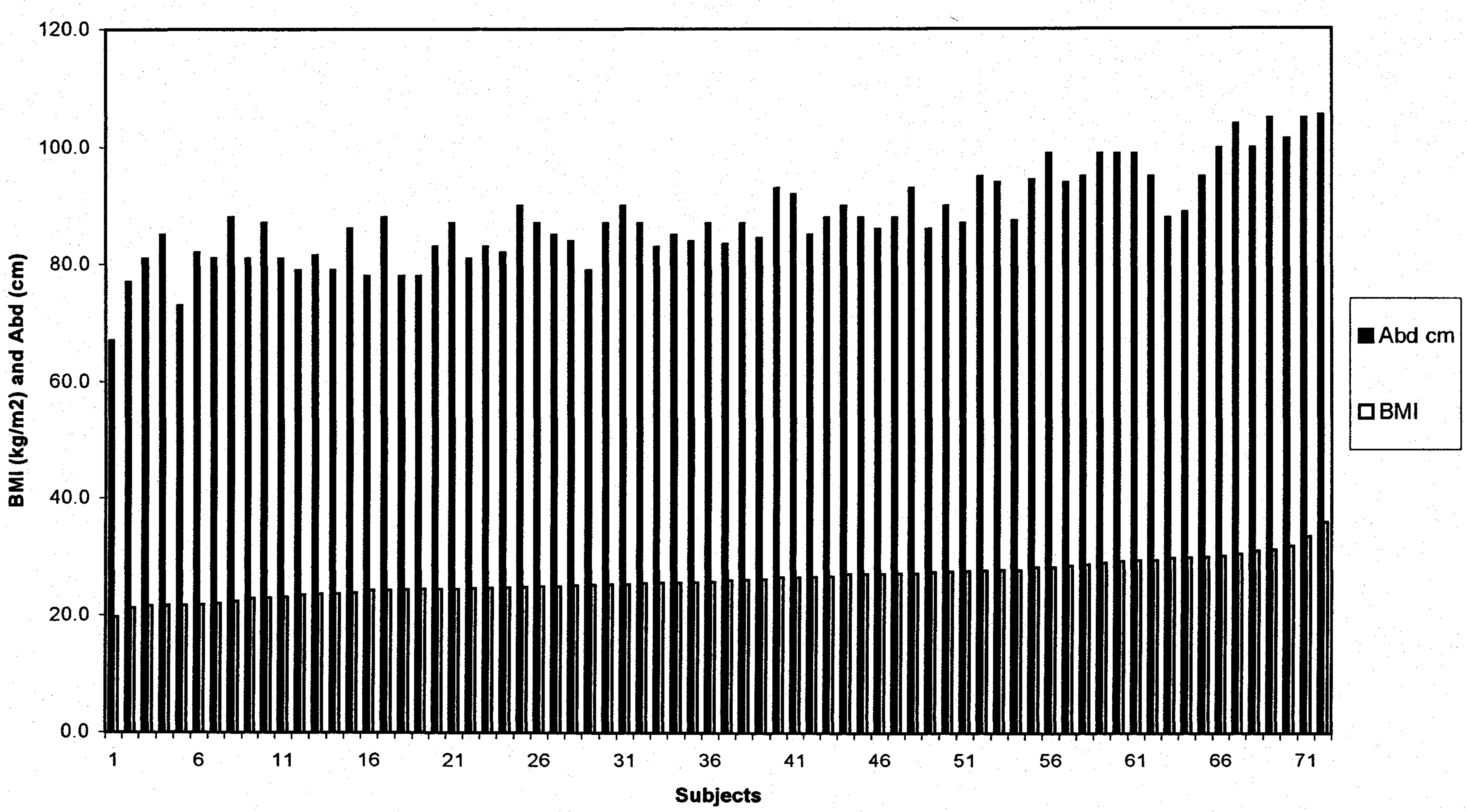

Table 7. Top ten combat ration foods expressed for each nutrient category

calcium mg

NARWHAL

food	calcium mg	Per subj	Pre-test
CHEESE TORTELLINI WITH MEAT SAUCE	4699	65	15
CHEDDAR CHEESE DEHYDRATED, IMP	4165	58	n/a
MACARONI WITH CHEESE SAUCE, IMP	4120	57	14
SALMON, NATURE, IMP,	3897	54	1
AERO CHUNKY BAR	3424	48	13
CHOCOLATE BAR, IMP	2826	39	23
CRACKER, RITZ BITS CHEESE	2788	39	2
CANDY BAR, KIT KAT	2768	38	7
DRINK CRYSTALS, IMP	2461	34	6
CRUNCHY CEREAL TYPE 3, IMP	2288	32	10

PRE-TEST

food	calcium mg	Per subj
SALMON, NATURE, IMP,	3561	71
CRACKER, RITZ BITS CHEESE	3078	62
FRUIT DESSERT	2745	55
ROTINI PRIMAVERA, IMP	2112	42
WATER, MUNICIPAL	1798	36
DRINK CRYSTALS, IMP	1730	35
CANDY BAR, KIT KAT	1543	31
MEATBALLS IN GRAVY, IMP	1522	30
OMELETTE WITH SALSA, IMP	1494	30
CRUNCHY CEREAL TYPE 3, IMP	1452	29

Carbohydrate g

NARWHAL

food	Carbohydrate g	Per subj	Pre-test
DRINK CRYSTALS, IMP	1677	23	2
CHOCOLATE BAR, IMP	1562	22	24
PEACHES, IMP	1510	21	3
CHEESE TORTELLINI WITH MEAT SAUCE	1228	17	32
BREAD, IMP	1145	16	1
CANDY BAR, KIT KAT	1074	15	10
AERO CHUNKY BAR	1061	15	20
GRANOLA BARS, SOFT	872	12	n/a
COFFEE CRISP BAR, IMP	837	12	19
CRUNCHY CEREAL TYPE 3, IMP	780	11	16

PRE-TEST

food	Carbohydrate g	Per subj
BREAD, IMP	1524	30
DRINK CRYSTALS, IMP	1179	24
PEACHES, IMP	1125	22
JAMS AND MARMALADE	817	16
FRUIT DESSERT	814	16
CRACKER, RITZ BITS	739	15
FRUIT COCKTAIL, IMP	726	15
PINEAPPLE, IMP	648	13
APPLESAUCE, IMP	621	12
CANDY BAR, KIT KAT	598	12

NARWHAL				PRE-TEST		
Folate DFE mcg						
food	**DFE**	Per subj	Pre-test rank	**food**	**DFE**	Per subj
BREAD, IMP	8124	112.8	1	BREAD, IMP	10819	216.4
CANDY BAR, KIT KAT	2382	33.1	4	RITZ BITS CHEESESANDWICH, W/ CHEESE FILLING	2431	48.6
CRACKER, RITZ BITS	2203	30.6	2	OATMEAL CHOCOLATE CHIP COOKIE, IMP	1445	28.9
BEANS AND WIENERS, IMP	2112	29.3	7	CANDY BAR, KIT KAT	1328	26.6
COFFEE CRISP BAR, IMP	1917	26.6	n/a	COOKIE, SHORTBREAD, IMP	1151	23.0
BEEF JERKY, IMP	1287	17.9	3	PEANUT BUTTER	1147	22.9
OATMEAL CHOCOLATE CHIP COOKIE, IMP	939	13.0	6	COFFEE CRISP BAR, IMP	888	17.8
PEANUT BUTTER	927	12.9	8	RICE, INSTANT, IMP	835	16.7
RICE, INSTANT, IMP	695	9.6	19	JAMS AND MARMALADE	392	7.8
CHIPS AHOY COOKIE BARZ, IMP	541	7.5	22	COOKIE, CHOCOLATE SANDWICH, CREME FILLING,	391	7.8
Fat g						
food	**fat g**	Per subj	Pre-test Rank	**food**	**fat g**	Per subj
CHOCOLATE BAR, IMP	846	11.8	11	BREAD, IMP	858	17.2
PEPPERONI, IMP	655	9.1	n/a	PEANUT BUTTER	791	15.8
BREAD, IMP	644	8.9	1	MEATBALLS IN GRAVY, IMP	420	8.4
PEANUT BUTTER	639	8.9	2	BEANS AND WIENERS, IMP	309	6.2
AERO CHUNKY BAR	550	7.6	10	CRACKER, RITZ BITS	253	5.1
MACARONI WITH CHEESE SAUCE, IMP	498	6.9	18	SAUSAGE AND HASH BROWNS, IMP	249	5.0
CANDY BAR, KIT KAT	428	5.9	7	CANDY BAR, KIT KAT	238	4.8
COFFEE CRISP BAR, IMP	378	5.3	13	COOKIE, SHORTBREAD, IMP	226	4.5
CHEESE TORTELLINI WITH MEAT SAUCE	374	5.2	24	OMELETTE WITH SALSA, IMP	201	4.0
SAUSAGE AND HASH BROWNS, IMP	355	4.9	6	AERO CHUNKY BAR	192	3.8

