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WORK SHIFT FOOD DELIVERY STRATEGIES DURING ARDUOUS WILDFIRE SUPPRESSION

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By

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Work shift food delivery strategies during arduous wildfire suppression

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PURPOSE: The purpose of this study was to compare two isocaloric feeding strategies for wildland firefighters (WLFF) on total kcal and macronutrient (e.g. carbohydrates, total fat and protein) intake, ratings of satisfaction, and food delivery system feasibility. **METHODS:** Fifty-two Type I and Type II wildland firefighters (WLFF) from five different Fire Crews participated in the study. Subjects consumed either the traditional sack lunch (SL) or shift-food (SF) ad lib during their work shift in a randomized cross-over design. Subjects reported ratings of satisfaction with each feeding strategy. The SL and SF nutrients were analyzed with Dietary Analysis 6.1 (Salem, OR, USA) and the USDA nutrition facts food label and both were entered into a food-item nutrient database in Microsoft Excel. Delivery method feasibility was examined through reported perception from on-site research director and research assistant. **RESULTS:** Subjects consumed significantly more kcals from the SF feeding strategy compared to SL feeding strategy [SF, 1701.7± 281.4 kcals and SL, 1333.7±356.4 kcals, $p<0.05$). There was a higher amount of fat and CHO kcals consumed in the SF group compared to the SL group [SF, 569.4±167.6 fat kcals and SL, 367.6±176.7 fat kcals; SF, 1010.8±247.3 CHO kcals and SL 725.2±238.4 CHO kcals, $p<0.05$]. There were no differences in protein consumed between groups. Survey data show that subjects prefer the SF over the SL for convenience, variety, satisfaction, appearance, and overall preference ($p<0.05$). Qualitative data indicated it is feasible to deliver adequate variety, choice, and decrease waste with the shift meal system. In addition, the SF delivery method is cost effective. **CONCLUSION:** The shift meal system provided greater nutrient variety and was more convenient to use than the current sack lunch meal system. WLFF's expressed higher satisfaction, consumed more energy (e.g. kcals) and carbohydrates, with the SF vs. SL system. The SF system is a feasible way to deliver adequate energy and nutrients to WLFFs while increasing nutrient variety and decreasing food waste. Finally, the SF system is more cost effective than the SL meal.

Keywords: FIREFIGHTING, SUPPLEMENTAL FEEDING, CARBOHYDRATE,

OCCUPATIONAL PHYSIOLOGY

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CHAPTER ONE
STATEMENT OF THE PROBLEM

Introduction

The wildland firefighter (WLFF) is exposed to a multitude of adverse working conditions, including hiking up steep terrain, digging fire lines, and chain sawing. This type of physical labor is classified as endurance or energy intensive based on task and duration.[35] With WLFFs, endurance is required for the majority of their shift with periodic bouts of rigorous work. The type of work replicates a work to rest cycle ratio each hour. For example, a 3:1 work to rest ratio applied to WLFFs may accurately represent the 12-14 hour work shift.[50] The range of total energy expenditure (TEE) of the WLFF is estimated at 12-26 MJ·day^{-1} (2868-6214 kilocalories (kcals)/day).[50] Thus, it is critical to provide foods during the WLFF's work shift that meet these energy demands and provide variety to meet their meal satisfaction. Additionally, WLFF shift foods need to contain a balance of nutrients (carbohydrates (CHO), fat, protein) that support their high energy output demands. At present, the WLFF diet consists of a traditional sack lunch consisting of 1300-2000 kcals and an unlimited, fully catered breakfast and dinner.

It is well know that supplemental feeding during long-duration exercise increases the subject's ability to complete physical work.[3, 7,9-12, 15, 16,19, 21, 27, 35, 37, 41, 54, 55] Research has been conducted to compare the effect of CHO feedings versus placebo on various outcomes including work performance, metabolic stress and time to exhaustion. Most of these studies, however, have been conducted for a limited duration, typically less than four hours. Frequent CHO feedings consumed during the WLFF workday have been shown to increase work output by approximately two hours.[47] Maintaining energy balance (e.g. kcal expenditure = kcal intake) with adequate CHO and kcals is essential for optimal performance under such strenuous working conditions throughout the season (often > 100 days).

Previous research has shown that WLFFs fall short in their CHO intake and consume more protein and fat than needed for such high physical work demands.[50] In addition, previous studies report that WLFFs often supplement their lunches with personal food preferences, such as energy bars and carbohydrate drinks and discard food items from the sack lunch.[17]

The Problem

WLFFs are currently provided a sack lunch that purportedly meets the energy requirements necessary to sustain a steady work output throughout the workday. Previous studies conducted by our laboratory show that work output typically drops during the post lunch hours of the work shift, indicating potential issues with adequate consumption of kcals and/or method of consumption with the current feeding strategy. Presently the sack lunch provides 5.4 to 8.8 MJ (1300-2000 kcal) and is typically consumed in a one hour time period. Previous studies report that WLFFs often supplement their lunches with personal food preferences, typically energy bars and carbohydrate drinks and discard food items from the sack lunch. This practice may be due to dissatisfaction with the sack lunches and may lead to inadequate energy consumption during the work shift. The sack lunch method of feeding is costly and may not be providing the appropriate feeding strategy to sustain a high and steady level of work output or sufficiently meet energy and nutrient requirement in this population. Further, the sack lunch delivery method may be limiting the WLFF's ability to consume lunch food items intermittently throughout the work shift. On the other hand, a lunch delivery strategy, such as the shift food method would give WLFFs a wider variety of lunch food items and enable them to snack on these foods throughout the day. Thus, the shift food delivery system could potentially maintain or increase energy (kcal) intake, and thus work output, throughout the work shift.

Our original purpose of this study was to evaluate two isocaloric feeding strategies for WLFFs on post lunch work output, rate of perceived exertion, meal satisfaction, energy and macronutrient intake, and food delivery system feasibility. Due to the study design's inability to hold constant a number of extraneous variables that negatively impacted the validity of the workload and perceived rate of exertion outcomes, we limited the study findings to report only those that compare the two isocaloric feeding strategies on total kcal and macronutrient (e.g. carbohydrates, total fat and protein) intake, ratings of satisfaction, and food delivery system feasibility. It is likely that future studies may use similar study designs that collect and analyze workload and perceived rate of exertion data in the WLFF population. Thus, Chapter 4 describes these measures and the problems encountered during this study that limited our ability to report these outcomes as originally intended and presents suggestions for how future studies could address these issues.

Research Question/Hypotheses

- The shift food delivery system will have higher ratings of convenience, variety, energy, and overall satisfaction rating than the traditional sack lunch consumed ad lib.
- Consumption of energy (kcals) will be greater for the SF group than SL group.
- Consumption of CHO & fat will be greater for the SF group compared to the SL group.
- Consumption of protein will be less with the SF group versus the SL group.
- The SF will be a more cost-effective way of feeding compared to the traditional sack lunch.
- Post lunch work output will be higher in the shift-food (SF) group compared to the traditional sack lunch (SL) group.
- Rating of Perceived Exertion (RPE) will be similar for both groups despite the differences in work output between groups.

Significance of Study

This study can provide practical information for the current composition of the WLFF lunch and report on a meal delivery strategy for improving food intake and, potentially, work performance in this population. Individuals with jobs requiring sustained work over a long period of time may benefit from this information. Studies show that regularly timed feedings, particularly carbohydrates, will improve work performance.[17,47,48] However, it is unclear if a self-selection feeding strategy with individually packaged foods will result in greater work output compared to the traditional sack lunch. An increase in work output during post lunch hours may improve safety and work capacity in WLFFs. Furthermore, if WLFFs are able to self-select a variety of small, packaged food items for their lunch they might consume more of the meal. This study may also develop a lunch delivery system that is more cost-effective than the current sack lunch model.

Rationale for Study

Previous research in areas of work physiology, particularly wildland fire suppression, has been limited. These studies address the effects of CHO feedings over the course of time in relation to work performance, but have not compared the effect of different feeding strategies on total kcal and macronutrient intake, ratings of satisfaction, and food delivery system feasibility.

Limitations

Subjects may decide to consume supplemental foods not provided by the researchers. This will be accounted for by thoroughly interviewing the subjects on their food intake and strongly encouraging subjects to only consume the food provided.

Subjects may discuss their opinions about each feeding strategy with other subjects, which may create bias.

Day to day work assignments can differ dramatically for WLFF. The crossover design minimizes these effects.

The amount of fatigue or rest subjects have prior to entering the study has the potential to impact food intake, work output, and RPE. There is little researchers can do to control this.

Inter-day fire variability has the potential to impact work output and RPE. There is little researchers can do to control fire behavior, although the cross-over design will minimize these effects if subject criteria is met.

ActiCal monitors may not provide consistent feedback by having numerous gaps in the data. If the data is too incomplete (daily activity counts totaling 100 ***or*** >2 hours of data recording '0' activity counts/minute), the subject's data will not be used.

Definitions

ActiCal: A name for the device that measures human movement by ascribing counts (an arbitrary unit) to the amount of work a person is performing.

Isocaloric: A term to describe the identical kilocalorie content of both lunch protocols administered in the study.

Rating of Perceived Exertion (RPE): The perception for how difficult a task is to complete on a scale of 6-20, where 6 is sitting and 20 is maximal work.

Sack Lunch (SL): The traditional lunch that the WLFF consumes and is provided by the particular caterer working at the fire.

Shift Food (SF): A new sack lunch consisting of individually packaged food items available in local grocery stores.

Shift Food Delivery System: A lunch line modeled system that allows for self-selection of a variety of individually packaged food items.

Satisfaction Surveys: Surveys consisting of questions regarding the likes and dislikes, satiety, convenience, and satisfaction with the different feeding strategies (SL or SF).

WLFF: An individual who performs firefighting tasks in the unpredictable wildfire environment.

Work Output: The amount of activity counts a subject achieves doing daily work tasks.

CHAPTER TWO
REVIEW OF LITERATURE

Introduction

An important goal of an individual's everyday diet, when performing laborious work, is to fuel the muscle with substrates that provide sufficient energy to perform at optimal levels. Carbohydrate (CHO) is the best nutrient to support high intensity and long duration exercise or work. For instance, dietary strategies for the athlete wanting to achieve large amounts of work were once believed to primarily consist of protein,[31] but the majority of studies show that high CHO diets are preferred to maximize work output for endurance athletes or individuals working in physically demanding jobs.[7, 31, 40, 41] Research for the impact of feeding strategies on extended duration (10-14 hr) physical labor is lacking. Wildland fire suppression requires long work hours (12-14 hr) under adverse conditions such as high ambient temperature, transporting heavy packs, compromised dietary intake, smoke inhalation, acute altitude exposure, and sleep deprivation. Therefore, a study that assesses the effect of a CHO feeding protocol on long-duration work may have considerable application to similar occupational environments. To better understand the implications of feeding protocols for WLFF field research three research areas will be thoroughly discussed; nutritional strategies for long-duration exercise, ergogenic effects of carbohydrates, and studies conducted on the WLFF.

Energy balance and performance. Energy balance is a challenge in an arduous field environment. Not only is total energy consumption important, but the composition of the energy supply is as well. The utility of carbohydrates for sustaining work performance is widely accepted in the sports science community.[40] This concept has had an emergent efficacy for performance enhancement in military soldiers and has been demonstrated in our laboratory to enhance work output in the arduous work environment of the WLFF.

The following studies represent the similarities between total energy expenditure (TEE) in military soldiers and WLFFs. Mudambo et al. (1997) examined the TEE of 12 male soldier performing strenuous work in hot field conditions (40°C and 29% relative humidity). TEE determined from doubly labeled water (DLW) methodology was 5,497 kcal/day. Hoyt et al (1994) reported similar results with six male soldiers performing work at high altitudes (2,500-3,100m elevation). The mean TEE was determined to be 4,558±566 kcal/day, using DLW methodology. In addition, our laboratory has conducted research on WLFFs using DLW methodology to determine TEE in WLFFs to be 3,000-6,300 kcals/day.

With a high energy demand in these arduous environments the need to maintain energy balance is essential for optimal work performance. Studies show military soldiers consume insufficient food to maintain energy[4, 34, 46] resulting in negative energy balance.[9, 26, 43] Ruby et al. (2002 & 2003) demonstrated that the WLFFs are able to maintain energy balance throughout the day.[49,50] However, in both studies, discrepancies in total energy intake[50] and body weight[50] and fat free mass[49] suggest that the WLFF's energy balance can become threatened. Collectively, these studies demonstrate the challenge and risk in meeting the high energy demands of individuals working in arduous environments.

