

ENERGY EXPENDITURE ANALYSIS OF WILDERNESS
BACKPACKING PARTICIPANTS

by

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ABSTRACT

Energy balance during multiday remote backpacking has not been sufficiently studied among general populations. Activities such as hiking that are conducted under a fixed energy input or rations and can result in an energy deficit in the body. Continued energy deficit can result in a myriad of medical problems such as injury, muscle cramping, depression, dehydration, and reduced coordination, which can lead to collapse, hypoglycemia, energy electrolyte imbalance and depressed immune function. The purpose of this study is to define the energy expenditure balance among a sample of participants engaging in strenuous outdoor activities. Anthropomorphic, resting metabolic rate and body mass index measurements were taken pre and post course. Course diet logs were taken as well as trip route logs, which included kilometers traveled as well as meters climbed in elevation. Energy expenditure was calculated using distance traveled and climbed and resting metabolic rate. Energy intake was calculated from diet logs. Results suggest that subjects in the study operated in an overall energy surplus but significant differences over the 7-days course were found when comparing energy balance day by day. A repeated measure ANOVA (actual and results) showed significant differences in energy balance over the course of the seven days. Post-hoc analysis suggested energy balance deficits differed significantly between day one and day two, day one and day four, day two and day six, day three and day four, day three and day six, and day four and day six. Many variables could have contributed to deficits on these days such as human factors, stress, event timing and increased energy expenditure. Understanding the pattern of energy deficits may help prepare those planning to engage in strenuous outdoor activities as well as inform organization that lead such activities.

INTRODUCTION

Many people in the United States participate in outdoor activities. In 2011, 12% of Americans ages six and older participated in hiking and 34.4 million people participated in hiking activity ("Outdoor Recreation, Participation Report," 2010). In the United States, nearly 7 million of these people participated in backpacking, suggesting that specific focus on the health and safety of this group warrants concern ("Outdoor Recreation, Participation Report," 2010).

Hiking and other activities done in the backcountry can result in increased energy expenditure and decreased energy intake. Overexertion and energy deficit on extended backcountry travel activities can cause exercise associated collapse, muscle cramps, heatstroke, hypoglycemia, hypothermia, hyponatremia, cardiac arrest, orthopedic conditions and rhabdomyolysis. Experiencing these medical conditions while in an isolated setting can result in delay to treatment, extreme cost of evacuation to death. Understanding the energy requirements of these activities will aid in developing nutritional recommendations, which may prevent possible medical complications for these participants.

Education on how to safely participate in the outdoor activity of backpacking can be acquired from books, Internet resources, peers, and educational courses. The National Outdoor Leadership School (NOLS) has been offering education on wilderness travel since 1965. As a leader in outdoor education, NOLS continues to research and develop curriculum to provide the best curriculum and support for its students. This research was initiated in collaboration with NOLS' Curriculum and Research Manager in order to

evaluate current practices in field nutrition at NOLS. The National Outdoor Leadership School has a significant need for this information as it provided backpacking education of approximately 3,085 students in 2011 (Gookin, 2013). All of these participants were involved in outdoor expedition activities that ranged from 12-96 days (Gookin, 2013).

Nutrition is provided for NOLS courses in the form of dried rations. Current practice for determining food supplies for these backpacking courses is to use a pound per person per day (PPPPD) format (Pearson, Pearson, & Clelland, 2012). Without having energy expenditure field data, specifics of whether these rations provide enough energy to sustain the participant over an extended period cannot be determined. There is limited research on extended period backpacking energy balance. Currently energy expenditure recommendations are based on Military Dietary Reference Intakes. As one can imagine, military activities have similarities and differences from recreational backpacking. Understanding the energy expenditure of participants on backcountry trips will allow for changes in nutrition, activity, and management of medical pathologies. With this information, nutritional experts will be able to understand the dietary needs of backpackers and make recommendations for energy balance. Knowledge of the energy needs for backpackers will also provide basis for medical providers to counsel participants in their pre activity physical exam, regarding signs and symptoms of serious medical conditions that they may encounter during their extended backcountry activities. Further research in this area may also result in specific food recommendations that will promote for energy balance for participants.