Table 7

Table 7

NARWHAL				PRE-TEST		

Fibre g

food	fibre g	Per subj	Pre-test rank	food	fibre g	Per subj
BREAD, IMP	286	4.0	1	BREAD, IMP	381	7.6
BEANS AND WIENERS, IMP	98	1.4	2	BEANS AND WIENERS, IMP	99	2.0
PEANUT BUTTER	70	1.0	3	PEANUT BUTTER	87	1.7
AERO CHUNKY BAR	61	0.8	13	ROTINI PRIMAVERA, IMP	72	1.4
PEARS, IMP	55	0.8	9	FRUIT DESSERT	53	1.1
CHEESE TORTELLINI WITH MEAT SAUCE	53	0.7	25	SAUSAGE AND HASH BROWNS, IMP	35	0.7
CHOCOLATE BAR, IMP	50	0.7	31	APPLESAUCE, IMP	31	0.6
SAUSAGE AND HASH BROWNS, IMP	50	0.7	6	OATMEAL CHOCOLATE CHIP COOKIE, IMP	29	0.6
GRANOLA BARS, SOFT	46	0.6	n/a	PEARS, IMP	28	0.6
SPAGHETTI W/ MEATBALLS & TOMATO SCE, IMP	34	0.5	44	OATMEAL TYPE 1, IMP	23	0.5

Iron mg

food	iron mg	Per subj	Pre-test rank	food	iron mg	Per subj
BREAD, IMP	124.055	1.7	1	BREAD, IMP	165.2	3.3
CHEESE TORTELLINI WITH MEAT SAUCE	59.855	0.8	24	MEATBALLS IN GRAVY, IMP	61.8	1.2
BEEF JERKY, IMP	52.05	0.7	n/a	BAKED CHOCOLATE DESSERT, IMP	39.3	0.8
MEATLOAF WITH ONION SAUCE, IMP	49.31	0.7	15	PENNE RIGATE, IMP	37.9	0.8
MEATBALLS IN GRAVY, IMP	42.27	0.6	2	SHEPERD'S PIE, IMP	33.4	0.7
TURKEY & VEGETALBLE STEW, IMP	34.545	0.5	33	OATMEAL TYPE 1, IMP	32.9	0.7
OATMEAL TYPE 1, IMP	32.95	0.5	6	CRACKER, RITZ BITS	28.7	0.6
GRANOLA BARS, SOFT	31.87	0.4	n/a	PEANUT BUTTER	28.7	0.6
CRUNCHY CEREAL TYPE 3, IMP	29.12	0.4	18	OATMEAL CHOCOLATE CHIP COOKIE, IMP	27.2	0.5
NAVARIN OF LAMB, IMP	28.615	0.4	36	GREEN PEPPER BEEF, IMP	26.4	0.5

NARWHAL / PRE-TEST

Energy (kcal)

food (NARWHAL)	kcal	Per subj	Pre-test rank	food (PRE-TEST)	kcal	Per subj
BREAD, IMP	13627	189	1	BREAD, IMP	18147	363
CHEESE TORTELLINI WITH MEAT SAUCE	10680	148	23	PEANUT BUTTER	9192	184
AERO CHUNKY BAR	9197	128	20	MEATBALLS IN GRAVY, IMP	7594	152
PEPPERONI, IMP	8742	121	n/a	BEANS AND WIENERS, IMP	6050	121
CANDY BAR, KIT KAT	8622	120	6	CRACKER, RITZ BITS	5713	114
MACARONI WITH CHEESE SAUCE, IMP	7630	106	32	CANDY BAR, KIT KAT	4806	96
CHOCOLATE BAR, IMP	7590	105	37	DRINK CRYSTALS, IMP	4770	95
PEANUT BUTTER	7427	103	2	COOKIE, SHORTBREAD, IMP	4749	95
COFFEE CRISP BAR, IMP	7101	99	16	PEACHES, IMP	4593	92
DRINK CRYSTALS, IMP	6785	94	7	SAUSAGE AND HASH BROWNS, IMP	4058	81

Potassium mg

food (NARWHAL)	potassium mg	Per subj	Pre-test rank	food (PRE-TEST)	potassium mg	Per subj
CHEESE TORTELLINI WITH MEAT SAUCE	10146	141	23	PEANUT BUTTER, SMOOTH	10370	207
SPAGHETTI W/ MEATBALLS & TOMATO SCE, IMP	9262	129	36	MEATBALLS IN GRAVY, IMP	8706	174
PEANUT BUTTER	8379	116	1	BREAD, IMP	6479	130
CRUNCHY CEREAL TYPE 3, IMP	7727	107	8	SHEPHERD'S PIE, IMP	5914	118
BEANS AND WIENERS, IMP	6965	97	24	PENNE RIGATE, IMP	5800	116
AERO CHUNKY BAR	6903	96	9	SCALLOPED POTATOES & HAM, IMP	5381	108
SAUSAGE AND HASH BROWNS, IMP	6798	94	25	CRACKER, RITZ BITS CHEESE,	5138	103
COFFEE, INSTANT, REGULAR, POWDER	6327	88	N/a	CRUNCHY CEREAL TYPE 3, IMP	4904	98
RAISINS, SEEDLESS (SULTANA)	6233	87	2	SAUSAGE AND HASH BROWNS, IMP	4779	96
HOT CHOCOLATE, RICH, MIX	6073	84	43	SALMON, NATURE, IMP,	4290	86

Table 7

Table 7

NARWHAL

Protein g

food	protein g	Per subj	Pre-test rank
BREAD, IMP	859	11.9	1
PEPPERONI, IMP	819	11.4	N/a
CHEESE TORTELLINI WITH MEAT SAUCE	694	9.6	15
BEEF JERKY, IMP	519	7.2	N/a
MEATLOAF WITH ONION SAUCE, IMP	499	6.9	9
TURKEY & VEGETALBLE STEW, IMP	394	5.5	24
MEATBALLS IN GRAVY, IMP	369	5.1	2
PEANUT BUTTER	316	4.4	3
NAVARIN OF LAMB, IMP	314	4.4	26
SALMON, NATURE, IMP,	314	4.4	4

Sodium mg

food	sodium mg	Per subj	Pre-test Rank
PEPPERONI, IMP	33395	464	N/a
MACARONI WITH CHEESE SAUCE, IMP	26228	364	17
SPAGHETTI W/ MEATBALLS & TOMATO SCE, IMP	25900	360	27
TURKEY & VEGETALBLE STEW, IMP	21903	304	26
CHEESE TORTELLINI WITH MEAT SAUCE	21894	304	25
BEEF JERKY, IMP	21250	295	N/a
BREAD, IMP	20749	288	1
MEATLOAF WITH ONION SAUCE, IMP	17959	249	15
BEANS AND WIENERS, IMP	15546	216	3
CRACKER, RITZ BITS CHEESE,	15201	211	10