There are strong and consistent correlations between the composition of dietary intake and performance. Consuming a low amount of CHO has been demonstrated to independently impair endurance exercise performance.[52] Furthermore, low CHO intake patterns has been shown to negatively impact marksmanship,[53] a performance task that is similar to the WLFF's cognitive skill and abilities.

In addition, environmental factors may directly affect the nutrition status of arduous workers. The conditions of soldiers and WLFFs share similarities such as high ambient temperature and high altitude. Hoyt & Honig (1996) have shown these two environmental conditions can negatively impact energy balance and thus increase concern that individuals in these occupations are meeting their energy (e.g. kcal) needs. Montain et al. (1997) performed a study on 27 soldiers to analyze carbohydrate supplementation (2600 kcal/day) and performance in hot and humid condition (30°C & 60% relative humidity). The soldiers performed three days of field training which included a 16-21 km march over difficult terrain, marksmanship training, two hours of rock climbing; a 14.5 km march, marksmanship, timed rock climb, and a 0.7 km uphill run.[41] During each training session subjects were assigned to carbohydrate-electrolyte (CHO-E), placebo, or water. There were no differences between the groups for fluid intake, body weight, climb time, run time, marksmanship, or mood. However, 70% of subjects consuming the CHO-E beverage on the final day sustained uphill run performance and superior marksmanship ability equal to or greater than the mean and 10-14% of the PLA and W groups were able to perform above the mean.

The importance of energy balance through CHO supplementation to enhance performance was supported in a subsequent study by Murphy et al. (1993). Using repeated measures design, researchers tested soldiers who performed two hours of aerobic exercise in the morning, rested seven hours, and a submaximal treadmill test to exhaustion. The feeding protocol consisted of either a placebo during the rest period, 2.2 g CHO/kg during the rest period, or 1.0 g CHO/kg during rest and 0.4g CHO/kg at 20, 40, and 60 minutes during the submaximal treadmill test.[44] Time to exhaustion was significantly increased with all CHO feedings and more so with CHO during rest and exercise. Additionally, Achten et al. (2003) conducted a randomized cross-over design study analyzing two different daily CHO intakes (65% CHO/8.4 g/kg per day (HCHO) vs. 40% CHO/ 5.4 g/kg per day (CHO)). The 11 day trial consisted of laboratory trials (day 1,5,8 and 11) 30 minutes at 57% VO_{2max} , 30 minutes @ 76% VO_{2max} , and 8 km time trial, easy training (days 2-4) 60 min. @ 75% HR_{max}, and hard training (days 6,7,9, and 10) 16 km run @ 100% VO_{2max}. A validated questionnaire showed a statistically significant deterioration in mood for both trials, although this outcome was more pronounced in the CHO trial. Finally, scores for fatigue were significantly higher in the CHO vs. HCHO trial. Collectively, these studies demonstrate the importance of maintaining energy balance to maintain performance and the importance of CHOs to enhance work performance.

Carbohydrate composition, amount and timing. The types of foods eaten, the timing of consumption, quantity and concentration is vital to the maintenance of steady work output and the prevention of gastrointestinal discomfort.[12, 18, 19, 38, 55] Studies cited within this review reported on the effects of carbohydrate solids,[2, 19, 21, 434, 55] liquids[11, 27, 54] and a combination of both[12] on various performance outcomes. Collectively, these studies show a positive association between CHO supplementation and work performance for all methods of CHO supplementation. The study designs vary, however, for quantity of CHO supplementation in relation to exercise duration, type, intensity, etc. Data shows long-duration physical labor tasks require that total CHO to be approximately 10 $g \cdot kg^{-1} BW^{-1} \cdot d^{-1}$.[50] Furthermore, the consumption of CHO during, or both before and during, exercise, results in the greatest ergogenic response. Thus, these studies suggest WLFF's work output may benefit from any form of carbohydrate consumed at intervals throughout the work shift.[17, 47]

Fat Oxidation during low-intensity work. Substrate utilization is determined by the intensity and duration of exercise as well as fitness level, diet, and environmental conditions.[5, 8, 30,51] It is well known that the major energy source at rest and during low-intensity work is fat oxidation and during higher intensities CHO are the body's primary fuel.[5,8,51] Jeukendrup (2003) states that with increased duration of activity there is a transition mainly to fat oxidation, primarily accounted for by substrate availability.[30] In a review written by Askew et al. (1984), it was reported that 50-60% contribution of fat to energy expenditure during low intensity, long duration exercise. When exercise intensity is increased to 65-85% of VO_{2max} fat utilization drops to 10-45% of the substrates used.[5]

In the WLFF, it has recently been reported by Cuddy et al. that the majority of the work day is spent performing sedentary, low-intensity work tasks.[17] Collectively, these studies demonstrate the importance of macronutrient balance for the long-duration energy intensive work of the WLFF.

Ergogenic Effects of Carbohydrates

With the exception of a small number of studies,[20, 36, 39] supplemental feeding during long-duration exercise (>2 hours) has been shown to increase the individual's ability to perform a set amount of physical work.[3, 10-12, 14-16, 19, 21, 27, 35, 37, 41, 54, 55] Most of these studies have compared the effects of CHO vs. placebo (PLA) on variables such as time to fatigue, work output, timing of consumption, supplement concentration, and metabolic stress. The majority of these studies have been conducted with endurance-trained subjects and typically do not last longer than four hours, with small exception.[33, 40, 41] Thus, there is a need for more studies examining the effect of supplemental feeding protocols on individuals performing long term (e.g. 12 hour shifts) arduous work. A number of studies have examined the effect of carbohydrate supplementation during exercise on metabolic-associated outcomes such as carbohydrate oxidation, sparing of liver and muscle glycogen, and blood glucose maintenance. A brief summary of studies in this these areas are described below.

Metabolic effects of carbohydrates. Carbohydrate supplementation during prolonged exercise has been shown to increase exogenous CHO oxidation[3, 19, 27, 28, 33, 55] and plasma glucose levels.[12, 15, 18, 37] While some studies report metabolic events spare muscle glycogen[16, 20, 21,] other do not.[15,19] These studies use a subject's maximal oxygen consumption (VO_{2max}) to standardize the exercise protocols. Fielding et al. (1985) reported no differences between exercise trials for muscle glycogen utilization. In this study, nine subjects were studied during three four hour cycling bouts consisting of 20 minutes at 50% VO_{2max} followed by 10 minutes intermittent exercise (30 seconds @ 100% VO_{2max} : 1 minute rest) and the final 30 minutes was a timed ride to exhaustion (20 minutes @ 50% VO_{2max} & 2 minutes rest and repeated). Subjects consumed either 10.75g of CHO w/ 200 ml of water at 30-minute intervals (F trial), 21.5g CHO w/ 400 ml water at 60-minute intervals (D trial), or a placebo at 60-minute intervals (C trial). Results showed an increase in CHO oxidation in both the F and D trials as well as significantly elevated blood glucose levels in trial D, although no significant differences in the rate of muscle glycogen depletion were observed. These findings indicate no relationship between CHO oxidation and muscle glycogen sparing. However, in addition to these findings, researchers had the subjects perform a sprint to exhaustion (100% VO_{2max}) at the end of each trial. Performance was significantly greater in trial F versus trial C (120.97 ±- 9.6 seconds vs. 81.0 ±- 7.1 seconds). It can be speculated that the absence of muscle glycogen sparing may be due to an insufficient supply of exogenous CHO. In short, this study reflects the ability of an exogenous supply of CHO to increase blood glucose concentrations, CHO oxidation, and work performance following four hours of exercise, but also concludes that CHO did not spare muscle glycogen stores.

In a subsequent study Hargreaves et al. (1984) reported the effects of carbohydrates consumed during the final minutes of exercise on blood glucose concentrations and muscle glycogen depletion. In this cross-over study design, 10 subjects cycling for four hours were given 43 g of sucrose (solid) w/ 400ml H_2O every hour (experimental (E) group) or 400 ml artificially sweetened drink w/o solid CHO (control (C) group). Results showed blood glucose concentrations were initially elevated at 20 minutes post-feeding ($p<0.05$) and at 230 minutes in group E versus C. The respiratory exchange ratios were significantly higher ($p<0.05$) and muscle glycogen utilization was significantly lower in the E group versus the C group (100.7±10.2 mmol·kg^{-1} w.w. versus 126.2±5.5 mmol·kg^{-1} w.w., respectively). During the final sprint to exhaustion at the end of each trial, group E performed 45% longer compared to the control group. These data indicate the crucial benefit of CHO during the final stages of exercise performance and thus, may have positive implications for the WLFF. For instance, the WLFF's long, arduous work shift may impair the ability to sustain blood glucose stores, especially if the WLFF doesn't eat enough carbohydrates. The WLFF may decrease his/her ability to react and perform quickly during the latter stages of the work shift, especially if their CHO intake is deficient or insufficient. Therefore, it is necessary to analyze an adequate feeding protocol that best fits the high energy and work demands of the WLFF.

Exogenous carbohydrates: time to fatigue and performance. Several studies have examined the relationship between CHO supplementation and increased time to exhaustion and performance.[3, 11, 12, 14-16, 18, 21, 27, 35, 37, 38, 54, 55] For example, Carter et al. (2003) reported eight subjects had a 13.5% (exercise @ 60% VO_{2max}) and 14.5% (exercise @ 73% VO_{2max}) improvement in time to fatigue during exercise in the heat (35°C). These subjects consumed a 6.4% CHO solution or a placebo during two trials until exhaustion at 60% and 73% VO_{2max}. At both moderate and high intensities time to fatigue was decreased in the CHO trial versus PLA (145.6±15.1 minutes and 123.1±13.4 minutes, respectively). Studies conducted by Coggan et al. (1987) and Wright et al. (1991) reported similar findings. For instance, Coggan et al. (1987) demonstrated the ability to perform longer during the second bout of exercise following a trial to exhaustion at 65-73% $VO_{2max.}$ Following a 20 minute rest period, the second exercise bout resulted in a 26±4 minute increase in performance with CHO ingestion before exercise (3g/kg) or 43±5 minute increase in performance with CHO infusion during exercise (20% dextrose).[12] Wright and colleagues demonstrated a 44% (5g/kg CHO prior to exercise and 0.2 g/kg CHO during), 32% (0.2g/kg CHO @ 20 minutes intervals during exercise), and 18% (5g/kg CHO prior to exercise) increase in work production with CHO supplementation.[55] Another study conducted by Tsintzas et al.(1993) analyzed two 30 km road race trials with seven endurance runners. The dose of supplementation provided was 250 ml @ 5% solution immediately prior and 150 ml every 5 km (CHO) versus water (W). Performance time was faster in the CHO trial compared to time of completion for the W trial (128.3±19.9 minutes vs. 131.2±18.7 minutes [$p<0.01$], respectively).

Lastly, Ivy et al. (1983) administered psychomotor tests in conjunction with exercise to analyze the ingestion of a CHO supplement. Ten subjects performed a series of psychomotor tests, exercise to fatigue on a treadmill (speed; 3.0-4.4 mph and grade; 2.0-4.0%), psychomotor tests (20 minutes), 10 minutes rest, and a run to exhaustion (80% VO_{2max}). The experimental (E) group consumed 120g glucose polymer @ 60, 90, 120, and 150 minutes versus control (C) group. Time to exhaustion was increased by 11.5% in group E versus C (E = 299.0±9.8 minutes; C = 268.3±11.8 minutes), indicating the ability to perform at a higher intensity following longer-duration exercise with CHO supplementation. Collectively, these studies demonstrate that supplemental CHO consumption during exercise increased time to fatigue by 13 to 44%, which is directly associated with increased overall performance. Thus, if WLFFs consume more CHO foods during their long work shifts, their work performance and output will improve.