The National Outdoor Leadership School will be able to use the energy balance information in their rationing process for their courses company wide. With an understanding of baseline estimate of energy requirements accurate rationing can help prevent over packing of heavy foodstuffs on extended trips. The National Outdoor Leadership School furthermore will utilize this information as a basis for future study looking into counseling that may be done to prepare students for their courses.

Purpose of the Study

The purpose of this study is to 1) define the energy expenditure balance of participants on NOLS multiday backcountry trips and 2) to determine the extent to which an energy deficit exists in order to make recommendation and provide background for future studies.

LITERATURE REVIEW

Introduction

Minimal research has been conducted in the arena of long-term energy balance while backpacking among general populations. Perhaps because of the challenge in measuring energy expenditure outside the lab, studies to date have used small sample sizes of 1-3 subjects over a short period of observation or food deprivation in military troops (Hill, Swain, & Hill, 2008; Hoyt & Friedl, 2006). These subjects are ultra endurance athletes who are being tested over 3 months. Notable studies on exercise and food deprivation include; Tour de France athletes, Norwegian military training exercises, U.S. Army Ranger course, G-2 trans Greenland expedition, Zimbabwean commando training, Trans-Antarctic expedition and U.S. Marine Corps 'Crucible' recruit training exercise (Hoyt & Friedl, 2006). None of these sample groups represents well represents the specifics of participants or programming at NOLS in a generalizable fashion. NOLS participants are novices in the activities in which they are learning and are attending the outdoor school to learn the leadership and travel skills necessary to travel in the backcountry. It is the responsibility of the institution, NOLS, to provide adequate supplies and nutrition for their participant's in a wide variety of activities and climates.

NOLS participants come to courses in a variety of fitness levels. The enrollment process includes a physical exam and health screening by a medical provider and the program informs possible participants that prior physical conditioning is a necessity (Appendix A). Survey questions on the health form include; Does the applicant exercise

regularly?, Is this person overweight?, Underweight? If so, how much?. This health survey utilizes the health care provider as the filter for determining if the applicant is medically fit for the activities described.

Most typical fit young men have body fat stores around 15% or approximately 10-11 kg equaling approximately 100,000 kcal of energy (Friedl et al., 1994). Energy stores of 100,000 kcal provides many of the theoretical energy deficiencies during strenuous outdoor activities. Backpackers on average expend roughly 5000 kcal a day (Auerbach, 2012). Energy expenditure while in the backcountry can range from 44-55 kcal/kg/day (Hill et al., 2008). Additional kcals are required for higher intensity activities such as climate, age, sex, health and metabolism (Auerbach, 2012; Hill et al., 2008).

Energy Balance

Energy balance equals energy intake (food) plus stored energy (fat and muscle) minus energy expenditure. Four to six percent body fat represents the lower limit for healthy men and this corresponds to a sum of four skinfolds <20 mm (Friedl et al., 1994). The body consists of two compartments; body fat, which includes the entire content of chemical fat or lipids in the body, and the fat-free mass (FFM), which includes all the rest of the body apart from fat (Durnin & Womersley, 1974). Nutrition in the backcountry differs from the nutritional recommendation for the general public (Hesterberg & Johnson, 2013). The specifics of exact energy expended during activities and the exact nutritional energy daily are not as much of a concern for the advanced practice provider. The advanced practice provider will be more concerned with total body weight lost or

gained over the period of the trip. The average of energy balance will be seen in the changes in body weight.