PRE-TEST

food	protein g	Per subj
BREAD, IMP	1143	22.0
MEATBALLS IN GRAVY, IMP	540	10.4
PEANUT BUTTER, SMOOTH	391	7.5
SALMON, NATURE, IMP,	287	5.5
SHEPHERD'S PIE, IMP	253	4.9
SCALLOPED POTATOES & HAM, IMP	248	4.8
SALISBURY STEAK, IMP	230	4.4
PENNE RIGATE, IMP	230	4.4
MEATLOAF WITH ONION SAUCE, IMP	208	4.0
PORK CHOW MEIN, IMP	206	4.0

food	sodium mg	Per subj
BREAD, IMP	27632	553
SCALLOPED POTATOES & HAM, IMP	17027	341
CRACKER, RITZ BITS CHEESE,	16780	336
HAM STEAK WITH MUSTARD SAUCE, IMP	16310	326
MEATBALLS IN GRAVY, IMP	13768	275
OMELETTE WITH SALSA, IMP	12205	244
SALT, TABLE	11627	233
GREEN PEPPER BEEF, IMP	11489	230
PENNE RIGATE, IMP	11000	220
SAUSAGE AND HASH BROWNS, IMP	10444	209

NARWHAL

Vitamin A RAE

food	Vit A REA	Per subj	Pre-test rank
MACARONI WITH CHEESE SAUCE, IMP	2512	35	15
CHEESE TORTELLINI WITH MEAT SAUCE	2136	30	N/a
TURKEY & VEGETALBE STEW, IMP	2071	29	14
NAVARIN OF LAMB, IMP	1953	27	1
CHEDDAR CHEESE DEHYDRATED, IMP	1837	26	13
SPAGHETTI W/ MEATBALLS & TOMATO SCE, IMP	1287	18	23
AERO CHUNKY BAR	986	14	2
SNACKS, RICE KRISPIES TREATS SQUARES	859	12	7
CHOCOLATE BAR, IMP	814	11	6
CANDY BAR, KIT KAT	805	11	10

Vitamin C mg

food	vit C mg	Per subj	Pre-test Rank
DRINK CRYSTALS, IMP	4141	57.5	1
PEARS, IMP	621	8.6	6
BLUEBERRIES, IMP	582	8.1	3
MACARONI WITH CHEESE SAUCE, IMP	493	6.8	14
FRUIT COCKTAIL, IMP	380	5.3	4
SPAGHETTI W/ MEATBALLS & TOMATO SCE, IMP	257	3.6	23
FRUIT DESSERT	190	2.6	2
HAM STEAK WITH MUSTARD SAUCE, IMP	168	2.3	9
MANGO APPLE SAUCE, IMP	168	2.3	8
MEATLOAF WITH ONION SAUCE, IMP	163	2.3	18

PRE-TEST

Vitamin A RAE

food	Vit A REA	Per subj
PENNE RIGATE, IMP	1475.1	30
TARRAGON CHICKEN, IMP	1142.4	23
HUNGARIAN GOULASH, IMP	840.0	17
MACARONI WITH CHEESE SAUCE, IMP	703.9	14
SCALLOPED POTATOES & HAM, IMP	590.0	12
MEATBALLS IN GRAVY, IMP	575.1	12
PEACHES, IMP	558.3	11
CHEESE TORTELLINI WITH MEAT SCE	516.4	10
TURKEY & VEGETALBE STEW, IMP	497.9	10
NAVARIN OF LAMB, IMP	485.7	10

Vitamin C mg

food	vit C mg	Per subj
DRINK CRYSTALS, IMP	2911	58.2
FRUIT DESSERT	811	16.2
BLUEBERRIES, IMP	569	11.4
FRUIT COCKTAIL, IMP	408	8.2
PENNE RIGATE, IMP	338	6.8
PEARS, IMP	316	6.3
SCALLOPED POTATOES & HAM, IMP	283	5.7
MANGO APPLE SAUCE, IMP	250	5.0
HAM STEAK WITH MUSTARD SAUCE, IMP	216	4.3
ROTINI PRIMAVERA, IMP	192	3.8

Table 7

Table 8 Top ten discarded foods from 48 hours of combat rations

Food	Frequency of foods discarded
JAMS AND MARMALADE	53
HONEY	53
COFFEE, INSTANT, REGULAR, POWDER	51
COFFEE WHITENER (NONDAIRY), POWDERED	51
SUGAR	51
DRINK CRYSTALS, IMP	49
SALT, TABLE	43
HOT CHOCOLATE, RICH, MIX	41
TOMATO KETCHUP	40
FRUIT DESSERT	39

Energy (kcal)

Food	kcal
BREAD, IMP	24128
DRINK CRYSTALS, IMP	16228
JAMS AND MARMALADE	13504
FRUIT DESSERT	13011
SUGAR	11798
PEANUT BUTTER	10911
COFFEE WHITENER (NONDAIRY), POWDERED	10461
HONEY	9345
POTATOES, INTSTANT, IMP	8001
HOT CHOCOLATE, RICH, MIX	7208

Carbohydrate (g)

Food	g
DRINK CRYSTALS, IMP	4011
JAMS AND MARMALADE	3345
FRUIT DESSERT	3242
SUGAR	3045
HONEY	2533
BREAD, IMP	2027
POTATOES, INTSTANT, IMP	1816
HOT CHOCOLATE, RICH, MIX	1560
RICE, INSTANT, IMP	1499
PUDDING, INSTANT, IMP	1409

Table 9 The means from an analysis of nutrients discarded from 48 hours of combat rations

Nutrient Measured	Mean	±Std Dev
weight	509	232
kcal	1367	500
protein g	31	19
fat g	32	18
Carbohydrate g	245	80
fibre g	8.7	5.9
calcium mg	340	159
iron mg	6.7	3.2
potassium mg	1622	664
sodium mg	2527	1040
vitA RE	68	47
vit C mg	110	66
folate DFE mcg	215	147

Appendix 1 Estimated energy expenditure of various military studies

Author	Energy Expenditure	Estimated energy Intake	Method	Climate/ Environment	Subjects
(Booth, Coad et al. 2003))	3650 ± 1060 kcal/d	2200, 1600, 2850 kcal/d	doubly labelled water	10 d patrol exercise Australia	33 ♂ Australian DF
(Burstein, Coward et al. 1996)	4281 kcal/day winter 3937 kcal/d summer	2792 ± 124 kcal/d	doubly labelled water	Winter Israel 0C Summer Israel 30 C	30 ♂ Israeli DF
(Forbes-Ewan, Morrissey et al. 1989)	4750 kcal/d	4040 kcal/d	doubly labelled water	7 days jungle warfare Australia	4 ♂ Australian DF
(Hoyt, Jones et al. 1991)	4919 ± 190 & 4705 ± 181 kcal/d	3132 ± 165 kcal/d	doubly labelled water & food intake/anthropometric	11 day cold weather 2200m	23 ♂ US Marines
(Jacobs, Van Loon et al. 1989)	5500-6500kcal/d 4.875 kcal/L O_2	2571 ± 303 3217 ±410 kcal/d	Continuous recording of heartbeat & direct measure of O_2 consumption	5 day extremely strenuous mil tasks Sept temperate	29 ♂ CF Army Commandos
(Jones, Jacobs et al. 1993)	4317 ± 927 kcal/d	2633 ± 499 kcal/d	doubly labelled water	Arctic -25 to -35C	20 ♂ CF Army
(Nindl, Friedl et al. 1997)	4200 kcal/d	1600 kcal/d	doubly labelled water	62 d Ranger course, temperate forrest,mountains, desert, swamp (18-30C)	10 ♂ US Army
(Shukitt-Hale, Askew et al. 1997)	3250-3275 kcal/d	2000 kcal/d	caloric intake & body weight loss	25 d Vermont Sept-Oct 4-11C	34 ♂ US Army Special Forces
(Westerterp-Plantenga, Westerterp et al. 1999)		Energy deficiency (-)4.2 MJ/d	doubly labelled water	Simulated ascent to Mount Everest to 7000m	8 ♂
(Young, Castellani et al. 1998)	~4100 kcal/d	~3300 kcal/d	Caloric intake ~3300 kcal/d + avg change in body fat and lean mass	Cold (10C) laboratory after 61 d of strenuous military trg	8 ♂ US Army
Mean of studies	**4385 kcal/d**	**Median of studies**	**4625 kcal/d**		

Appendix 2 Consent Form (English)

Consent Form
Title of Project:

A comparative study of food and beverage consumption against food offerings in an operational setting: what are Canadian Forces soldiers eating and are they getting adequate nutrition?