Wildland Firefighting Research

Literature regarding the impacts of feeding strategies on extended work duration (8-12 hour) that requires high intensity physical labor is lacking. Wildland fire suppression requires long work hours (12-14 hr) under adverse conditions such as high ambient temperature, transporting heavy packs, compromised dietary intake, smoke inhalation, acute altitude exposure, and sleep deprivation. Ruby et al. (2003) demonstrated the impact of supplemental CHO feeding on WLFFs with both liquid CHO and solid CHO feedings. Twenty-nine subjects consumed solid CHO every odd hour and fluid CHO every even hour. The combination of solid (25g carbohydrate, 10 g protein, and 2 g fat) and fluid (200 ml/h of 20 % CHO) contributed to an additional 160kcal·hr^{-1} (CHO trial) vs. placebo trial (PLA). Investigators converted work output, determined by CSA activity monitors, to kcal expenditure and found no significant difference for work output during the first six hours between groups ($p<0.05$), although work output did significantly increase post-lunch by hour six in the CHO group (241±56kcal·hr^{-1} and 202±47kcal·hr^{-1}; $p<0.05$). Furthermore, blood glucose concentrations increased prior to lunch and at four and six hours post lunch (CHO group), demonstrating the times in which CHO were consumed. In short, Ruby et al. (2003) demonstrated that a consistent consumption of solid and liquid CHO prohibits blood glucose concentrations from dropping during the work shift and as a result, work output increased during the latter stages of the work shift compared to the PLA trial.[47]

Montain et al. (2003) reported an inverse relationship between caloric intake and decreased military task performance ($r = -0.75$; $p < 0.05$), and concluded individuals who had "disciplined, good food practices" would be more likely to sustain performance. Our laboratory has reported that WLFFs deviate away from the dietary recommendations for their particular work environment. For instance, self reported dietary recall data reported WLFF's CHO intake may be displaced by a slightly higher intake of dietary protein and fat during five days of wildfire suppression.[50] Most recently, Cuddy et al. (2007) reported an increase in self-selected work output during wildland fire suppression, especially during the latter hours of the work shift. In this cross-over study design, 76 subjects consumed one of two different isocaloric lunches. The sack lunch (SL) was prepared by the catering staff and consumed during a two hour window. The snack-on-the go lunch (SNA) consisted of individually packaged snack items consumed throughout the day every 90 minutes. Average counts per minute, measured by ActiCal units, were significantly higher for the SNA during hours 10-12 compared to SL, [521 ± 421 counts·min^{-1} and 366 ± 249 counts·min^{-1}, respectively; $p<0.05$]. In short, intermittent feedings increased work output in WLFF by 28% during the latter portion of the work shift.

Summary

Collectively, these studies consistently demonstrate several key factors in CHO supplementation and work performance. First, the consumption of CHO during exercise attenuates the decrease of blood glucose concentrations. Second, CHO consumption during exercise enhances performance by increasing the time to fatigue during long-duration exercise. Third, the sparing of muscle glycogen may or may not occur with CHO during exercise. Fourth, the consumption of CHO appears to allow subjects to sustain greater intensities during the latter phases of long-duration exercise, as well as increase the ability to perform bursts of work during the latter stages. Finally, intermittent CHO feedings appear to improve WLFF work output in the final hours of the work shift. The proposed study will build on previous research and investigate the effect of two isocaloric work shift food delivery systems consumed by WLFFs on post lunch work output, meal satisfaction and cost effectiveness.

CHAPTER THREE
METHODOLOGY

Introduction

The WLFF performs a physically demanding job on a consistent basis throughout the fire season. Therefore, there is a need to consume adequate nutrition to sustain a high level of work output through their laborious work day. Previous research shows that WLFF supplement their lunches with personal food items possibly due to dissatisfaction with the current feeding strategy. The production of the traditional sack lunch is quite expensive. The cost variability depends on the Mobile Catering Company that is contracted at an incident. These lunches can range from $9.96 to $12.77 per person. A practical delivery system that increases worker satisfaction, meal consumption, providing variety, self-selection, and low cost is needed. Therefore, this study will compare two isocaloric lunch delivery systems on total kcal and macronutrient intake, ratings of satisfaction, and food delivery system feasibility.

Research Design

A two-day randomized crossover design was used for this study. Subjects consumed two different isocaloric lunches; the traditional sack lunch (SL), which contained items provided by the caterer, and a shift food lunch (SF), that included food items provided by the researchers. The two lunch protocols served as the independent variables for the study. The first day of the study researchers randomly assigned subjects to either the SL group or the SF group. The following day the subjects consumed the opposite type of lunch they received the previous day. Both the SL and SF were consumed ad lib throughout their work shift. All subjects were informed that a commercial sport drink can be consumed as long as the same amount was consumed the following day. Subjects completed a survey following each work day that reported their overall satisfaction with the type of feeding strategy they consumed. Nutrient intake was determined for total kcals, fat, CHO and protein.

Population and Sample

The population consisted of 60 male WLFF working fires in the Northwest United States during the 2006 fire season. Both Type I (Interagency Hot Shot crews that are the primary ground wildland firefighting force) and Type II (a crew that does not meet experience, financing, training, and travel requirements of a type I crew) were eligible for study participation. Subjects were recruited based on availability, work assignments, and duration of employment at that particular fire. The subjects used in this study included WLFF from the M Q Franko Reforestation Type II crew (Aumsville, OR), Vale Type I crew (Vale, OR), Beaverhead-Deerlodge Type II crew (Dillon, MT), and Fort Peck (Fort Peck, MT) Bonneville Type I crew (Salt Lake City, UT). Of the 60 measured, 8 were not used in the data analysis due to incomplete survey data (n=2) and incomplete caloric intake data for day 2 of the study (n=6). The total number of subjects from each crew was 17, 20, 10, 6, and 7, respectively; of these 17, 20, 8, 6, and 1 were used for data analysis.

Researchers met with the crew boss one day prior to the study to recruit subjects. Upon approval researchers further discussed the obligations, the objectives and protocol for the study with the subjects. Subjects read and signed the informed consent form approved by The University of Montana's Institutional Review Board (IRB).

On the morning of the first experimental day subjects were weighed using a digital scale (Befour Inc., Cedarburg, WI). Subject wore standard issued Nomex pants, Nomex shirt, and work boots. All subjects emptied their pockets prior to weigh in. Next, the subjects' height was measured and their age was verbally provided.

Feeding Protocol

Nutrient database for sack lunch and shift food items. The SL food items were analyzed for total kilocalories, CHO, fat, and protein using a computer based dietary analysis program (Dietary Analysis, 6.1 Salem, OR, USA). The SF items were analyzed using their USDA nutrition facts food label. SF and SL nutrient information was entered into a separate food-item nutrient database. This database was developed for this study using Microsoft Excel.

The ~ 75 shift food items were numbered. The number associated with the specific food item and its nutrient content was listed in the food-item nutrient database. The subject's food choices were entered into this database. The database calculated the total caloric content and the percentage of kcals from CHO, protein, and fat. This information was pertinent to ensure that the feeding protocols were isocaloric. (The layout of this database is located in Appendix A).

Food Delivery Systems

SL Delivery System. The sack lunch consisted of a sandwich, fruit, candy bar (2) and juice prepared by the contracted caterer. Researchers meet with catering staff one day prior to the first experimental day to record the contents of the scheduled SL.

SF Delivery System. On the experimental day half of the subjects selected their SF items from the delivery line. The food delivery system had six different bins containing various categories of individually packaged food items purchased from a local grocery store. The bins contained beverages (~200 kcals/each), fruit (~100 kcals/each), candy bars (~300 kcals/each), chips/cookies (~200 kcals/each), high-kcal/protein items (~300 kcals/each), and low-kcal protein items (~100 kcals/each). The subjects were given two options for selecting food items from each of the six bins. The two options were provided to enhance the variety by which the subjects could choose. Each option resulted in approximately the same amount of kilocalories (~1500kcals). Table 1 illustrates the food delivery system guidelines and set-up.

After the subject selected his/her food items for the SF, the investigator entered the foods into the food-item nutrient database to determine the exact caloric content. Then, the on-site project director instructed the subjects to add or subtract food items in order to meet the previously entered kilocalorie content of the SL, to ensure both lunch protocols are isocaloric. Subjects were instructed to save all wrappers, food remnants, etc. from their lunch. At the end of the shift the on-site project director conducted a brief interview with the subject to determine the items consumed, amount, missing items, and supplemental food items or commercial sport drinks consumed.

Data Collection

The SF items were recorded in the food-item nutrient look-up database under the subject's identification number. Following subject interviews at the end of the work shift this information was updated and stored in a file for total food consumption. The same procedure was used to determine SL consumption. At the end of the work shift subjects completed a food delivery system satisfaction survey. On the second experimental day a comparative survey and a personal food preference questionnaire was administered. The comparative survey evaluated the subject's opinion for the different food delivery systems (e.g. SF or SL). The personal food preference survey allowed subjects to record their own food preferences beyond the food items provided in the SF. Refer to Appendix B for the surveys.

Food delivery system feasibility was determined by food waste data collected from post work shift interviews. An item-by-item list was discussed, and subjects verbally responded with a yes or no to the item that they fully or partially consumed. In addition, food eaten or sport drink(s) consumed that was not provided by researchers were recorded. Additionally, feasibility data also consisted of cost analysis derived from price per lunch compared to national average of Mobile food catering units and perception from on-site project director and staff. Refer to figure 1 for complete research timeline.

Statistical Procedures

Frequencies were performed on the final survey data and compared between groups. Individual survey's were analyzed using non-parametric, correlated Wilcoxon's Rank test, $p<0.05$ (SPSS 14.0, Chicago, IL). Caloric and nutrient intake differences between groups were determined paired t-tests ($p<0.05$). Qualitative data consisted of verbal comments from the research staff assessing the feasibility of the shift food delivery system ad interviews with the WLFF's determined food item waste. These verbal responses were summarized by frequency counts of common responses.

Work shift food delivery strategies during arduous wildfire suppression.

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Running Title: Work shift food delivery strategies during arduous wildfire suppression.

ABSTRACT

Purpose: The purpose of this study was to compare two isocaloric feeding strategies for wildland firefighters (WLFF) on total kcal and macronutrient (e.g. carbohydrates, total fat and protein) intake, ratings of satisfaction, and food delivery system feasibility.

Methods: Fifty-two Type I and Type II wildland firefighters (WLFF) from five different Fire Crews participated in the study. Subjects consumed either the traditional sack lunch (SL) or shift-food (SF) ad lib during their work shift in a randomized cross-over design. Subjects reported ratings of satisfaction with each feeding strategy. The SL nutrients were analyzed with Dietary Analysis 6.1 (Salem, OR, USA) and the shift food was analyzed by USDA nutrition facts food label and both were entered into a food-item nutrient database in Microsoft Excel. Delivery method feasibility was examined through reported perception from on-site research director and research assistant. **Results:** Subjects consumed significantly more kcals from the SF feeding strategy compared to SL feeding strategy (SF, 1701.7± 281.4 kcals and SL, 1333.7±356.4 kcals, $p<0.05$). There was a higher amount of fat and CHO kcals consumed in the SF group compared to the SL group (SF, 569.4±167.6 fat kcals and SL, 367.6±176.7 fat kcals; SF, 1010.8±247.3 CHO kcals and SL 725.2±238.4 CHO kcals, $p<0.05$). There were no differences in protein consumed between groups. Survey data show that subjects prefer the SF over the SL for convenience, variety, satisfaction, appearance, and overall preference ($p<0.05$). Qualitative data indicated it is feasible to deliver adequate variety, choice, and decrease waste with the shift meal system. In addition, the SF delivery method is cost effective.

Conclusion: The shift meal system provided greater nutrient variety and was more convenient to use than the current sack lunch meal system. WLFF's expressed higher satisfaction, consumed more energy (e.g. kcals) and carbohydrates, with the SF vs. SL system. The SF system is a feasible way to deliver adequate energy and nutrients to WLFFs while increasing nutrient variety and decreasing food waste. Finally, the SF system is more cost effective than the SL meal.

Keywords: FIREFIGHTING, SUPPLEMENTAL FEEDING, CARBOHYDRATE, OCCUPATIONAL PHYSIOLOGY

INTRODUCTION

Paragraph 1 The wildland firefighter (WLFF) is exposed to a multitude of adverse working conditions, including hiking in steep terrain, digging fire lines, and chain sawing while working in hot, dry and often hostile environment. This type of physical labor, based on task and duration, is classified as arduous, endurance or energy intensive.[45] For the WLFFs, endurance is required for the majority of their shift with periodic bouts of rigorous work. The range of total energy expenditure (TEE) of the WLFF is estimated at 12-26 $MJ\cdot day^{-1}$ (2868-6214 $kcals\cdot day^{-1}$).[50] Maintaining energy balance (e.g. kcal expenditure = kcal intake) with adequate CHOs and kcals as well as a balance of nutrients (CHOs, fat, protein) is essential for optimal performance under strenuous working conditions throughout the season (often > 100 days).