Energy balance can be determined in very sophisticated to very elementary ways. Previous studies have utilized VO_2 and heart rate correlations to determine energy expenditure by determining the basal metabolic rates of individuals. VO_2 is reached when oxygen consumption remains at steady state despite an increase in workload. Hill et al. 2008 utilized a small cohort of 3 subjects over a 5-day backpacking trip to analyze energy expenditure from VO_2 . This study's subjects had a wide range of VO_2 max between 57-72 $\text{ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ (Hill et al., 2008). Hill et al. 2008 compared two methods to determine energy expenditure: 1) terrain and 2) heart rate. The terrain method involved a calculation using meters traveled and meters climbed. The heart rate calculation was based on VO_2 correlations to HR to define energy expenditure. There was a 28% decrease in energy expenditure when comparing the Terrain Method to the heart rate method (Hill et al., 2008). This discrepancy provides challenges for analyzing energy expenditure. Actual weight loss during this study was very close to the predicted weight loss due to the calculated energy deficit (Hill et al., 2008). This study suggests the heart rate method of calculating energy expenditure was more accurate as well as that predicted weight loss was very close to expected weight loss. Despite the strengths of this study it was conducted over a short period of time with a very small cohort. In an extended expedition environment present at NOLS challenges occur when trying to track heart rate for multiple participants over an extended period of time.

Energy expenditure can be calculated over a period of time in many different ways. Equations for EE due to distance = $(m \text{ traveled})(\text{combined mass})/(2000 \text{ kg} \cdot \text{m} \cdot \text{kcal}^{-1})$, EE due to elevation gain = $(m \text{ gained})(\text{combined mass})/(111.1 \text{ kg} \cdot \text{m} \cdot \text{kcal}^{-1})$ were used to calculate terrain based energy expenditure of hiking (American College of Sports Medicine, 2006). Average caloric expenditure uphill was 9.85 kcal/min and downhill was 5.64 kcal/min (DeVoe, Gotshall, & Subudhi, 1997). Challenges are present in the wilderness backcountry setting because of increased load of monitoring equipment. For simplicity estimating total energy expenditure in the backcountry environments considers food intake and changes in body composition (Hoyt et al., 1991).

In understanding the changes in body composition it may be possible to understand the changes in energy balance for backpacking participants over a longer period of time. Energy expenditure during activity has been shown to be similar across sexes based on weight (approximately 350 kJ/kg per day) (Hoyt et al., 2006). Fat-predominate metabolism implies reduced glycogen use, a significant capacity for endurance exercise and less loss of FFM (Hoyt et al., 2006).

Health

An individual's health and performance is very important to being successful in the backcountry (Auerbach, 2012). As an individual continues to be in an energy deficit changes occur in the body. Specifically weight is lost in the form of fat, muscle and fluid hydration. Total body weight and fat mass are the main components of rapid weight loss in the athlete over a short term fast (Sagayama et al., 2014).

Fat is essential to life as components of cell membranes, nerve sheaths and other cellular constituents (Friedl et al., 1994). As body fat decreases to a point of 4-6% the body starts to catabolize fat free mass (FFM). FFM is mass made up of muscle. Women use more fat mass and less FFM to meet metabolic fuel requirements and thus preserving FFM (Hoyt et al., 2006). Muscle catabolism resulting from energy deficiency can cause morphologic changes and decreased strength (Friedl et al., 1994). Men preserve lean mass more effectively if they have a greater initial body fat availability (Hoyt & Friedl, 2006).

Energy deficit can also result in neurologic changes in the body. The Minnesota Experiment studied the effects of food deprivation in humans during the post war 1940's. This study showed that the neurological deficits in semi-starvation subjects were largely absent (Keys, Brozek, Henschel, Mickelsen, & Taylor, 1950). The only positive neurological deficit present in the Minnesota Experiment of the semi starvation group were diminished patellar reflexes in a few subjects (Keys et al., 1950). Reduction in fast-twitch type II muscle fibers was evident in a 3 week study of Swedish ski troops in energy deficit (Schantz, Henriksson, & Jansson, 1983). This is comforting information for the backcountry traveler. Despite this situation, there are still psychological changes that occur while in energy deficit.

Many expeditions through history have encountered a semi-starvation state in which extreme energy deficit has occurred (Keys et al., 1950). In the Minnesota Experiment "tiredness, appetite, muscle soreness, irritability, apathy, hunger pain, and ambition" were all significant self-rated by study subject of the psychological testing

(Keys et al., 1950). The sensation of hunger pain is important, as it is often something perceived by students on NOLS courses because they have a rationed diet provided for them. Many subjects during the Minnesota Experiment utilized hot drinks to “fill up” and reported reduced hunger pains (Keys et al., 1950). Cannon (1912) did the first physiological research on hunger pains finding that they related to a reduced volume of the stomach by an increased contraction. Hunger is the dull ache or gnawing sensation in the mid-chest region and the epigastrium and can be mitigated by chewing and smoking (Cannon & Washburn, 1912; Carlson, 1916). The stresses of energy deficit result in emotional instability (Keys et al., 1950).