Submitted to:
Funded by the Department of National Defence
Principal Investigator:
Pamela Hatton, Department of National Defence
and MSc. Candidate, McGill University
Co-Investigators:
Dr. K. Gray-Donald, Director School of Dietetics and Human Nutrition
McGill University
and
Dr. D. Reid, Acting National Manager
Strengthening the Forces health promotion program
DCOS - Force Health Protection
DGHS, Department of National Defence

Institution in which the study is being conducted:
Department of National Defence

DHRRE authorizes the administration of this survey within DND/CF in accordance with CANFORGEN 145/02 ADMHRMIL 079 UNCLASS 131028Z DEC 02. Authorization number: 327/04.

Introduction: The Department of National Defence (DND)/ Canadian Forces (CF) is responsible for providing food services to meet the nutritional needs of healthy military men and women on military operations. Combat rations are designed to be nutritionally adequate and used when logistics do not permit fresh feeding.

Studies have shown that soldiers often do not consume enough energy to meet their physical demands while on military manoeuvres. The consequences of not eating enough on the long term may have negative effects on health such as decreased immune function, altered sex hormones and decreased bone mineralization. Inadequate consumption in the short-term can reduce physical performance, such as an increase in run times and poorer marksmanship.

We are conducting a survey on combat ration consumption to determine the nutrient intakes of soldiers in operational environments. The information will help to recommend changes in food service procedure and the combat ration programme. The goal is to promote the most nutritious intake of combat rations for optimal operational readiness. All male soldiers over the age of 18 years who are on this operation are invited to participate.

This consent form will give you a general idea of the survey study and what your participation involves. Please take the time to read the information carefully and make sure that you understand it. If you would like more information, please feel free to contact us.

Purpose:
The purpose of the study is to determine the intakes of macro and micronutrients of CF soldiers when consuming combat rations. What are CF members consuming on operations when there is no fresh feeding and are they getting adequate nutrition to optimize combat readiness?

Description of the study: Participants will be asked to fill out questionnaires about your consumption of combat rations. The survey will include the following:

1. Questionnaire: The questionnaire will be in a booklet that you carry with you and fill out throughout the day. Some participants may be asked to fill out the questionnaire a second time.

2. Interview: The study investigator will ask you a few questions about how you answered the questionnaire to confirm what you ate and to clarify any questions you may have.

3. Waste collection: Some participants will be asked to dispose of all their uneaten food and packaging waste in coded garbage bags as another method to collect data.

- Personal information: You will be asked about your rank, service number, age, military occupation code (MOC) and home unit.
- Dietary habits: You will be asked about foods and supplements eaten and their amounts over the past 24 hours.

4. Body measurements: Your body weight will be measured before going to the field and upon returning from the field. For your weight, you will be asked to stand on a weighing scale without combat boots. The same apparatus will be used for measuring height. Waist circumference will be measured with a tape measure. A nurse, Medical Assistant or the study investigator will note your weight, height and wais circumference.

Right to refuse participation: Your decision to participate in the study is completely up to you. Whether you participate or not, there will be no career or military consequences.

Benefits and risks: There are no risks associated with your participation in the study. The questionnaire will take about 20 minutes of your time.

Cost of participating: There are no costs of participating in the study.

Confidentiality: All information obtained about you will only be used for the purposes of this study. Your identity will be kept confidential. Each participant will be given a study number. The database will not include your name. Only your study number will be given to those analyzing data. No personal information will be passed on to any other agency.

Right to withdraw: Your participation is voluntary and you can withdraw at any time from the study. Also, you are allowed to not respond to some questions or part of the interview. If you feel uncomfortable about any issue related to the study or do not understand a section, you should contact the study investigator, Captain Hatton or your military supervisor.

Contact Persons:
Dr. Katherine Gray-Donald, Director School of Dietetics and Human Nutrition
McGill University (514) 398-7842

Dr. Debra Reid, Acting National Manager, Strengthening the Forces Health Promotion Program, DCOS - Force Health Protection, DGHS, Department of National Defence
tel : (613) 945-8062 x 3151 CSN 849-8062 x 3151
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email : Reid.DJ2@forces.gc.ca

Captain Pamela Hatton, DLBM/Food S, Department of National Defence and MSc. Candidate, McGill University
Email: capt.pc.hatton@dnd.ca

3 PPCLI representative or
2RCR representative accordingly

Publication of research: The information on the overall outcome of survey will be provided to you in a unit presentation. The information collected will be used to determine the nutrient intakes when consuming combat rations. The findings will not include names or any information that can be used to identify individuals. No information will be presented to public health conferences or in journals without first presenting the results to the unit.

Consent: My consent is given voluntarily and under free power of choice. I have been informed that I may revoke my consent to the survey procedures at any time.

______________________	______________________
Name of participant (print clearly)	Signature of Participant and Date
______________________	______________________
Age of participant	Service Number
______________________	
Home unit	

Appendix 3 Consent form (French)

Formulaire de consentement
Titre du projet :

Une étude comparative sur la consommation de brevages et de nourriture dans un environnement opérationnel : que mangent les soldats des Forces canadiennes et que faisons-nous pour satisfaire leurs besoins nutritifs ?

Soumis à :
Financé par le Ministère de la Défense nationale
Enquêteur principal:
Pamela Hatton, Ministère de la Défense nationale
et candidate à la M.Sc., Université McGill
Enquêteur adjoint :
M. K. Gray-Donald, Directeur de l'École de diététique et de nutrition humaine
Université McGill
et
M. D. Reid, Gestionnaire national intérimaire
Programme de promotion de la santé, Energiser les Forces
DCOS – Protection de la santé des Forces
DGS San, Département de la Défense nationale

Institution dans laquelle l'étude est menée :
Département de la Défense nationale

DRERH autorise l'administration de ce sondage dans le MDN/FC en accord vec CANFORGEN 145/02 ADMHRMIL 079 UNCLASS 131028Z DEC 02.
Numéro d'autorisation : 327/04.

Introduction: Le Ministère de la Défense nationale (MDN)/Forces canadiennes (FC) a la responsabilité de répondre aux besoins nutritionnels d'hommes et de femmes en bonne santé participant à des opérations militaires. Les rations de combat sont conçues afin d'être adéquates sur le plan nutritif et utilisées dans des situations où la logistique ne permet pas de fournir aux soldats des rations fraîches.

Des études ont démontré que les soldats ne consomment pas assez d'énergie afin de faire face aux épreuves physiques auxquelles ils sont confrontés durant les maneuvres militaires. Les conséquences à long terme d'une alimentation insuffisante pourraient avoir des effets négatifs sur la santé tels qu'une défaillance des fonctions immunitaires, une altération des hormones sexuelles et une décroissance de la minéralisation des os. À court terme, une alimentation insuffisante peut réduire la performance physique et provoquer, par exemple, de moins bonnes performances à la course à pied et au tir.

Nous sommes en train de mener un sondage sur la consommation de rations de combat afin de déterminer dans quelle mesure les soldats obtiennent une quantité suffisante d'éléments nutritifs dans les environnements opérationnels. L'information vous aidera à recommander des changements en ce qui concerne les services alimentaires et le programme de rations de combat. Le but est de promouvoir la consommation la plus nutritive possible de rations de combat afin d'en arriver à un état de préparation opérationnelle optimale. Tous les soldats de sexe masculin qui sont âgés de plus de 18 ans et qui font partie de cette opération sont invités à participer au sondage.