Paragraph 2 It is well documented that supplemental feeding during long-duration exercise increases the subject's ability to complete physical work.[3, 10-12, 15, 16, 19, 21, 27, 35, 37, 41, 54, 55] Furthermore, frequent CHO feedings consumed during the WLFF workday have been shown to increase work output by approximately two hours.[47] At present, the WLFF diet consists of a traditional sack lunch containing 1300-2000 kcals. Additionally, WLFF receive a fully catered breakfast and dinner of unlimited quantity. In spite of this access to food previous research has shown that WLFFs fail to eat a balance of appropriate nutrients to meet their work demands, falling short in their CHO intake by consuming more protein and fat than needed for such high physical work.[50] Moreover, one study reports that WLFFs often supplement their lunches with personal food preferences, such as energy bars and carbohydrate drinks while discarding unwanted food items from the sack lunch.[17]

Paragraph 3 Intermittent consumption of high-carbohydrate foods and/or supplementation during the work shift resulting in improved work outcomes, combined with the dissatisfaction with the current WLFF sack lunch, has prompted a need for a practical delivery method. Lunches should be nutritionally balanced, have nutrient variety and be convenient to eat and carry. Therefore, the purpose of this study was to examine a feeding protocol that provided choice, promoted intermittent snacking throughout the work shift, and increased meal satisfaction.

METHODS

Paragraph 4 **Subjects.** Subjects were 52 WLFFs from five different fire crews in the Northwest United States (mean±SD: age 30.5±10.2, mass 81.8±12.4 kg, height 180.4±8.7 cm) during the 2006 fire season. Both Type I (Interagency Hot Shot crews that are the primary ground wildland firefighting force) and Type II (crews that do not meet experience, financing, training, and travel requirements of a type I crew) participated in this study. Subjects were recruited based on availability, work assignments, and duration of employment at that particular fire. The University of Montana's Institutional Review Board (IRB) approved the study protocol, and subjects provided written informed consent before beginning the study.

Paragraph 5 **Research Design.** A two-day randomized crossover design was used for this study. Subjects consumed two different isocaloric lunches. The traditional sack lunch (SL), consisted of items provided by the caterer, and a shift food lunch (SF) consisted of food items provided by the researchers. Both the SL and SF were consumed ad lib throughout their work shift, with the shift food encouraged to be consumed regularly throughout the day. Subjects were allowed to consume commercial sport drinks (125 kcals/beverage) during the work shift if consumption was meet both experimental days. Subjects completed a survey following each work day that reported their overall satisfaction with the type of feeding strategy they consumed.

Paragraph 6 Food items were analyzed for nutrients using a nutrient database and their USDA food labels. Food delivery system feasibility was determined by food waste information collected from post work shift interviews with WLFF and perceptions about the meal systems from the on-site project director and staff. Cost analysis was acquired from the national database for Mobile Catering services for WLFF incidents.

Paragraph 7 Feeding Protocol*. Nutrient database for sack lunch and shift food items.* The SL and SF unlabeled food items were analyzed for total kilocalories, CHO, fat, and protein using a computer based dietary analysis program (Dietary Analysis®, 6.1 Salem, OR, USA) and the packaged food items were analyzed by their USDA nutrition facts food labels. Both the SF and SL nutrient information was entered into a separate food-item nutrient database developed for this study using Microsoft Excel (The layout of this database is in Appendix A). The ~ 75 food items used in the study were numbered, the number associated with the specific food item and its nutrient content were listed in the database. The subject's food choices were entered into this database which calculated total caloric content and percentage of kcals from CHO, protein, and fat.

Paragraph 8 *SL Delivery System.* The SL consisted of a sandwich, fruit, candy bar (2) and juice prepared by the contracted caterer.   Researchers met with catering staff one day prior to the first experimental day to record the contents of the scheduled SL.

Paragraph 9 *SF Delivery System.* On the experimental day half of the subjects selected their SF items from the delivery line. The food delivery system was comprised of six different bins containing various categories of individually packaged food items purchased from local grocery stores. The bins contained beverages (~200 kcals/each), fruit (~100 kcals/each), candy bars (~300 kcals/each), chips/cookies (~200 kcals/each), high-kcal/protein items (~300 kcals/each), and low-kcal protein items (~100 kcals/each). The subjects were given two options for selecting food items from each of the six bins. The two options increased the variety of foods and nutrients each subject consumed. Each option resulted in approximately the same amount of kilocalories (~1500kcals). Table 1 illustrates the food delivery system guidelines and set-up. After the subject selected the SF food items, the investigator entered the foods into the food-item nutrient database to determine the exact caloric content. Then, they were instructed to add or subtract food items, if necessary, to meet the previously entered kilocalorie content of the SL and to ensure both lunch protocols were isocaloric.

Paragraph 10 **Data Collection.** Subjects were asked to save all wrappers, food remnants, etc. from their lunch. At the end of the shift the on-site project director conducted a brief interview with each subject to determine the items consumed, amount, missing items, and supplemental food items or commercial sport drinks consumed.

The SF items were recorded into the food-item nutrient look-up database under the subject's identification number. Following each subject's post-work interview the food information was updated and stored in a file for total food consumption. An item-by-item list was discussed, and subjects verbally responded with a *yes* or *no* to the item that they fully or partially consumed. In addition, food eaten or sport drink(s) consumed that was not provided by researchers were recorded.

Paragraph 11 Subjects were given either a SF satisfaction survey or SL satisfaction survey at the end of each day corresponding to that day's lunch assignment. At the end of the second experimental day a comparative survey and a personal food preference questionnaire was administered and collected. The comparative survey evaluated the subject's opinion for the SF vs. SL. The personal food preference survey allowed subjects to record their own food preferences beyond the food items provided in the SF. Refer to figure 1 for complete research timeline.

Paragraph 12 **Statistical Procedures.** Frequencies were performed on the final survey data and compared between groups. Individual SF and SL survey's were analyzed using non-parametric, correlated Wilcoxon's Rank test, $p<0.05$ (SPSS 14.0, Chicago, IL). Caloric and nutrient differences between groups were determined paired t-tests ($p<0.05$). Qualitative data, to determine food delivery system feasibility, consisted of verbal comments from the project director and staff. These verbal responses were summarized by frequency counts of common responses. Post-work shift interviews with the WLFF's determined food item waste and lunch cost derived from price per lunch compared to national average of Mobile food catering units determined cost effectiveness.

RESULTS

***Paragraph 13* Nutrient Intake.** Subjects consumed significantly more kcals from the SF feeding strategy compared to SL feeding strategy, even though these food delivery systems were isocaloric (SF, 1701.7±281.4 kcals and SL, 1333.7±356.4 kcals; $p<0.05$, Fig. 2). There was a higher amount of fat and CHO kcals consumed in the SF group compared to the SL group (SF, 569.4±167.6 fat kcals and SL, 367.6±176.7 fat kcals; SF, 1010.8±247.3 CHO kcals and SL 725.2±238.4 CHO kcals, $p<0.05$, Fig. 2). Average consumption of kcals from protein were not significantly difference between groups ($p<0.05$, Fig. 2).

***Paragraph 14* Food Delivery System Surveys**. Frequencies were reported for the sack lunch vs. shift food survey (Table 5). The choices for each question of this survey were; sack lunch, CHO snacks (shift food), or both were the same. A higher percentage of subjects indicated that SF was more convenient to carry and eat than the SL (45.3% vs. 7.5% and 58.5% vs. 7.5%, respectively). An equal number of subjects indicated that the SF and the SL gave them the ability to work better (45.3%). A higher percentage of subjects indicated that the SF had greater variety, satisfaction, appearance, and overall preference compared to the SL (84.9% vs. 7.5%, 73.6% vs. 15.1%, 69.8% vs. 9.4%, and 60.4% vs. 13.2%, Table 5).

Paragraph 15 Individual surveys that evaluated each dietary intervention were compared quantitatively. The median, interquartile range (IQR), score for convenience to carry for SF was 0.72 (0.52-0.91) compared to 0.54 (0.51-0.76) (Table 6, $p=0.008$). The median

(IQR) score for convenience to eat for SF was 0.72 (0.52-0.90) compared to the SL 0.52 (0.42-0.61). There was a significantly different median (IQR) score for subject's perception of the lunch system's ability to make them work better and keep them energized throughout the day [SF; 0.52 (0.51-0.57) and SL; 0.48 (0.30-0.53), $p=0.008$. SF; 0.55 (0.51-0.80) and SL; 0.50 (0.32-0.54), respectively, $p=0.003$]. The median (IQR) score between SF and SL was different for variety, taste, and appearance [$p<0.001$ for all three variables]. The number of additional food items preferred in the SL were higher than the SF [2.0 (0.0-3.0) and 1.5 (0.0-3.0), respectively ($p=0.253$)]. Finally, the median (IQR) score for overall satisfaction was significantly different between SF and SL 0.67 (0.51-0.90) and 0.43 (0.30-0.54), respectively, $p<0.001$).

Paragraph 16 **Food Delivery System Feasibility.** Shift food delivery system feasibility was determined qualitatively. The on-site director and research staff perceived the shift food delivery system set-up to be both simple and comprehensive. The shift food method of delivery provided a great deal of variety and choice while maintaining an easy to follow selection system. However, our observations are based on low volume of subjects and can only estimate the feasibility of using the SF system during a full fire camp. Additionally, the cost of the SF versus the SL was considerably lower than the USFS contract costs for SL [SF; \$4.38 and SL; \$9.96-\$12.77].

DISCUSSION

Paragraph17 The utility of carbohydrates for sustaining aerobic athletic performance and to enhance recovery has previously been widely demonstrated in the sports science community and their regular use as an easy, safe, and cost effective supplement is well documented. However, even the longest duration studies are generally less than three hours. Our laboratory has conducted numerous field studies evaluating the effects of supplemental feeding strategies on self-selected work rates in the long-duration work of a wildland firefighter (WLFF).[17,47,48] These investigations have consistently shown that when carbohydrates are consumed regularly across a 10 to 12-hour work shift, work performance is increased and recovery is enhanced the following day. Furthermore, Ruby et al. (2003) reported that the self-selection of food in fire camp resulted in higher intake of dietary protein and fat than is recommended for long-duration work, displacing CHO intake. However, no practical food item delivery system has been investigated for self-selected nutrient intake. Food consumed during an extended work shift of 10 or more hours, under varying and uncontrolled conditions including extreme heat, smoke, and low humidity needs to be readily available, highly palatable, and provide the necessary energy for sustained work.

Paragraph 18 The current study was designed to test a new and practical method to provide food that could be eaten throughout the work shift (shift food), while achieving adequate consumption of energy, balance of nutrients, and producing higher ratings of satisfaction for the SF compared to the conventional SL delivery system. This design differed from previous studies which have added scheduled feedings of supplemental carbohydrate or mixed food items to the conventional SL feeding system during the work shift.

Paragraph 19 The nutrient data verified the isocaloric balance between SL and SF provided. Furthermore, these data demonstrated that the SF group consumed a greater percentage of their lunch compared to the SL group resulting in less SF waste. These data were based on post-work shift interviews, where data on both the items consumed were reported and wrappers collected and those items not consumed were returned. While previous studies have not collected data on the sack lunch consumption habits of WLFF, anecdotal evidence shows a high percentage of the regular sack lunches are not consumed during the work shift, either being thrown away or collected and given to food banks. Many fire crews are said to provide collection boxes for these unwanted food items. The food delivery method tested in this trial provided WLFF's a choice of items while maintaining nutritional balance and adequate calories.