The consequences of providing a nutritionally inadequate diet are well documented. Dietary insufficiency can depress immune function (Keusch, 2003), prolong recover from illness and injury (Brown, 1994) and compromise physical performance (Hermansen, Hultman, & Saltin, 1967). It is important to be aware of risk factors when operating in negative energy balance. The rate of weight loss and the total amount of body weight lost are important risk factors to consider (Hoyt & Friedl, 2006). Despite significant weight loss in Army Rangers; grip strength did not change and strength capacity only decreased modestly (Hoyt & Friedl, 2006). Physiological changes in Army Rangers included; metabolic conservation, subclinical suppression of the thyroid axis, low core body temperatures, greater susceptibility to hypothermia, increased economy of motion and increased susceptibility to bacterial infection (Hoyt & Friedl, 2006).

Despite the negative effects of being in energy deficit it has been shown that individuals can return to pre energy deficit levels in 5 weeks with rest and re-feeding

(Hoyt & Friedl, 2006). Adequate diet and appropriate work/rest cycles can minimize degradation of endurance capacity (Hoyt et al., 2006). It also emphasizes the importance of re-feeding to allow recovery from deficits that will occur during field deployments (Tharion et al., 2005). Despite the many negative effects of a negative energy balance there are some positives with improvements in hepatic fat, liver function tests, and insulin resistance despite regaining of weight (Haufe et al., 2013). As a medical care provider it is essential to understand the effects of an extended energy balance and be able to counsel patients on these points.

Fitness

Human endurance during activity is based on numerous factors including fitness, oxygen consumption, fuel, hydration and genetics (Robergs & Roberts, 1997). Fitness level can affect a person's energy expenditure, as they will be able to perform the same with less breath or “VO₂”. Energy balance is essential to continued activity over long periods of time. Fitness and pack weight affects a backpacking participants comfort and VO₂ max (Shoenfeld, Shapiro, Portugeeze, Modan, & Sohar, 1977). Carrying a heavier pack decreases participant comfort, increases heart rate, and decreases VO₂ (Shoenfeld et al., 1977). VO₂ is dependent on absolute weight of the carried load rather than to the weight of the subject or the load percentage to body weight (Shoenfeld et al., 1977). No changes were observed in creatine-phosphokinase (CPK), in subjects not exposed to excessive physical stress (Shoenfeld et al., 1977). Therefore developing rhabdomyolysis is not significant (Shoenfeld et al., 1977). To avoid significant decrease in VO₂ max the

maximum backpacking load carried by individuals in good physical conditions for long distance should not exceed 25 kg (Shoenfeld et al., 1977).

NOLS participants may want to increase their fitness level to increase their efficiency and comfort during backpacking activities. Daily walking with loads of 3-6 kg can improve the aerobic capacity of subjects with low initial fitness (Knapik, Harman, & Reynolds, 1996). Load carriage speed can be increased with physical training that involves regular running and resistance training. Training with loads can result in greater energy efficiency since walking with backpack loads over several weeks decreases energy cost (Taylor, Heglund, McMahon, & Looney, 1980). It is possible to substantially improve aerobic physical fitness in three weeks by walking daily with a light backpack load (Shoenfeld, Keren, Shimoni, Birnfeld, & Sohar, 1980). The most pronounced increased in aerobic work capacity (VO_2 max) while carrying a pack was a result of walking 5km/hr for thirty minutes with a 3-kg pack for 3 weeks and a 6-kg pack for 1 week (Shoenfeld et al., 1980).