Ce formulaire de consentement vous donnera une idée générale du sondage et de ce que l'on attend de vous. Veuillez prendre le temps de bien lire l'information ci-jointe et assurez-vous de bien la comprendre. Si vous désirez de plus amples renseignements, n'hésitez pas à communiquer avec nous.

Objectif :
L'objectif de l'étude est de déterminer la proportion de macro et de microéléments consommés par les soldats des FC lorsqu'ils s'alimentent à l'aide de rations de combat. Que consomment les membres des FC lorsqu'ils participent à des opérations où il n'y a pas de rations fraîches et obtiennent-ils alors les éléments nutritifs dont ils ont besoin afin d'optimiser leur état de préparation au combat ?

Description de l'étude : Les participants devront remplir des questionnaires au sujet de leur consommation de rations de combat. Le sondage comprendra ce qui suit :

1. Questionnaire : Le questionnaire prendra la forme d'un livret que vous traînerez sur vous toute la journée et que vous remplirez au besoin. On pourra demander à certains participants de remplir le questionnaire une seconde fois.

2. Entrevue : L'enquêteur associé à l'étude vous posera quelques questions sur la façon dont vous avez répondu au questionnaire afin de confirmer ce que vous avez mangé et de répondre aux questions que vous pouvez avoir.

3. Cueillette des déchets : On demandera à certains participants de se débarrasser de la nourriture qu'ils n'auront pas mangée et de jeter leurs déchets dans des sacs à ordure encodés, ce qui permettra de recueillir des données.

- Renseignements personnels : On vous demandera votre grade, votre numéro de service, votre âge, votre code de groupe professionnel militaire (GPM), votre unité d'origine.
- Habitudes alimentaires : On vous demandera quelles sont les nourritures et les suppléments alimentaires que vous avez mangés au cours des dernières 24 heures.

4. Mensurations : Votre poids corporel sera mesuré avant que vous ne partiez sur le terrain et à votre retour du terrain. Au moment de prendre votre poids, on vous demandera de vous tenir debout sur une balance et sans bottes de combat. On utilisera le même appareil pour prendre en note votre taille. Le circonférence de taille serai pris. Une infirmière, un adjoint médical ou l'investigateur de l'étude prendra votre poids en note.

Droit de refuser de participer : Votre décision de participer ou non à l'étude est entièrement la vôtre. Que vous décidiez de participer ou non, il n'y aura aucune conséquences sur votre carrière.

Avantages et risques : Vous ne courez aucuns risques en participant à l'étude. Le questionnaire ne prendra qu'environ 20 minutes de votre temps.

Coût de votre participation : Il n'en coûte rien pour participer à l'étude.

Confidentialité : L'information que nous avons obtenue à votre sujet ne sera utilisée qu'aux fins de cette étude. Votre identité demeurera confidentielle. Chaque participant se verra donner un numéro d'étude. La base de données ne comportera pas votre nom. Seul votre numéro d'étude sera donné à ceux qui analysent les données. Aucune information personnelle ne sera divulguée à aucune autre agence.

Droit de retrait : Votre participation est volontaire et vous pouvez choisir de ne plus participer à l'étude à n'importe quel moment. De plus, vous avez le droit de ne pas répondre à certaines questions ou à une partie de l'entrevue. Si vous vous sentez inconfortable à propos de questions ayant trait à l'étude ou que vous ne comprenez pas une section, vous devriez communiquer avec l'investigateur de l'étude, le capitaine Hatton, ou votre superviseur militaire.

Personnes ressource :
Dr. Katherine Gray-Donald, Directeur de l'école de diététique et de nutrition humaine
Université McGill (514) 398-7842

Dr. Debra Reid, Gestionnaire national intérimaire, Renforcir le programme de promotion de la santé des Forces, DCOS - Protection de la santé des Forces, DGHS, Ministère de la Défense nationale
tel : (613) 945-8062 x 3151 CSN 849-8062 x 3151
fax : (613) 945-6823
courriel : Reid.DJ2@forces.gc.ca

Capitaine Pamela Hatton, DLBM/Food S, Ministère de la Défense nationale et candidate au MSc., Université McGill
courriel: capt.pc.hatton@dnd.ca

Personne-ressource locale :

Capitaine Chris Allen, Officier des opérations, 3 PPCLI
tel: (780) 973-4011
CSN: 528-5107
Fax: (780) 973-1642
courriel: allen.cs@forces.gc.ca

Ou represent de 2RCR comme requis

Publication de la recherche : L'information au sujet des résultats du sondage vous sera fournie au cours d'une présentation faite à l'unité. L'information recueillie sera utilisée afin de déterminer la quantité d'aliments nutritifs absorbés durant la consommation de rations de combat. Les résultats ne feront pas mention de noms ou de toute autre information pouvant être utilisée afin d'identifier les personnes. Aucune information ne sera présentée dans le cadre de conférences sur la santé publique ou dans les journaux sans que l'on ne présente d'abord les résultats à l'unité.

Consentement : J'accorde mon consentement de façon volontaire et tout à fait libre. On m'a informé que je pouvais révoquer mon consentement quand bon me semblerait.

______________________________	________________________
Nom du participant (écrivez clairement)	Signature du participant et date
______________________________	________________________
Age du participant	Numéro de service
______________________________	
Unité d'origine	

Appendix 4 DND Ethics Board approval

Director Human Resources Research and Evaluation
National Defence Headquarters
101 Colonel By Drive
Ottawa ON K1A 0K2

DHRRE RESEARCH REVIEW BOARD DECISION

Serial Number: 327/04

Title: Combat Ration study

Researcher: Captain Pam Hatton

Organization: University of McGill

Review and Discussion:

1. The general idea of any research on individuals is to provide a product respecting the rules of the scientific approach and following the deontological code of behavioural sciences. Your research proposal satisfies these two requirements and is therefore approved.

2. Your project is assigned survey coordination number: 327/04. **The following text shall be displayed on the front page of your survey(s) and consent form(s):**

> DHRRE authorizes the administration of this survey within DND/CF in accordance with CANFORGEN 145/02 ADMHRMIL 079 UNCLASS 131028Z DEC 02. Authorization number: 327/04.
>
> DRERH autorise l'administration de ce sondage dans le MDN/FC en accord vec CANFORGEN 145/02 ADMHRMIL 079 UNCLASS 131028Z DEC 02. Numéro d'autorisation : 327/04.

3. You are reminded that any changes to the approved protocol or any untoward incidents or injuries arising as a result of any subject's participation in the study shall be brought to the attention of the Committee Chairperson in writing immediately.

4. This approval is valid for the period of 18 months from the date of this meeting. Subject involvement must be complete by this date; otherwise, the protocol will require further review.

5. To ensure that the survey co-ordination function primarily serves practical rather than research interests, DHRRE requires an electronic copy of any research reports arising out of this request/project.

6. **The following disclaimer shall be presented as the first page of the research report.**

"The opinions expressed in this document are those of the author and are not necessarily those of the Department of National Defence or the Canadian Forces"

7. You are required to contact the Level 1 authority, LCol K. Farley and Maj JAM Beauchemin, prior to the administration of your survey in order to coordinate appropriate timings and locations. Failure to do so will result in revocation of this authorization.

8. Please accept our acknowledgements for your contribution to research within the Canadian Forces and the Department of National Defence.

(*original signed by*)

C.D. Lamerson, Ph.D.
Colonel
Director Human Resources Research and Evaluation
(613) 992-0244

(Forwarded 19 July 2004)

Appendix 5 McGill University Ethics Board approval

McGill

Certificate of Ethical Acceptability for
Research Involving Humans

Project Title: A comparative study of food and beverage consumption against food offerings in the an operational environment: What are the Canadian Forces soldiers eating and are they getting adequate nutrition #840

Applicant's Name: Katherine Gray-Donald

Supervisor (if applicable):

Reviewers: P Jones, P Bender, M Humphries

Type of review: Expedited review

DECISION: Approved for one year.