Paragraph 20 By design, the macronutrient content between the SF and the SL delivery systems were similar for kcals and CHO kcals, however the SF group were supplied a lunch with higher fat kcals and lower protein kcals. The percentages of kcals for the three macronutrients were based on recommended guidelines for long-duration sustained aerobic performance, 55-60% CHO, 25-30% fat, and 12-15% protein.[1,13] The macronutrient distribution provided in both the SL and SF lunches were within these recommendations. The average nutrient percentage for food supplied to the SF group was 61% total kcals from CHO, 33% total kcals from fat, 10% total kcals from protein, and compared to the SL group which was 63% total kcals from CHO, 23% total kcals from fat, and 14% total kcals from protein. More importantly the percentage of total kcals for nutrients consumed for the SF group resulted in 33% fat, 11% protein, and 59%

CHO compared to the SL group where the average percentage of total kcals for nutrients were 27.5% fat, 15% protein, and 54% CHO. Ultimately, the SF group consumed a higher amount of fat, an equal amount of protein, and higher CHO kcals compared to the SL group. This data suggests an adequate balance of nutrients were consumed by both groups for these working conditions.

Paragraph 21 The recommended CHO consumption during continuous arduous work at a moderate intensity is 5-7g/kg per day and 7-10g/kg for hard intensity.[13] It was reported that WLFF's spend 61-66% of their time performing sedentary, low-intensity work tasks.[16] Accounting for the intensity of the work performed by the WLFFs, they would require on average 5-7g/kg per day of CHO. (e.g. a 70kg individual would need 350 to 490 grams of CHO/day). Nutrient analysis (Dietary Analysis, 6.1 Salem, OR, USA) of the breakfast and dinner food item requirements established by the United States Forest Service (USFS), the wildland firefighter consumes an average of 182-190 grams of CHO/day. Including the SF lunch, the WLFF would receive 442-434 grams of CHO/day while the SL would result in a total of 371-362 grams of CHO/day. Thus, the higher amount of CHO consumed for the SF group is more favorable for the long-duration energy intensive type of work performed.

Paragraph 22 The SF group also consumed a significantly higher percentage of fat compared to the SL. It would appear that a lunch comprised of 33% total kcals from fat would not be beneficial under arduous working conditions. However, recommendations for fat consumption specific to WLFFs are 20-35% of daily kcals.[13] In addition, the higher percentage of fat is not of concern since previous research has demonstrated

WLFFs spend 61-66% of there 12-hour work shift performing sedentary, low-intensity activities, of which require less than 7kcals/min. It is well known that under low-intensity activities the body favors fat oxidation for energy.[5, 8, 51] Therefore, the higher average percentage of fat in the SF delivery system is not detrimental and may, in fact, be beneficial to the WLFF.

Paragraph 23 Carbohydrates are utilized during the low-intensity working conditions of a WLFF.[17] The intermittent work:rest periods during the work shift may allow for the resynthesis of glycogen from these exogenous CHOs not being readily oxidized.[17] The maximum rate of CHO oxidation from exogenous sources is 1.0-1.75 $g \cdot min^{-1}$, the supplemental feeding of CHOs can potentially delay liver glycogenolysis.[17] The majority of the time spent performing low-intensity work may allow for glycogen resynthesis and higher substrate utilization of fat. Therefore, the higher percentage of fats consumed with SF delivery system should not have detrimental effects during wildfire suppression.

Paragraph 24 There was no difference between groups for protein kcals consumed. The average protein content of the SF and SL were 48.7 grams and 51.0 grams, respectively. Including these values with the mobile food contract requirements established by the USFS for breakfast and dinner the total protein provided could range from 186.2-199.7 grams of protein/day using the SF method and 188.5-202.4 grams of protein/day using the SL method. These protein amounts exceed the recommended requirements for the WLFF. For example, a 70 kg WLFF performing moderate to hard work needs 84-105 grams of protein/day based on 1.2 to 1.8 g/kg/day recommendations.[1,13] The theoretical maximum safe intake of protein is approximately 3.5-4.5 g/kg/day or >35% of total dietary intake (245-315 g/kg/day for a 70kg individual).[6] While neither group exceeded the maximum limit of protein intake, both groups consumed much more protein than their daily requirements. Whether or not these high protein intakes positively or adversely impact work output or physiology would be valuable to explore in further studies.

Paragraph 25 The individual delivery system survey data showed the SF group had a significant difference for the nine questions addressing different variables (Table 6). Additionally, comparative survey data showed the SF group had a higher percentage of positive responses for this lunch delivery system compared to the SL group. Subjects perceived the SF to be more convenient, improve ability to do their work, provide greater variety, and an increased satisfaction in taste and appearance. With greater perceived convenience to eat and to carry this may suggest that the SF items influence the subjects to consume these items more readily throughout the day. Furthermore, the delivery method gave subjects the ability to choose from two options of which increased the selection of food items. Thus, the SF group perceived their lunch to provide greater variety, along with greater satisfaction in taste and appearance compared to the SL group lunch. Due to subject's positive perception of the SF compared to the SL a higher consumption rate can be expected with these food items supplied. Overall this survey data suggest a higher preference and overall satisfaction for the SF over the SL.

Paragraph 26 Approximately 60% of the subjects preferred the SF over the SL (Table 5) and overall satisfaction there was higher for SF group compared to the SL group ($p<0.001$, Table 6). These qualitative data are in agreement with the food consumption data showing that the SF group had higher energy, CHO, and fat intakes than the SL group. On average, only 75.7% of the SL contents were consumed compared to 95.0% of the SF contents. These findings coincide with anecdotal evidence of considerable waste from the traditional SL.

Paragraph 27 The feasibility of the SF delivery system was determined qualitatively through perception of the on-site project director and research assistant. The daily set-up of the SF delivery system was perceived as unproblematic by the on-site research director. The 75 items provided in the delivery system appeared adequate in providing variety and choice to the study participants. The on-site research assistant perceived the delivery system's two bin options as an essential component in adding to the subject's choice of food items. Project staff felt that the instructions and signs provided for each bin were easy to understand and allowed for quick assembly of the lunch. The time obligation to compile a lunch from the SF delivery system was minimal with the volume of subjects in our study.

Paragraph 28 Recent presentations of the SF delivery system preliminary results, by Dr. Brian Sharkey of the Montana Technology and Development Center (MTDC), has gained support of the incident management teams, MTDC workforce, mobile food contractors, and National Interagency Fire Center (NIFC) Contracting Personnel. As a result, the Big Sky Mobile Catering unit will work during the 2007 fire season under new contract language to provide SF lunches to full fire camp as a test project.

Paragraph 29 We perceive the limitations of the SF delivery system to be based around logistics. The SF delivery system was tested under low-volume conditions (e.g. 10

subjects per day). The typical fire camp can range from 200 to 1000 people. The feasibility of the SF delivery system is unknown under this type of volume. However, we believe that the system can be altered and magnified to accommodate for high-volumes.

Paragraph 30 The traditional sack lunches are normally picked up by one crew member for the entire crew. The SF delivery system requires each individual to assemble their own lunch. This would require several SF delivery lines with the required bins and items for each line. Previously, the sack lunch delivery required one to two workers who distributed the lunches in addition to a large crew to pre-assemble all lunches. The SF delivery system may require more workers to re-supply bins, monitor proper food distribution, and answer questions. However, the preparation required to pre-assemble the sack lunches will not be unnecessary with the SF delivery system.

Paragraph 31 Other concerns with the SF delivery system are possible contamination issues that may arise with self-selecting from bins. A possible solution may be to enforce a hand-washing requirement prior to entering the assembly line. Issues concerning incidents that include up to 1000 individuals may be resolved by increase in number of assembly lines to accommodate personnel volume.

Paragraph 32 The current cost of the traditional SL averages $12.77 across the nation, the average cost of the SF lunch was $4.38. The 24.3% that was reported for SL waste during the study equates to $3.20 lost per lunch. Therefore, on an incident with 500 sack lunches distributed for fire crew personnel on a 10-day fire the potential for a loss of $16,000 is likely. We believe that with this data and the cooperation of the USFS, NIFC, and MTDC these issues can be resolved and a feasible SF delivery system will be utilized throughout the nation.

Paragraph 33 Collectively, the results of this study show that it is feasible to deliver a choice of practical food items providing a nutritionally balanced diet, isocaloric to the traditional sack lunch, which can be snacked on throughout the work shift. The data show that WLFF preferred the new delivery system over the traditional sack lunch system. The self-selection of food items increases meal satisfaction and energy intake, and also improves nutrient balance. Adequate energy and nutrient balance during arduous wildfire suppression prepares the WLFF to maintain work output and reduce fatigue during the latter hours of the work shift when fire behavior is typically unstable. Thus, these data from real-life field testing can improve the safety of the WLFF's working conditions on the fire line. Future studies should be conducted on a full fire camp to ensure the feasibility of the SF delivery system and address other issues that may arise with various incident volumes.

CHAPTER FOUR
Description of Additional Study Outcomes and Methodological Issues: Informing Future Studies

Introduction

While the previous thesis chapters and manuscript focus on the impact of the two feeding strategies on total kcal and macronutrient intake, ratings of satisfaction, and food delivery system feasibility the original design was to also examine the effect of the food delivery systems on work output and RPE. Due to the study design's inability to hold constant a number of extraneous variables that negatively impacted the validity of the workload and perceived rate of exertion, these outcomes were withheld from the main body of the thesis and manuscript. Nonetheless, the problems encountered with collecting and analyzing these data are important to consider when designing future studies in this area. Therefore, this chapter reports and discusses the work output and RPE outcomes.

Methodology

The study methodology includes the previously reported methodology and the addition of the following:

ActiCal units (MiniMitter, Bend, Oregon) were used to analyze work output. Monitors were initialized the night prior to the first experimental day and distributed the morning of day one. The units were placed in 3"x 3" foam squares to ensure stability and security as well as damage protection. They were inserted into the left-hand shirt pocket of the subject's Nomex shirt, for the purpose of obtaining an accurate analysis of their total body movement since WLFF frequently use their upper body for daily work tasks.

Actical placement to obtain more accurate results has been validated during wildfire suppression.[21] ActiCal monitor data was downloaded upon completion of the two-day study and the data will subsequently be analyzed for mean daily activity and 2-hr increments throughout the work day.

Each subject received a daily task card at the beginning of each experimental day. The card consisted of adequate space to record hourly tasks throughout the work shift (digging line, hiking, chain sawing, etc). It also contained Borg's 6-20 RPE scale and spaces to record RPE during each hour of the work shift. At the end of the work shift each RPE card was collected.

Extraneous Variables That Were Not Well Controlled

- Fire Activity (fire behavior)
- Small number of subjects from crews with higher fire behavior
- Feeding intake times
- Inconsistent RPE & work task reporting (e.g. over or under reporting variability)

Data Analysis

All descriptive data are discussed as means±SD. A one-way repeated measures ANOVA was used to determine differences in total activity counts between groups. A 2x4 repeated measures ANOVA will be used to determine the differences in hourly activity counts and time spent in different intensities between the two groups (See Table 2). To analyze work output by different intensities, activity counts will be divided into three categories: sedentary (0-99 counts·min^{-1}), light (100-1499 counts·min^{-1}), and moderate/vigorous (≥1500 counts·min^{-1}). A 2X3X3 ANOVA will be used to determine time spent in each intensity zone at each time point between groups. For RPE, a 2x5 repeated measures ANOVA was used to determine differences in perceived exertion (See Table 3). (SPSS 13.0, Chicago, IL).

Outcomes

Total Activity. Total daily work output was similar between groups, [454.9 ± 185.5 and 476.9 ± 225.6 counts·min^{-1}] for the SF and SL days, respectively ($p=0.48$, Fig. 3 and Table 7).

Hourly Activity. The group by time interaction was not significant ($p<0.05$). There was a main effect of time on activity. Average activity counts·2hr^{-1}during hours 10-12 were significantly higher versus hours 8-10 [686.5 ±537.9 and 387.5 ± 317.2, respectively; $p<0.05$, Fig. 4 and Table 8]. There were no significant differences for average counts·2hr^{-1} between the SF and SL group at any time point.