Summary

Although some research has been done to understand the occurrence of energy deficit in highly specific populations, little data-based information is available to advise a program such as NOLS on specific trends in energy deficit among more general populations. Knowledge of energy balance among NOLS participants will provide information that can be used to tailor activity and provisions in order to keep participants in a health balance and avoid possible ill health effects. By knowing the total energy

requirements of the trip especially those that are of long duration and the body fat reserves of participants, medical personnel may be able to identify individuals at increased health risk because of low body fat energy reserves (Tharion et al., 2005). Understanding the energy requirements, energy balance and ways of improving energy efficiency will prove beneficial information for NOLS participants on backpacking courses.

METHODS

Study Design

The purpose of this study was to determine the energy balance for participants in courses provided by the National Outdoor Leadership School (NOLS). There have been few specific studies examining this topic of energy expenditure on extended expeditions. This information was requested by NOLS in order to better understand the energy balance of their participants, provide a foundation for future nutritional studies, and to provide scientific evidence to support nutritional decisions for these expeditions. This is a nested study from data collected by Cara Ocobock of Washington University. Data analyzed for this thesis includes only a small subset of data associated with a 7-day hiking period.

Setting and Sample

This study took place in the mountains of the Wind River Range of Wyoming and Absaroka mountain range of Montana. Over a three-month time span from June to mid August in the summer of 2011 and September to mid December in the fall of 2011 study subjects participated in a combination of backpacking, rock climbing, river rafting, and backcountry skiing. The analysis reported here specifically investigated subjects while backpacking and omitted an examination of other activities. While participating in these activities, participants lived outdoors in tents and prepared their own meals on camp stoves.

Fifty-nine students of the National Outdoor Leadership School semester program participated in this study. Semester programs at NOLS take place in the Fall and Summer seasons. Two separate cohorts were defined based on the semester program for which they were enrolled; two summers and two fall. The two summer courses (n=25) lasted 3 months each and the two fall courses (n=28) lasted four months each. A pilot study (n=6) was also conducted in the summer of 2010 to determine the feasibility of data collection. To be included in the study, participants must apply to the NOLS program and be accepted based on written response and clearance by a medical doctor that they are fit for the activities involved in the program.

Protection of Human Subjects

This study was initially approved by the Institutional Review board of Washington University of St. Louis, Missouri for the primary research of Cara Ocobock (Appendix A). The Institutional Review board at Montana State University granted secondary approval (see Appendix B).

Subjects of this study were consented upon their admission to the study. These subjects were notified of the risks, benefits, and requirements of the study (Appendix B). Subjects received no official compensation for participation. However, as a gesture of appreciation, subjects received a NOLS t-shirt, a selection of three NOLS books, and were provided candy bars and fresh fruit while on their course in the wilderness.

Data Collection Procedure

Anthropomorphic data was collected at different locations across the Western United States. (Table 1)

Table 1. Course locations.

<i>Course</i>	<i>Pre-Course</i>	<i>Mountain Range</i>	<i>Post- Course</i>
WSS 1	Lander, WY	Absaroka Range, WY	Lander, WY
WSS 2	Vernal, UT	Absaroka Range, WY	Lander, WY
FSR 5	Lander, WY	Wind River Range, WY	Lander, WY
FSR 8	Lander, WY	Wind River Range, WY	Lander, WY

Pre, interval, and post body weights were recorded to determine anthropomorphic changes throughout the test period. Diet logs were recorded to determine caloric intake (Appendix D). Weight change, energy consumed through food, distance traveled, elevation gained and resting metabolic rate were used to determine overall energy balance.

Upon entering the study descriptive data was collected that included age, gender, and geographic hometown. The parent study neglected to collect other descriptive variables of race, education, income, and marital status.

The subject's anthropomorphic measurements were taken at the beginning of the study. These measurements included body weight and height. Weight was measured in kilograms on a factory-calibrated scale, Tanita BC-558 Ironman Segmental Body Composition Monitor (Tanita Corporation, Arlington Heights, IL, USA). Height was measured with a cloth tape. Resting metabolic rates were collected from each subject using a portable respirometry unit (Costmed K4b2, Chicago, IL, USA) following the procedures of (Gayda et al., 2010). This system measures oxygen consumption and carbon dioxide production using a breath-by-breath analysis. Resting metabolic rate measurements were taken early in the morning before subjects had their first meal. Subjects were in a supine position on foam pads placed on the floor and rested 15-20 minutes before measurements were taken. Measurements were then taken for 6-8 minutes with the last four minutes of the measurement averaged to determine RMR in kcal/24 hours.