Peter Jones, Chair
Research Ethics Committee
Faculty of Agricultural and Environmental Sciences

May 19th, 2004

Tel: 514-398-7547
Fax; 514-398-7739
E-mail; Jonesp@macdonald.mcgill.ca

Appendix 6 Dietary intake questionnaire

Defence nationale

COMBAT RATION SURVEY

June 2004

Canada

A FEW MORE QUESTIONS...

1. Did you get enough to eat today?

____

____

____

2. If you did not get enough to eat, what food would you like more of?

____

____

____

3. If no, are there reasons why you don't eat enough?

____

____

____

4. What could be added or changed to the IMPs/LMCs to make you eat more?

____

____

____

5. Do you have any other comments that would help to improve combat rations?

____

____

____

THANK YOU FOR YOUR PARTICIPATION IN THIS STUDY. YOUR CONTRIBUTION WILL ASSIST IN THE FURTHER DEVELOPMENT OF COMBAT RATIONS.

STUDY NUMBER

COMBAT RATION SURVEY

DO NOT WRITE YOUR NAME ON THIS QUESTIONNAIRE

Date of Consumption: ______________________________

Age: ____________

☐ **Male** ☐ **Female**

☐ **Regular Force** ☐ **Reserve Force**

Home Unit: ______________________________

INSTRUCTIONS:

- Please put a check in the box that most closely corresponds to the amount you have eaten.
- The questionnaire is sectioned into four meals plus an LMC if applicable.
- Fill out the questionnaire for what applies to you during the 24 hrs – if you only eat 2 meals, then just fill out 2 meals worth and so on.
- Don't forget to answer the questions about foods from home on the back of the booklet.

THANK YOU FOR YOUR PARTICIPATION!

MEAL 1 TIME OF DAY: ________					
CHECK THE BOX TO INDICATE HOW MUCH OF THE PACKAGE YOU ATE	**HOW MANY PKGS**	**100%**	**75%**	**50%**	**25%**
Main entrée name:					
Main dessert name:					
BEVERAGES					
Beverage Crystals					
Coffee					
Flavoured Coffee					
Hot Chocolate					
Tea					
Water – approx number of canteens					
CEREAL					
Cereal Crunchie					
Oatmeal Cereal					
SOUP					
Cream of Celery Soup					
Cream of Tomato Soup					
Chicken Noodle Soup					
SIDE DISHES AND CRACKERS					
Bread					
Mashed Potatoes					
Crackers Mini Cheese Sandwich					
Rice					
CANDY					
Aero Chunky Bar					
Candy (Lifesavers, Caramel)					

Please list items that are not included in IMPs but that you might have brought from home. Examples: power bars, granola bars, sports drinks, protein powders, vitamins, candy, meat jerky, gum. Approximate how much you ate, such as 3 bars, 1 litre, 50 grams.

CHECK THE BOX TO INDICATE HOW MUCH OF THE PACKAGE YOU ATE	**HOW MANY PKGS**	**100%**	**75%**	**50%**	**25%**
EXAMPLE					
Ex: Nature Valley Granola Bars	3 pkgs				
Gatorade	1.5 litre				

LMC ITEMS **TIME OF DAY:** ___________

CHECK THE BOX TO INDICATE HOW MUCH OF THE PACKAGE YOU ATE	HOW MANY PKGS	100%	75%	50%	25%
Beef Jerky					
Pepperoni					
Dried Cheddar Cheese					
Dried Pineapple					
Raisins					
Granola Dipps Bar					
Chocolate Chunk Muffin Bar					
Dried Apple Chiplets					
Cranberry Apple Cereal Square					
Rice Krispies Squares					
Chocolate Bar					
Candy Roll					
Hot Chocolate					

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CHECK THE BOX TO INDICATE HOW MUCH OF THE PACKAGE YOU ATE	HOW MANY PKGS	100%	75%	50%	25%
CANDY CONT'D					
Chewing Gum					
Chunky KitKat					
Coffee Crisp Bar					
Creamy Caramel Bar					
Dream White Chocolate Bar					
Mint Flavour Choclate Bar					
COOKIES AND DESSERTS					
Shortbread Cookies					
Chips Ahoy Cookie Bar					
Sandwich Cookies with Cream					
Pudding					
Oatmeal Chocolate Chip					
CONDIMENTS					
Honey					
Jelly, jams or marmalade					
Ketchup					
Mustard					
Peanut Butter					
Pepper Sauce					
Salt					
Soya Sauce					
Steak Sauce					
Sugar					
Teriyaki Sauce					
Whitener					

MEAL 2	**TIME OF DAY:** ___________				
CHECK THE BOX TO INDICATE HOW MUCH OF THE PACKAGE YOU ATE	**HOW MANY PKGS**	**100%**	**75%**	**50%**	**25%**
Main entrée name:					
Main dessert name:					
BEVERAGES					
Beverage Crystals					
Coffee					
Flavoured Coffee					
Hot Chocolate					
Tea					
Water – approx number of canteens					
CEREAL					
Cereal Crunchie					
Oatmeal Cereal					
SOUP					
Cream of Celery Soup					
Cream of Tomato Soup					
Chicken Noodle Soup					
SIDE DISHES AND CRACKERS					
Bread					
Mashed Potatoes					
Crackers Mini Cheese Sandwich					
Rice					
CANDY					
Aero Chunky Bar					
Candy (Lifesavers, Caramel)					

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CHECK THE BOX TO INDICATE HOW MUCH OF THE PACKAGE YOU ATE	**HOW MANY PKGS**	**100%**	**75%**	**50%**	**25%**
CANDY CONT'D					
Chewing Gum					
Chunky KitKat					
Coffee Crisp Bar					
Creamy Caramel Bar					
Dream White Chocolate Bar					
Mint Flavour Choclate Bar					
COOKIES AND DESSERTS					
Shortbread Cookies					
Chips Ahoy Cookie Bar					
Sandwich Cookies with Cream					
Pudding					
Oatmeal Chocolate Chip					
CONDIMENTS					
Honey					
Jelly, jams or marmalade					
Ketchup					
Mustard					
Peanut Butter					
Pepper Sauce					
Salt					
Soya Sauce					
Steak Sauce					
Sugar					
Teriyaki Sauce					
Whitener					

MEAL 4 **TIME OF DAY:** ___________

CHECK THE BOX TO INDICATE HOW MUCH OF THE PACKAGE YOU ATE	HOW MANY PKGS	100%	75%	50%	25%
Main entrée name:					
Main dessert name:					
BEVERAGES					
Beverage Crystals					
Coffee					
Flavoured Coffee					
Hot Chocolate					
Tea					
Water – approx number of canteens					
CEREAL					
Cereal Crunchie					
Oatmeal Cereal					
SOUP					
Cream of Celery Soup					
Cream of Tomato Soup					
Chicken Noodle Soup					
SIDE DISHES AND CRACKERS					
Bread					
Mashed Potatoes					
Crackers Mini Cheese Sandwich					
Rice					
CANDY					
Aero Chunky Bar					
Candy (Lifesavers, Caramel)					

CHECK THE BOX TO INDICATE HOW MUCH OF THE PACKAGE YOU ATE	HOW MANY PKGS	100%	75%	50%	25%
CANDY CONT'D					
Chewing Gum					
Chunky KitKat					
Coffee Crisp Bar					
Creamy Caramel Bar					
Dream White Chocolate Bar					
Mint Flavour Choclate Bar					
COOKIES AND DESSERTS					
Shortbread Cookies					
Chips Ahoy Cookie Bar					
Sandwich Cookies with Cream					
Pudding					
Oatmeal Chocolate Chip					
CONDIMENTS					
Honey					
Jelly, jams or marmalade					
Ketchup					
Mustard					
Peanut Butter					
Pepper Sauce					
Salt					
Soya Sauce					
Steak Sauce					
Sugar					
Teriyaki Sauce					
Whitener					