Intensity. There was no significant day by time interaction for the sedentary (0-99 counts·2hr^{-1}), light (100-1499 counts·2hr^{-1}), and moderate/vigorous (≥1500 counts·2hr^{-1}) intensities. However, there was a significant main effect of time on minutes spent in sedentary from hours 6-8 to 8-10 [71.5 ± 26.9 minutes·2hr^{-1} and 58.8 ± 25.3 minutes·2hr^{-1}, respectively; $p<0.05$, Fig. 5a]. A main effect of time was also present from hours 6-8 and 10-12 [71.5 ± 26.9 minutes·2hr^{-1} and 55.9 ± 23.1 minutes·2hr^{-1}, respectively; $p<0.05$, Fig. 5a]. For the light intensity range there was a significant main effect for time, demonstrating an increase in time spent in the light range between hours 6-8 and 8-10 of the work shift ($p<0.05$). The mean time spent in the light range was 71.5 ± 26.9 and 58.8

± 25.3 minutes·$2hr^{-1}$ for hours 6-8 and 8-10, respectively ($p<0.05$, Fig. 5b). For the moderate/vigorous range there was a significant main effect for time, demonstrating a decrease in time spent in the sedentary and light ranges between hours 6-8 and 10-12 as well as hours 8-10 and 10-12 of the work shift ($p<0.05$). The mean time spent in the moderate/vigorous category was 71.5 ± 26.9 and 58.8 ± 25.3 minutes·$2hr^{-1}$, respectively ($p<0.05$, Fig. 5c).

RPE. The day by time interaction was not significant. The main effect for time, demonstrating an increase in RPE for hour 8 versus hour 1 ($p<0.05$, Fig. 6).

Discussion

The current study focused on the food delivery method and while regular periodic eating throughout the day was encouraged during the shift food consumption trial, the study design did not monitor when the groups ate their foods. The study design did not control well for several extraneous variables. These variables were fire behavior, limited number of subjects between fires, feeding intake times, and inconsistent reporting of RPE and work tasks. Thus, the following results for work output and RPE should be interpreted with caution.

The total daily work output in the SF group did not differ significantly at any time during the work shift compared to the SL group (Fig. 3). The differences in fire behavior between fire crews and the uncontrolled feeding times are both factors that negatively impacted the validity of work output data. If these data were collected under more stable conditions they would partially agree with findings from a similar isocaloric study conducted by researchers from our laboratory in 2005. Cuddy et al. (2007), investigated the traditional sack lunch (SL), consumed in a two-hour window mid day, versus snack food items (SNA) consumed at two-hour intervals throughout the work shift. Results showed there was no difference in total daily work output between diets. However, unlike our study where no hourly differences were found, average counts$\cdot$min^{-1} were 42.3% higher in the SNA compared to SL during hours 10-12.[17] These differences can in part be explained by the different study designs.

Unlike Cuddy et al. (2007), our subjects were not required to snack regularly or to record food consumption throughout the day. The recommendation of intermittent feeding was only encouraged for those who were consuming the SF and when consuming the SL subjects were told to consume as they normally would. The lack of control for specific feeding times limits our knowledge of when the SF items were consumed and if total and/or hourly activity outcomes would have been different had we controlled for this variable. Furthermore, the isocaloric design of the study may explain the similar activity pattern throughout the work shift. Previous studies have shown a significant increase in work performed (9.8 hours) when fed supplemental CHO (160 kcal$\cdot$hr^{-1}) in addition to the 1500-1800 kcal sack lunch. It is possible that the SF and SL group may have consumed similar portions of their lunch each hour. Thus, under isocaloric conditions regular feedings from both SF and SL groups produced no differences in amount or intensity of work performed.

Future studies should attempt to control for these extraneous variables with the following recommendations: 1) monitor meal system intake throughout the work day, 2) obtain an equal amount of subjects when using multiple fires during analysis, 3) make an effort to study work output under moderately stable fire conditions and similar day to day work tasks, 4) maintain hourly contact with the crew boss and/or thorough explanation of the importance of RPE and work task reporting should be made each experimental day. These changes in study design would allow for more accurate and valid analysis of the effect of nutrient intake on self-selected work rates during wildfire suppression.

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Table 1. Food Delivery System Guidelines and Set-up for Shift Foods.
The SF delivery system consisted of three pairs of bins with two options for each pair. Assembly of the SF lunch based on the two options equaled ~1500 kcals. Subjects were prompted to add or take back food items to ensure the SF lunch was isocaloric to the SL.

	Beverages	**Fruit**	**High-Kcal CHO**	**Moderate-Kcal CHO**	**High-Kcal protein**	**Low-Kcal protein**
Bin Number	**1**	**2**	**3**	**4**	**5**	**6**
Option A	Choose 2	1	1	1	2	1
Option B	Choose 1	3	1	1	1	3

Table 2. **Statistical analysis for work output** A mixed design ANOVA analyzed work output for two groups and four time points. T= time; Work Output= 2-hour mean activity counts				
	2X4 Work Output			
SF	T4	T6	T8	T10
SL	T4	T6	T8	T10

Table 3. Statistical analysis for RPE A mixed design ANOVA analyzed RPE for five time points and two groups. HR= hour					
	2X5 RPE				
SF	HR6	HR7	HR8	HR9	HR10
SL	HR6	HR7	HR8	HR9	HR10

Table 4. Descriptive data. Mean±SD	
N	52
Age	30.5 ± 10.2
Height (cm)	180.4 ± 8.7
Weight (kg)	81.8 ± 12.4
BMI	20.07 ± 3.04

Table 5. Sack Lunch vs. Shift Food Survey data. Frequencies for each response are shown.*

	Percentage (%)		
Survey Questions	**Sack Lunch** n=52	**Shift Food** n=52	**Both were the same** n=52
Question 1. *Which eating strategy did you find more convenient to carry with you?*	7.5	45.3	45.3
Question 2. *Which eating strategy did you find more convenient to eat?*	7.5	58.5	30.2
Q3. *Which eating strategy made you feel like you were able to work better?*	13.2	37.7	45.3
Q4. *Which eating strategy gave you a greater variety of foods*	7.5	84.9	3.8
Q5. *Which eating strategy gave you greater satisfaction in taste of foods?*	15.1	73.6	9.4
Q6. *Which lunch foods had a better appearance?*	9.4	69.8	18.9
Q9. If you had your choice of lunch, which would you prefer to have?	13.2	60.4	20.8

*Variable frequencies not equaling 100% due to percentage of respondents not answering the specific survey question (data not shown).

Table 6. SF and SL survey's*

Correlated, non-parametric Wilcoxon's Rank Test analyzed responses for the SF and SL surveys. The median score and the interquartile ranges are represented for each question.

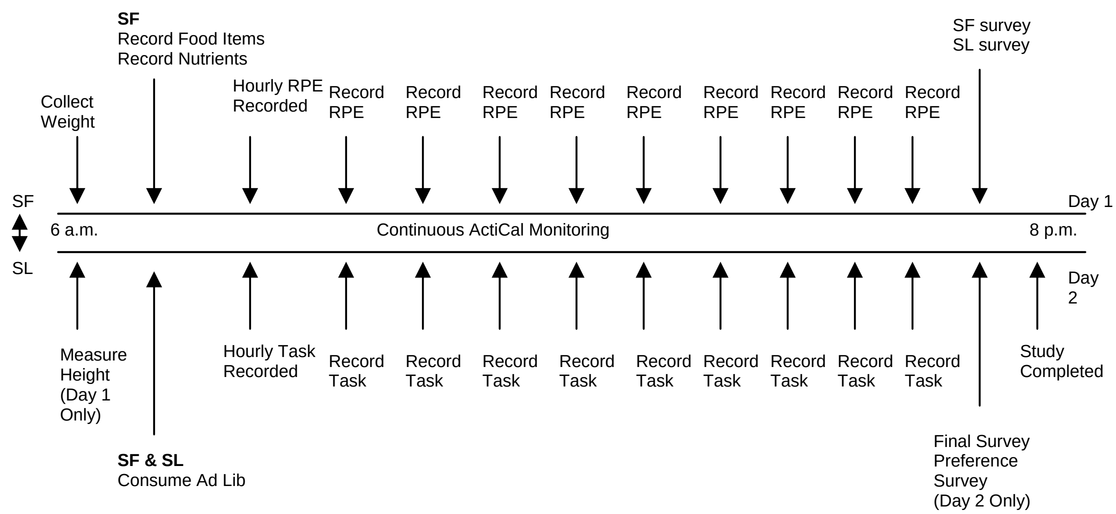
n=52 (IQR; interquartile range)

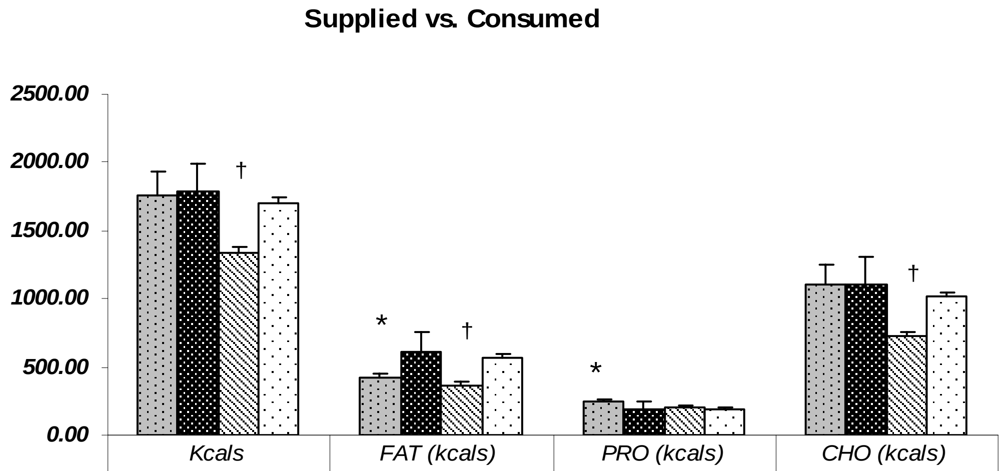
	Convenience to carry	Convenience to eat	Ability to work	Variety	Taste	Appearance	Energized	# of additional items preferred	Overall Satisfaction
Question	1	2	3	4	5	6	7	8	9
Signed mean rank	15.39	10.84	9.74	14.17	11.74	11.02	17.61	6.21	18.31
Median SF	0.717	0.715	0.519	0.729	0.822	0.690	0.547	1.5	0.667
IQR SF	0.523-0.907	0.516-0.899	0.508-0.574	0.544-0.899	0.534-0.899	0.544-0.899	0.505-0.797	0.00-3.00	0.513-0.891
Median SL	0.535	0.519	0.475	0.421	0.494	0.481	0.504	2.0	0.426
IQR SL	0.512-0.755	0.424-0.606	0.297-0.533	0.209-0.564	0.241-0.526	0.222-0.572	0.321-0.541	0.25-3.00	0.292-0.538
p-value	0.008	0.001	0.008	0.000	0.000	0.000	0.003	0.253	0.000

Table 7. Daily Mean Activity Counts. Activity counts (ActiCal units) calculated by one minute average across the 12-hour work shift. There was no difference in mean counts. (counts·min^{-1}±SD)		
Sack Lunch N=40	**Shift Food** n=40	**p-value**
476.9±225.6	454.9±185.6	0.478

Table 8. Effect of Sack Lunch vs. Shift Food on Activity during 2-hr Work shift increments. Activity counts (ActiCal units) calculated by one minute average across a 2-hour interval during the 12-hour work shift. There were no differences in hourly activity.			
Hours	**Sack Lunch** **counts/minute·2hr^{-1}**±SD n=40	**Shift Food** **counts/minute·2hr^{-1}**±SD n=40	**P-value**
1-2	344.0±246.7	355.6±283.3	0.804
2-4	580.9±543.1	609.7±531.9	0.652
4-6	550.8±381.2	441.5±290.0	0.058
6-8	270.4±269.3	286.0±248.0	0.748
8-10	393.4±330.6	381.6±303.8	0.845
10-12	719.9±546.0	653.0±529.8	0.336

Figure 1. Research Timeline





	Kcals	FAT (kcals)	PRO (kcals)	CHO (kcals)
Sack Supplied	1761.25	414.58	248.75	1110.28
Shift Supplied	1791.75	603.92	193.00	1104.00
Sack Consumed	1333.74	367.57	204.12	725.15
Shift Consumed	1701.75	569.37	194.96	1010.84

Figure 2. Nutrition Differences in Supplied vs. Consumed between SF and SL trials. *p<0.05, significant differences between SL supplied and SF supplied. †p<0.05, significant differences between SL consumed and SF consumed.