Subjects were asked to keep self-reported activity and food diaries for the duration of the study. Subjects reported activity type (hiking, walking, climbing, cross country skiing, digging snow etc.). Hiking activity was quantified in distance and elevation gained. Subjects reported type and quantity of food. Collapsible measuring cups were provided to aid measuring accuracy, though many subjects opted not to use these and instead estimated food amounts. Activity diaries kept by subjects were transcribed to an excel database over a period of time from April 2013 to July 2013. Data for each day was entered separately to include the activity and its corresponding distance and elevation (Appendix C). All distances and elevations were converted to meters. Data from the food

logs were also transcribed into a database on a day-by-day basis (Appendix D). Calories were calculated and assigned to each food entry using the *NOLS Cookery* (Pearson et al., 2012), *NOLS Backcountry Cooking* (Pearson & Kuntz, 2008), *NOLS Backcountry Nutrition* (Ryan, 2008), and the official USDA National Nutrient Database for Standard Reference (USDA, 2012). Calories were summed for each day along with total carbohydrates, dietary fiber, sugar, protein, total fat, trans fat and saturated fat. The average daily caloric intake for each subject was calculated. Undergraduate students at Washington University transcribed data sheets.

Daily energy expenditure was calculated by utilizing a terrain model. Energy expenditure due to distance traveled and elevation gained was calculated by the following equations (American College of Sports Medicine, 2006).

$$EE_{\text{D}} = (m \text{ traveled})(\text{combined mass}) / (2000 \text{ kg/m/kcal}^{-1})$$

$$EE_{\text{E}} = (m \text{ traveled})(\text{combined mass}) / (111.1 \text{ kg/m/kcal}^{-1})$$

Estimated backpack weight was utilized to determine combined mass. An assumption was made that packs weighed 30% of body weight. Daily pack weights were not collected during this study. Previous studies utilized pack weights of 26% (DeVoe et al., 1997). Thirty percent of body weight was decided upon as it is a reference weight for NOLS maximum pack weight (Harvey, 1999). Energy expenditure of descent in elevation was considered to be similar to level walking (Hill et al., 2008).

Total energy expenditure was calculated by the following equation.

Resting Metabolic Rate (RMR)

$$RMR + EE_{\text{D}} + EE_{\text{E}} = \text{Total Daily Energy Expenditure (TDEE)}$$

Total daily energy balance was calculated by the following equation.

$$(T_{DEE}) - \text{Total Energy Intake} = \text{Total Daily Energy Balance.}$$

Instruments

Scale Tanita BC-558 Ironman Segmental Body Composition Monitor

Body Tape

Stature (Height): heels together stretching upward to the fullest extent (Weiner & Lourie, 1969).

Weight: nude or lightweight shorts. (Weiner & Lourie, 1969)

Portable Respirometry Unit Costmed K462

Data Analysis

Data was consolidated into IBM SPSS Version 21. A review was conducted of the data for missing values. Six subjects were identified to have missing values in their food logs and post course body weight. Of these six subjects, 5 had missing data exceeding 50% and were treated by listwise deletion. The remaining subject missed post course body weight and was treated by replacement with pre course weight as a conservative approach to maintain the sample. Although each course had varied trip lengths from seven to eleven days, all subjects engaged in a strenuous hiking section for a minimum 7-day duration. For this reason, only the first 7 days of hiking activity were selected for all four groups for the current analysis.

Descriptive analysis was performed with regard to age, pre-hike and post-hike body weight, total course energy balance, body weight loss, pre-hike and post-hike BMI, hometown location and overweight classification. Overweight is defined as a body mass index greater than equal to 25.0. Normal weight is defined as body mass index less than or equal to 24.9. Daily energy balance means were calculated over the 7-day course. A repeated measures ANOVA with a Greenhouse-Geisser correction and Bonferroni corrected t-test were also conducted on daily energy expenditure. A descriptive analysis of total energy balance was conducted.