MEAL 3 **TIME OF DAY:** __________

CHECK THE BOX TO INDICATE HOW MUCH OF THE PACKAGE YOU ATE	HOW MANY PKGS	100%	75%	50%	25%
Main entrée name:					
Main dessert name:					
BEVERAGES					
Beverage Crystals					
Coffee					
Flavoured Coffee					
Hot Chocolate					
Tea					
Water – approx number of canteens					
CEREAL					
Cereal Crunchie					
Oatmeal Cereal					
SOUP					
Cream of Celery Soup					
Cream of Tomato Soup					
Chicken Noodle Soup					
SIDE DISHES AND CRACKERS					
Bread					
Mashed Potatoes					
Crackers Mini Cheese Sandwich					
Rice					
CANDY					
Aero Chunky Bar					
Candy (Lifesavers, Caramel)					

CHECK THE BOX TO INDICATE HOW MUCH OF THE PACKAGE YOU ATE	HOW MANY PKGS	100%	75%	50%	25%
CANDY CONT'D					
Chewing Gum					
Chunky KitKat					
Coffee Crisp Bar					
Creamy Caramel Bar					
Dream White Chocolate Bar					
Mint Flavour Choclate Bar					
COOKIES AND DESSERTS					
Shortbread Cookies					
Chips Ahoy Cookie Bar					
Sandwich Cookies with Cream					
Pudding					
Oatmeal Chocolate Chip					
CONDIMENTS					
Honey					
Jelly, jams or marmalade					
Ketchup					
Mustard					
Peanut Butter					
Pepper Sauce					
Salt					
Soya Sauce					
Steak Sauce					
Sugar					
Teriyaki Sauce					
Whitener					

Appendix 7 Quality Test Engineering Establishment certification

Department of National Defence
Quality Engineering Test Establishment
Ottawa Ontario
K1A 0K2

Calibration certificate for Mettler balance
Model PE 600

DEPARTMENT OF NATIONAL DEFENCE
QUALITY ENGINEERING TEST ESTABLISHMENT
OTTAWA ONTARIO K1A 0K2

CALIBRATION CERTIFICATE

WORK ORDER No.: 116366
CLIENT: 2689 02

Wednesday, November 26, 2003

INSTRUMENT

TEMMIS No.:	233210103
Manufacturer:	00000
Description:	BALANCE
Model:	PE6000
Serial No.:	21010
Instrument Received Date:	24/11/2003

Date Format DD/MM/YYYY

CALIBRATION DETAILS

Calprocedure:	QTE0501/MANUAL
Change No. :	
Calprocedure Date:	24/11/2003
Lab Temperature:	20±1°C
Lab Humidity:	30-50%RH
Instrument Cal Date:	24/11/2003
Instrument Due Date:	22/11/2004

STANDARDS AND TEST EQUIPMENT USED

PIN	NSCM	MFR	Model	Serial	Name	DueDate
237220348	OHAU0	TEANS	NIL	QTE0348	WEIGHT SET 1GM TO 2KG	16/05/2008

CALIBRATION RESULTS / COMMENTS:

CONDITION: CALIBRATED

LIMITED USE due to the fact that the balance's performance falls short of manufacturer's specifications.
+/- 0.2g

All of the equipment used in the performance of this calibration is traceable to National Standards.
Measurement uncertainties are expanded using a coverage factor k=2 for a confidence factor of approximately 95% assuming a normal distribution.

CALIBRATED BY:

Aline Bourbonnais

AUTHORITY:

D. McEvoy
Section Head
Metrology & Test Equipment Services

QUALITY ENGINEERING TEST ESTABLISHMENT
DEPARTMENT OF NATIONAL DEFENCE
Ottawa ON K1A 0K2

INSTRUMENT CALIBRATION REPORT

INSTRUMENT: **BALANCE**	SERIAL No.: F25788	TEMMIS No.: 233210103
MODEL No.: PE6000	MANUFACTURER: METTLER	CALIBRATION STATUS: **LIMITED USE**
CLIENT: **QETE 3-2**		DATE: 24 NOVEMBER 2003

METHOD, SPECIFICATIONS, REFERENCES

QTE0501/MANUAL

EQUIPMENT USED

INSTRUMENT	MFR/MODEL	TEMMIS / SERIAL No.
WEIGHT SET	STO-WEIGH	237220348

ALL OF THE EQUIPMENT USED IN THE PERFORMANCE OF THIS CALIBRATION IS TRACEABLE TO NATIONAL STANDARDS

CALIBRATION RESULTS

APPLIED VALUE IS APPARENT MASS VERSUS STAINLESS STEEL 8.0g/cm3

UNCERTAINTY OF THE CALIBRATION RESULTS

This balance has a measurement expanded uncertainty of ± 0.2g

REMARKS

NEXT DUE DATE: NOVEMBER 2004

CALIBRATED BY :	REVIEWED BY:
A. Bourbonnais QETE 5 Quality Management, Standards, and Metrological Services	D. McEvoy Section Head Quality Management, Standards, and Metrological Services

TEMMIS: 233210103
SERIAL# : F25788

QUALITY ENGINEERING TEST ESTABLISHMENT
DEPARTMENT OF NATIONAL DEFENCE
Ottawa ON K1A 0K2

INSTRUMENT CALIBRATION REPORT

INSTRUMENT: **BALANCE**	SERIAL No.: F25788	TEMMIS No.: 233210103
MODEL No.: PE6000	MANUFACTURER: METTLER	CALIBRATION STATUS: **LIMITED USE**
CLIENT: **QETE 6**		DATE: MAY 23 2002

METHOD, SPECIFICATIONS, REFERENCES

MANUAL

EQUIPMENT USED

INSTRUMENT	MFR/MODEL	TEMMIS / SERIAL No.
WEIGHT SET	STO-WEIGH	237220348

ALL OF THE EQUIPMENT USED IN THE PERFORMANCE OF THIS CALIBRATION IS TRACEABLE TO NATIONAL STANDARDS

CALIBRATION RESULTS

APPLIED VALUE IS APPARENT MASS VERSUS BRASS 8.4g/cm3

UNCERTAINTY OF THE CALIBRATION RESULTS

±0.2g

REMARKS

NEXT DUE DATE: MAY 2003

CALIBRATED BY :	REVIEWED BY:
A. Bourbonnais QETE 10 Quality Management, Standards, and Metrological Services	M. Hilash QETE 10 Quality Management, Standards, and Metrological Services

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TEMMIS: 233210103
SERIAL#: F25788

Appendix 8 Pre-test waste-bag and questionnaire agreement data

Menu Item		meal 1	meal 2	meal 3	totals[1]
Main	Quest[2]	15	15	14	**44**
	Bag[3]	14	14	12	**40**
Dessert	Quest	12	13	11	**36**
	Bag	11	10	9	**30**
Beverages	Quest	11	10	10	**31**
	Bag	8	4	7	**19**
Cereal					
	Quest	3	0	0	**3**
	Bag	3	0	0	**3**
Soup	Quest	1	0	0	**1**
	Bag	1	2	2	**5**
Side	Quest	9	11	12	**32**
	Bag	9	13	13	**35**
Candies	Quest	7	14	6	**27**
	Bag	5	16	5	**26**
Cookies	Quest	2	0	7	**9**
	Bag	2	0	7	**9**
Condiments	Quest	16	14	22	**52**
	Bag	11	15	19	**45**

[1] Totals= the number of reported foods eaten or waste evidence
[2] Quest= positive response in Questionnaire
[3] Bag= positive findings for waste bag

Appendix 9 Height Weight Protocol

To measure height

1. The subject was asked to relax and stand in a straight, upright position, with arms at the sides, shoulders relaxed, legs straight, feet flat and heels together (no shoes).
2. the subject's heels were lined up at the back of the wall.
3. Before taking the measurement, the subject's eyes and head were looking straight forward.
4. The measurement was recorded to the nearest 0.5 cm.