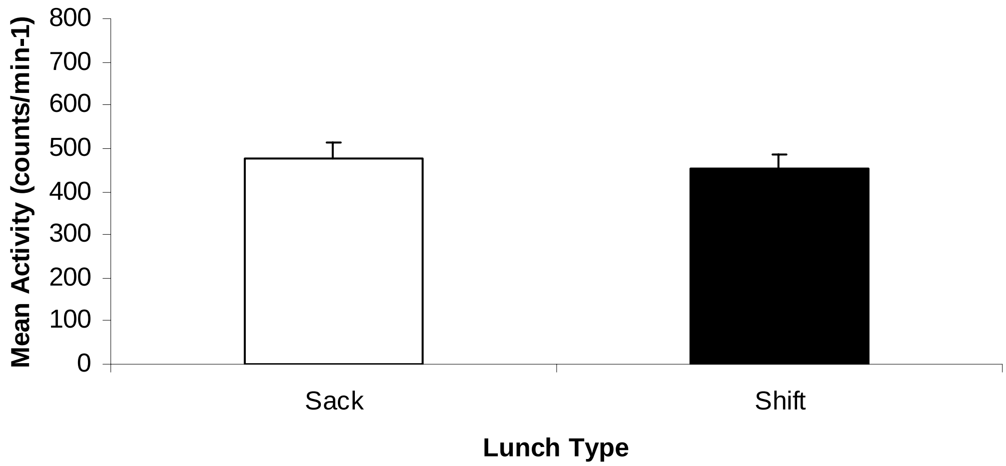


Figure 3. Mean counts·min^{-1} for the SF and SL groups using Actical® monitors, n=40. There were no differences.

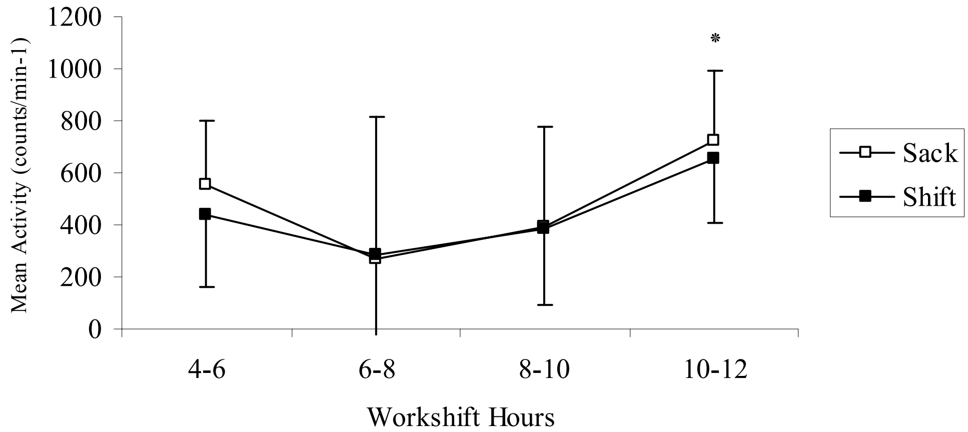
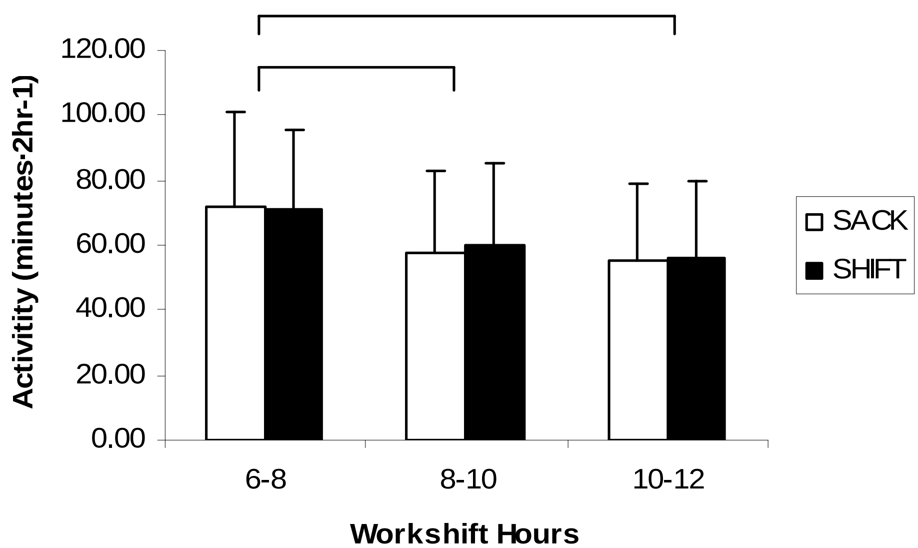


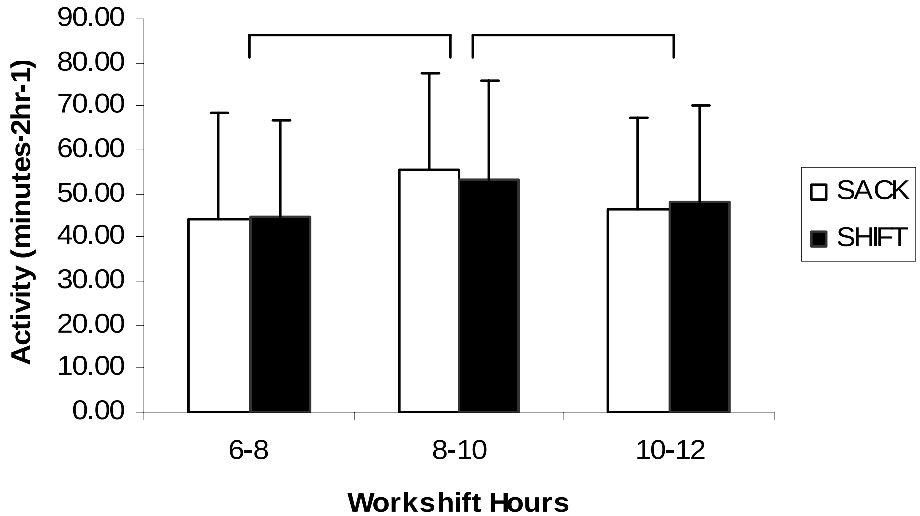
Figure 4. Mean counts·min^{-1} for SF and SL groups. *$p<0.05$ versus hours 6-8, main effect of time, but no difference between SF and SL.

Figure 5. The min $\cdot 2hr^{-1}$ spent in sedentary intensity (a), the min $\cdot 2hr^{-1}$ spent in light intensity (b), and the moderate/vigorous intensity (c) for SF and SL trials. Bars show main effect for time, $p<0.05$.

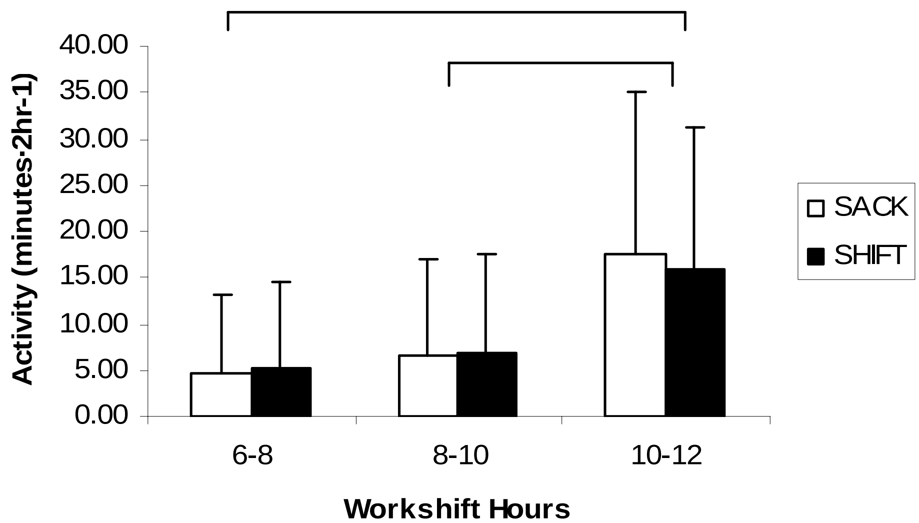
(a).



(b).


90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Activity (minutes·2hr-1)
6-8
8-10
10-12
Workshift Hours
SACK
SHIFT

(c).



40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Activity (minutes·2hr-1)
6-8
8-10
10-12
Workshift Hours
SACK
SHIFT

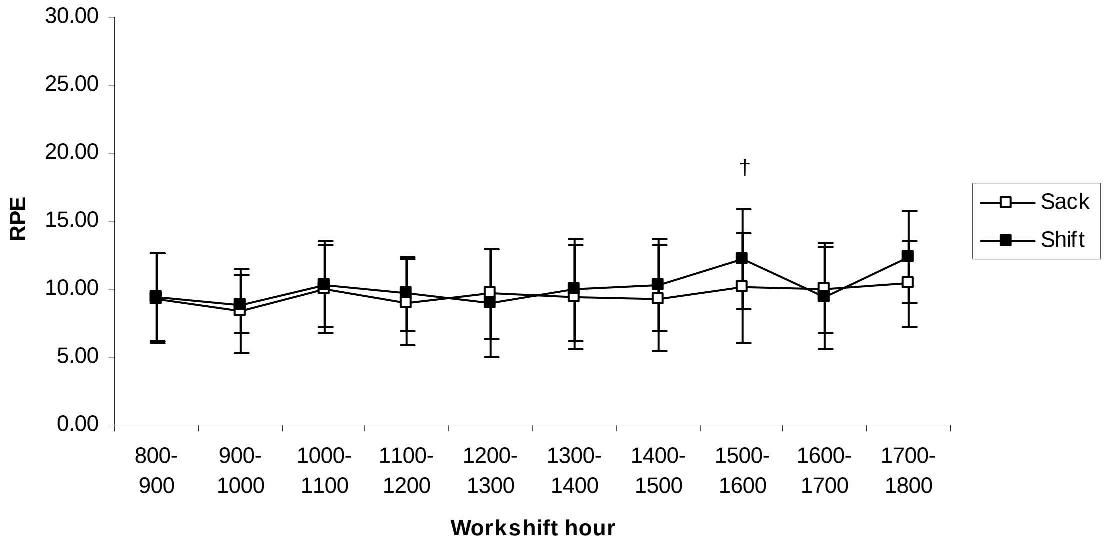


Figure 6. RPE for SF versus SL trials. †, $p<0.05$, vs. hour 1(8-9am), main effect for time.

Appendix A

Subject #	BOB	Item Name	Total Calories	Fat Calories	PRO Calories	CHO Calories	COST	LOOKUP TABLE Item #	item
Food Item 1	2	Multi-Grain Bagel	280	18	48	216	0.33	1	Plain Bagel
Food Item 2	3	Cinnamon/Raisin Bagel	290	31.5	32	232	0.33	2	Multi-Grain Bagel
Food Item 3	2	Multi-Grain Bagel	280	18	48	216	0.33	3	Cinnamon/Raisin Bagel
Food Item 4	10	Fruit Bowls- Mixed	70	0	2	72	0.389	4	Cream Cheese
Food Item 5	7	Yogurt Raisins	120	0	4	132	0.498	5	Apple
Food Item 6	16	Cheese Sticks- Cheddar	110	81	28	0	0.166	6	Raisins
Food Item 7	30	Pringles- Sour Cream	140	81	4	48	0.31	7	Yogurt Raisins
Food Item 8	13	Yogurt- Blue	240	18	36	192	0.499	8	Banana
Food Item 9	2	Multi-Grain Bagel	280	18	48	216	0.33	9	Clementine
Food Item 10	5	Apple	80	0	0	88	0.4825	10	Fruit Bowls- Mixed
Food Item 11								11	Fruit Bowls- Peaches
Food Item 12								12	Yogurt- Straw
Food Item 13								13	Yogurt- Blue
Food Item 14								14	Yogurt- Peach
Food Item 15								15	Frigo Cheese Sticks (mont.)
Food Item 16								16	Chees Sticks- Cheddar
Food Item 17								17	Cheese Sticks- Mont.
Food Item 18								18	Pudding- Choc.
Food Item 19								19	Oreos
Food Item 20								20	Chips Ahoy
Food Item 21								21	Animal Crackers- Sponge Bo
Food Item 22								22	Animal Crackers- Frosted
Food Item 23								23	Animal Crackers- Iced
Food Item 24								24	Nutri-grain bars
Food Item 25								25	Indulgence Trail mix

	Total	Fat	PRO	CHO		Item #	item
						26	Mtn. Trail Mix
Calories	1890	265.5	250	1412	$3.66	27	Berry Trail Mix Bar
Percent of Total		14%	13%	75%		28	Rice Krispies
Desired Calories	1750	437.5	262.5	1050		29	Pringles- Original
Percent of Total		25%	15%	60%		30	Pringles- Sour Cream
Variance (percent of desired)	108%	61%	95%	134%		31	Pringles- Cheese

Appendix B

Sack Lunch Survey

Instructions: Please make a mark with a pen or pencil along the line provided regarding your feelings to the questions. Thank you.