RESULTS

The subjects lost weight over the duration of their course even with an average total energy balance of 1286 kcal (Table 2). There was a large range of total energy balance across individuals (Table 2).

Table 2. Descriptive analysis of subjects (n=48)

	Range	Minimum	Maximum	Mean	x(sd)
Age	18	18	36	20.83	3.9
Pre-hike (kg)	57.2	55.9	113.1	75.0	13.0
Post-hike (kg)	50.0	58.0	108.0	72.7	11.5
TE Balance (kcal)	19528.5	-9471.9	10056.6	1286.0	3924.3
Weight Loss (kg)	14.1	-2.7	11.4	2.3	2.9

Table 3. Descriptive analysis of participants “normal weight” and “overweight” at pre-hike and post-hike times. (n=48)

	Frequency	Percent
Pre Trip “Normal Weight”	35	72.9
Pre Trip “Overweight”	13	27.1
Post Trip Normal Weight	38	79.2
Post Trip Overweight	10	20.8

The majority of the participants in this study were male (70.8%) and resided in the western, northeastern and southern United States.

Mean daily energy balance varied throughout the study duration (Figure 1). Day 1 and day 6 resulted in a negative mean daily energy balance (Table 7). A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean energy balance differed statistically significantly between time points ($F(3.136, 147.378) = 4.326, P < 0.0005$). Post hoc tests using the Bonferroni correction revealed that there was a time effect on energy balance on specific days (Table 7). There were significant negative mean differences between days 1 < 2, days 1 < 4, and days 3 < 4 (Table 7). There was a significant positive mean difference between days 2 > 6, and days 3 > 6 (Table 7).

Table 4. Daily Energy Balance Means (n=48)

	Mean	Standard Deviation
Day 1 Energy Balance (kcal)	-181.6	890.2
Day 2 Energy Balance (kcal)	484.2	956.2
Day 3 Energy Balance (kcal)	360.6	1013.7
Day 4 Energy Balance (kcal)	568.2	1043.8
Day 5 Energy Balance (kcal)	146.9	1157.7
Day 6 Energy Balance (kcal)	-225.0	1135.8
Day 7 Energy Balance (kcal)	132.8	1453.8

Figure 1. Mean Daily Energy Balance.

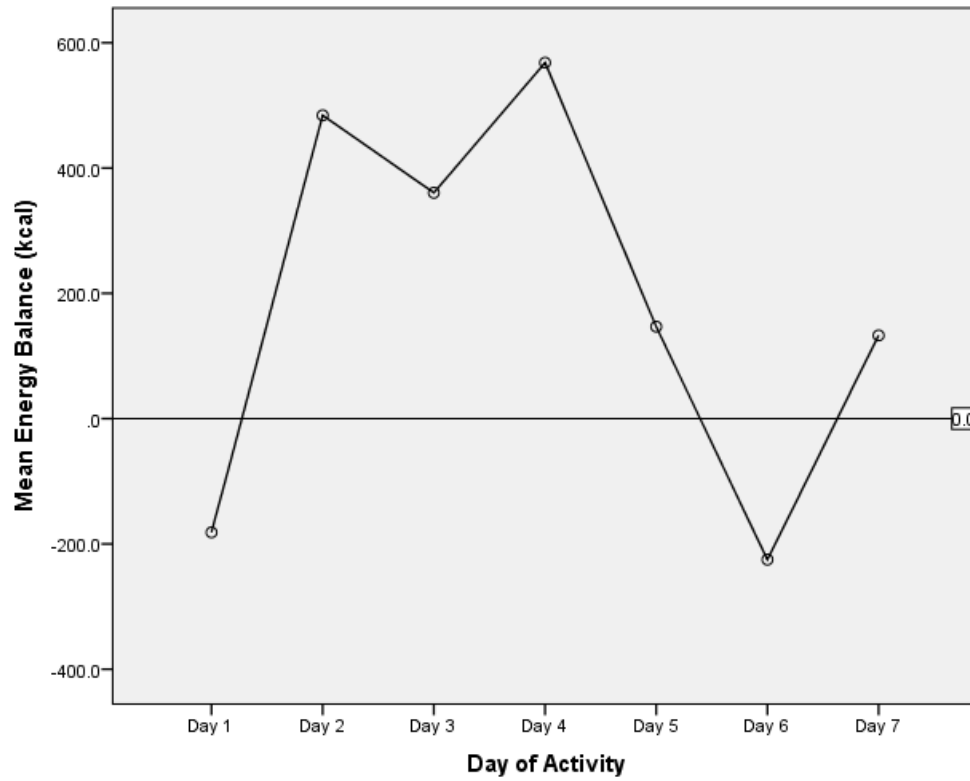


Table 5. Significant daily difference in energy balance (n=48)