To measure weight

1. The scale was zeroed prior to measurement.
2. The subject were wearing combat pants with emptied pockets and sock feet.
3. The subject stood at the centre of the scale without assistance, in a straight, upright position, arms at the sides, feet slightly apart.
4. The subject waited for the digital readout of the body weight
5. The measurement was recorded to the nearest 0.5 lb

To measure waist circumference

1. The subject relaxed and stood with his/her arms at the sides, in a straight, upright position, with feet about 25 to 30 cm apart.
2. The waist area is exposed.
3. The landmarks were located by palpation: the lower costal margin (rib cage) and the top of the right iliac crest. (The waist is the natural narrowing between these two points. It is not always visibly more narrow, making palpation necessary.)
4. The measuring tape is placed around the abdomen at the mid-point between the lower costal margin (rib cage) and the top of the right iliac crest. The tape is snug but not compressing the skin, and is parallel to the floor.
5. A cross-handed technique is used to bring the zero line of the tape in line with the measuring aspect of the tape.
6. The measurement is taken at the end of a normal expiration.

7. The measurement is recorded to the nearest 0.5 cm.(National Institutes of Health 2000)

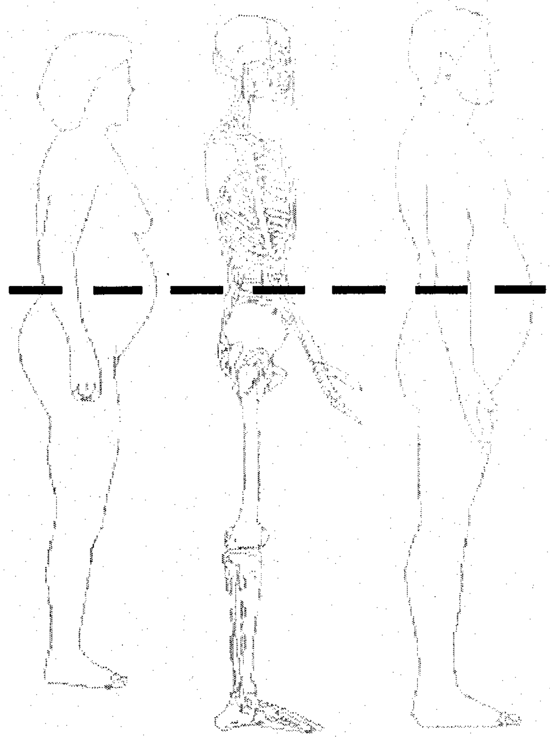

Diagram excerpted from *The Practical Guide to the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults*, National Institutes of Health, National Heart, Lung and Blood Institute, North American Association for the Study of Obesity, NIH Publication Number 00-4084. October 2000

Appendix 10. Nutritional analysis results of homogenized IMP meals 03 provided by DND

Menu Cod	CHO	Fat	Protein	Fibre	Kcal	KJ	Calcium	Sodium	Iron	Potassiun	Vit A RAE	Vit C	Folate
B1	256.5	43.06	42.32	19.88	1582.81	6622.48	443.46	2392.05	10.97	1898.71	0.03	22.28	0.29
B2	223.03	21.76	38.94	9.53	1243.53	5202.94	411.23	2841.22	7.65	1744.25	0.15	31.93	0.3
B3	222.7	52.68	36.06	13.52	1508.99	6313.61	404.54	2341.01	8.32	1666.9	0.05	11.42	0.35
B4	204.42	36.61	52.49	32.66	1357.2	5678.52	385.18	3124.19	7.93	1778.26	0.03	41.11	0.33
B5	212.28	35.11	31.92	12.19	1292.69	5408.61	489.06	1912.66	9.85	1660.64	1.24	263.32	0.27
mean	**223.786**	**37.844**	**40.346**	**17.556**	**1397.044**	**5845.232**	**426.694**	**2522.226**	**8.944**	**1749.752**	**0.3**	**74.012**	**0.308**
L1	218.24	53.33	53.69	14.49	1567.83	6559.79	430.51	2680.77	10.38	1719.14	0.05	25.57	0.59
L2	185.54	60.63	51.94	11.58	1496.13	6259.81	329.15	2197.73	6.85	1366.91	1.19	87.87	0.29
L3	231.44	50.48	18.68	10.46	1407.81	5890.27	459.72	2433.64	4.57	897.07	0.29	88.4	0.35
L4	194.35	43.32	70.52	38.54	1382.9	5786.05	252.27	3902.51	9.66	1659.42	0.8	10.54	0.44
L5	211.9	33.99	42.33	7.59	1322.83	5534.72	243.77	2002.14	5.57	1491.6	3.61	48.8	0.22
L6	215.5	40.06	57.92	12.99	1454.23	6084.51	223.52	2055.96	7.17	1533.91	0.18	72.76	0.33
mean	**209.495**	**46.96833**	**49.18**	**15.94167**	**1438.622**	**6019.192**	**323.1567**	**2545.458**	**7.366667**	**1444.675**	**1.02**	**55.65667**	**0.37**
S1	261.84	33.52	47.83	10.11	1540.33	6444.75	282.31	4245.03	9.08	1441.52	0.88	30.96	0.64
S2	243.41	33.79	55.68	16.25	1500.45	6277.9	324.16	4333.81	10.26	2178.62	0.02	17.54	0.45
S3	229.49	26.62	36.31	17.02	1302.8	5450.93	302.37	4211.76	7.88	1302.88	0.03	15.34	0.48
S4	302.47	53.47	58.28	16.2	1924.23	8050.96	328.05	5277.13	11.97	1717.47	0.04	11.94	0.56
S5	229.3	42.52	61.15	15.47	1544.49	6462.16	228.46	4127	11.39	1888.16	0.77	29.22	0.56
S6	222.19	38.45	48.73	10.07	1429.72	5981.97	130.23	3686	7.47	1146.42	0.67	27.08	0.49
mean	**248.1167**	**38.06167**	**51.33**	**14.18667**	**1540.337**	**6444.778**	**265.93**	**4350.746**	**9.675**	**1612.512**	**0.401667**	**22.01333**	**0.53**
mean all n	**226.2043**	**41.27433**	**47.06926**	**15.89725**	**1457.612**	**6098.653**	**337.7811**	**3039.183**	**8.593719**	**1594.016**	**0.597368**	**50.82888**	**0.400947**
LMC1	240.09	42.4	40.37	18.08	1503.39	6290.2	402.02	2317.21	9.53	1399.17	0.12	97.66	0.05
LMC2	225.29	57.78	29.54	7.47	1539.02	6439.24	431.6	1491.28	9.51	1500.1	0.51	96.47	0.05
LMC3	212.14	47.47	29.08	10.75	1392.1	5824.56	797.25	1060.21	5.09	1058.54	0.43	117.41	0.26
Mean	**225.84**	**49.21667**	**32.99667**	**12.1**	**1478.17**	**6184.667**	**543.6233**	**1622.9**	**8.043333**	**1319.27**	**0.353333**	**103.8467**	**0.12**
mean B	223.786	37.844	40.346	17.556	1397.044	5845.232	426.694	2522.226	8.944	1749.752	0.3	74.012	0.308
mean L	209.495	46.968.33	49.18	15.94167	1438.622	6019.192	323.1567	2545.458	7.36667	144.675	1.02	55.65667	0.37
mean S	248.1167	41.27433	47.06926	15.89725	1457.612	6098.653	337.7811	4350.746	8.593719	1594.016	0.597368	50.82888	0.400947
Daily total	**681.3977**	**79.11833**	**136.5953**	**49.39492**	**4293.278**	**17963.08**	**1087.632**	**9418.43**	**24.90439**	**3488.443**	**1.917368**	**180.4976**	**1.078947**