The **SACK LUNCH** *was convenient to carry with me on the fireline.*

Strongly disagree — Somewhat agree — Strongly agree

The **SACK LUNCH** *was convenient to eat.*

Strongly disagree — Somewhat agree — Strongly agree

The **SACK LUNCH** *made me feel like I was able to work better*.

Strongly disagree — Somewhat agree — Strongly agree

The **SACK LUNCH** *provided a variety of foods*.

Strongly disagree — Somewhat agree — Strongly agree

The **SACK LUNCH** *provided satisfaction in taste of foods.*

Strongly disagree — Somewhat agree — Strongly agree

The **SACK LUNCH** *had an appealing appearance.*

Strongly disagree Somewhat agree Strongly agree

The **SACK LUNCH** *provided enough food to keep me energized throughout the day.*

Strongly disagree Somewhat agree Strongly agree

The **SACK LUNCH** *didn't provide you with enough food, how many more food items would you like to have?*

1 2 3 4 5 6 7 8 9 10

My overall satisfaction with the **SACK LUNCH** *was*:

Very low Pretty good Very High

Grocery Store Shift Food Survey

Instructions: Please make a mark with a pen or pencil along the line provided regarding your feelings to the questions. Thank you.

The **SHIFT FOOD** *was convenient to carry with me on the fireline.*

Strongly disagree | Somewhat agree | Strongly agree

The **SHIFT FOOD** *was convenient to eat.*

Strongly disagree | Somewhat agree | Strongly agree

The **SHIFT FOOD** made me feel like I was able to work better.

Strongly disagree | Somewhat agree | Strongly agree

The **SHIFT FOOD** *provided a variety of foods.*

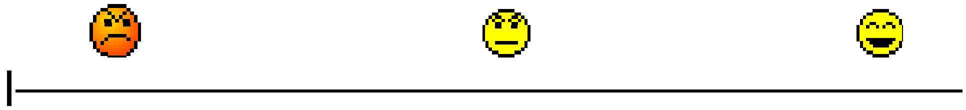
Strongly disagree | Somewhat agree | Strongly agree

The **SHIFT FOOD** *provided satisfaction in taste of foods.*

Strongly disagree | Somewhat agree | Strongly agree

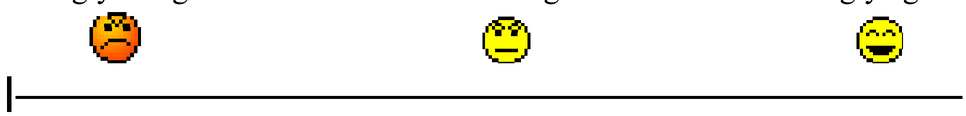
The **SHIFT FOOD** *had an appealing appearance*.

Strongly disagree Somewhat agree Strongly agree



The **SHIFT FOOD** *provided enough food to keep me energized throughout the day*.

Strongly disagree Somewhat agree Strongly agree

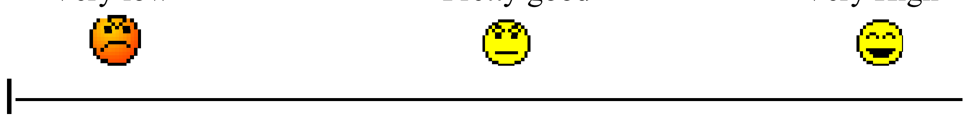


The **SHIFT FOOD** *didn't provide you with enough food, how many more food items would you like to have?*

1 2 3 4 5 6 7 8 9 10

My overall satisfaction with the **SHIFT FOOD** *was*:

Very low Pretty good Very High



Sack Lunch vs. Shift Food Survey

Which eating strategy did you find more convenient to carry with you?

Sack lunch CHO snacks Both were the same

Which eating strategy did you find more convenient to eat?

Sack lunch CHO snacks Both were the same

Which eating strategy made you feel like you were able to work better?

Sack lunch CHO snacks Both were the same

Which eating strategy gave you a greater variety of foods?

Sack lunch CHO snacks Both were the same

Which eating strategy gave you greater satisfaction in taste of foods?

Sack lunch CHO snacks Both were the same

Which lunch foods had a better appearance?

Sack lunch CHO snacks Both were the same

Do you think the sack lunch provided enough food to keep you energized throughout the day?

Yes No

If NO, how many more food items would you like to have?

1 2 3 4 5 6 7 8 9 10

Do you think the CHO lunch provided enough food to keep you energized throughout the day?

Yes No

If NO, how many more food items would you like to have?

1 2 3 4 5 6 7 8 9 10

If you had your choice of lunch, which would you prefer to have?

Sack lunch CHO snacks Both were the same

Only answer if you picked a preference in the previous question: Indicate the degree of preference between the 2 different lunches (in other words, how much more did you like the one over the other).

Slight Moderate Much Extreme

Indicate the food and quantity you threw away:

Sack Lunch:

Shift Food:

What foods you would like to see in future lunches?

What eating strategies work best for you in the field?

Shift-Food vs. Normal Sack Lunches during Arduous Wildfire Suppression

<u>Sponsor:</u> Missoula Technology and Development Center-USFS

Principal Investigator: Steve Gaskill, Ph.D.
Co-Investigator: Brent C. Ruby, Ph.D.
Co-Investigator: Nicole Plante

Location: Human Performance Laboratory
McGill Hall #121
The University of Montana
Missoula, MT 59812
(406)243-4268 or (406)243-4780

Purpose

The purpose of this project is to determine the effects of a shift food lunch strategy compared to normal wildland firefighting (WLFF) lunches on lunch satisfaction, work shift blood glucose and work output during wildfire suppression. The information collected in this study will help determine if the effects of regularly spaced, commercially available, food consumption will alter work performance and minimize fatigue compared to normal WLFF sack lunches. You are eligible for participation in the study if you are between the ages of 18-40.

As a participant in this study you will complete the following assessments. 1) a pre-screening assessment which involves a health/exercise history questionnaire (Par-Q), 2) a measure of activity rate during your work shifts using a digital activity monitor worn in your nomex shirt pocket, 3) consumption of a normal sack lunch one day and shift food (normal food items in 200-300 Kcal units) consumed regularly over the course of the work day during 2 days of firefighting activity, 4) one finger blood sample taken post-shift , 5) a simple hourly activity log to record your perceived level of exertion with a brief description of your work the prior hour, 6) body weight and 7) a brief questionnaires at the end of the two days rating your satisfaction with the lunches.

<u>Pre-screening Assessment — Physical Activity Readiness-Questionnaire (PAR-Q)</u>

The prescreening assessment is a simple questionnaire to evaluate your readiness for physical activity. It asks a series of questions related to heart disease and other reasons to limit your participation in exercise and requires about 2 minutes.

<u>Measurements of Physical Activity Levels</u>

Each day of the study, you will wear a small digital activity monitor in your shirt pocket. This will be used to record all bodily movements and will allow the researchers to estimate the amount of energy you expend during the observation period.

Consumption of your normal sack lunch or shift food.
During the 2 days of firefighting activity required for this study you will be given, in a random order, either your regular sack lunch or 'shift-food' package with equal calories to the sack lunch day. You are asked to eat your normal sack lunch as you typically would on a normal day adjusting for the work demands of the observation day. For the shift-food day you will be asked to eat one packet of food (6-7 packets in a shift food package) within every two hours after breakfast until the end of your shift. You are allowed to drink as much fluid as you wish, but if you drink a sport or energy drink, you must match the drink (same amount) both days**.** You will also be asked to not eat additional food except what is given to you. At the end of the day a researcher will interview you concerning what foods you ate, how much you ate and what you did not eat.

Activity Log
Hourly, you will be asked to rate your average perceived exertion and to record briefly what tasks you have been doing during the past hour. The rating scale will be explained in advance and requires only that you record a number from 6 to 20 related to your exertion level. The description of your activity will be a simple one or two word description (i.e., line digging, swamping, chainsaw, hiking: flat, hiking-uphill, lookout, etc.) This should take less than 30 seconds each hour.

Body Weight
Your clothed body weight (boots, nomex pants, t-shirt) will be measured using a digital scale before breakfast, after breakfast and post-shift each of the two days of the study. You will be asked to *remove* all items from your pockets to standardize the weight.

Satisfaction Surveys:
This survey will be administered following the two days of data collection. The questionnaire asks about your feelings about the lunches in terms of convenience, ability to complete work, taste, appearance, variety, energized, and overall satisfaction for their standard lunch provided by the fire camp caterer. The second survey will address the same questions regarding the grocery store shift-foods.

Risks and Discomfort
It is expected that you will have minimal discomfort as a result of your participation in this study. There are only minimal risks associated with the above measures. These risks include infection or soreness at the site of the finger stick blood sampling. This will be minimized by cleaning the finger site with an alcohol swab prior to and following obtaining a sample. All sampling will be done by trained technicians who will conduct all measures, thereby decreasing the amount of time required of the subjects.

Confidentiality
All results will be kept in strict confidence among the subject involved and the Principal Investigators and other Co-Investigators. During the entire period of data collection,

subject's records will be kept within the Human Performance Laboratory and will be locked under the direction of the Principal Investigator. The research documents that contain identifiable information will be retained for a period of seven years after which they will be destroyed using a paper shredder. No names will be used during data collection and all data will be kept using only subject numbers. No names will be used during presentation of data and only group means and data will be presented.

Benefits
It is important that you recognize that there are minimal benefits associated with your participation in this study. However you will have access to all of your testing information, which may assist you in your preparation and job as a wildland firefighter. Additionally, the information gained from this study *may serve* to increase what is known about the physical demands of wildland firefighting and may increase the safety precautions, medical care, and optimal nutrition for this occupation.

Compensation for Injury
Although we believe that the risk of taking part in this study is minimal, the following liability statement is required in all University of Montana consent forms. *In the event that you are injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by negligence of the University or any of its employees, you may be entitled to reimbursement pursuant to the Comprehensive State Insurance Plan established by the Department of Administration under the authority M.C.A., TitIe2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University's Claim representative or University Legal Counsel.*

Voluntary Participation and Withdrawal
- Your decision to take part in this research study is entirely voluntary.
- You may refuse to take part in or you may withdraw from the study at any time without penalty or loss of benefits to which you're normally entitled.
- If you decide to withdraw, please notify one of the researchers as soon as possible.
- You may leave the study for any reason.
- You maybe asked to leave the study for any of the following reasons:
    - Failure to follow the project director's instructions:
    - The project director thinks it is the best interest of your health and welfare; or
    - The study is terminated.
- A copy of this consent form will be provided for you. In addition, the data collected during this study will be done at no cost to you.

Statement of Consent
I have read the above statements and understand the risks involved with this study. I authorize Steven Gaskill, Brent Ruby and Nicole Plante and such assistants that they may

designate, to administer and conduct the testing as safely as possible with a minimal amount of discomfort. If I have additional questions, I may contact Steven Gaskill at home (406) 829-8978 or lab (406) 243-4268, or Brent Ruby at home (406) 542-2513 or at the lab (406) 243-2117 or (406) 243-4780. If you have any questions regarding your rights as a research subject, you may contact the Chair of the IRB through The University of Montana Research Office at 243-6670.

Participant (print) ________________________________

Signature ________________________________ Date ________________________

Investigator/Witness (Print) __________________________________

Investigator /Witness Signature _______________________________Date ____________

If you would like to have results of this research sent to you, please include your address below. Your address will remain confidential and will not be used for any other purpose than to send your results.

Your Permanent
Address____

____

Subject statement of consent to be photographed during data collection
During the wildland firefighter research I understand that pictures may be taken, I provide my consent to having my picture taken during the course of the research study. I provide my consent that my picture may be used in some presentations related to this study. If pictures are used at any time for presentation, names will not be associated with them.

Investigator /Witness Signature ________________________________Date ___________