	Mean Difference	x(sd)	Exact p-value (two sided)
Day 1 to Day 2	-665.8	131.1	0.000
Day 1 to Day 4	-749.8	188.7	0.005
Day 2 to Day 6	709.2	187.6	0.009
Day 3 to Day 4	-207.6	17.7	0.000
Day 3 to Day 6	585.6	154.0	0.009
Day 4 to Day 6	793.2	155.4	0.000

DISCUSSION

Introduction

Hiking for multiple days in a remote wilderness setting results in an energy expenditure. In these backcountry setting resources such as food can be limited. Backpackers try to plan food rations to cover their energy needs while on their trip. Over rationing can result in increased backpack loads and therefore increase the work of backpacking travel (Pandolf, Givoni, & Goldman, 1977; Shoenfeld et al., 1977). Under rationing can result in an energy deficit. In this context of NOLS courses there is an opportunity for energy deficit in the body due to limited food stocks. Program goals on courses at the NOLS traditionally do no account for situations of energy deficit. For example, course goals may include hiking from point A to point B with little consideration for the amount of energy (food rations) that will be required to accomplish the task. Despite this, instructors at NOLS are conscious of the broad energy needs of the participants. Instructors educate students on the necessity of good nutrition and hydration to support their expeditionary goals, but would benefit from information to guide decisions regarding energy balance.

In this study, energy balance was defined for 48 subjects over the period of seven days in a backcountry setting in the wilderness of the Absaroka and Wind River mountain ranges of Wyoming. Understanding the specific nutritional needs while traveling in the backcountry will help prevent many of these medical problems such as injury, hypoglycemia, electrolyte imbalance and depressed immune function, which can lead to

collapse, muscle cramping, depression, and altered mental status. The information from this study will allow NOLS to customize their daily rationing process and educational focus for their courses. With a baseline estimate of energy requirements, accurate rationing can prevent over packing of heavy foodstuffs on extended trips. Understanding the energy balance on NOLS courses will also help instructors dispel conceptions of starvation symptoms experienced on courses. This study also will provide valuable information for consoling dietary behaviors for participants on backpacking expeditions.

Review of Results

Independent subjects in this study had different energy balances on their seven-day hiking course. Subjects were primarily in their third decade of life coming to participate in NOLS programming. At the start of the course subjects Body Mass Index (BMI) varied with 27.1% classified as overweight. The BMI levels pre and post course suggest that no subjects displayed a critically low body mass composition. Therefore the medical concerns surrounding low body fat mass were not a concern for the subjects (Deurenberg, Weststrate, & J.C., 2007). The body fat reserve present in all subjects throughout the course can be depended on for situations where energy expenditure is greater than energy intake. For example if the course elects to do a fast for one day, their body composition would allow for this negative balance. Or if the course for some reason had lost food and had to endure a non-elective fast, they would have the energy stores to complete the course.

The average energy balance of participants on NOLS multiday backcountry trips resulted in an overall positive balance for the hike. Specific days within the course (Day 1 and Day 6) resulted in a daily negative energy balance. The extent of this energy balance deficit was minimal. Many reasons for this may be suggested. It is important to quantify this energy deficit not only in numbers of kcals but also in more tangible means. The Mars company candy bar Snickers contains 250 kcal and this kcal value was the extent of the mean energy deficit on these days (Mars, 2014). Weight loss did occur across the surveyed group by an average of 2.3 kg. There were a few individuals who did gain weight within the group. Weight loss is a product of energy intake plus energy stores minus energy expenditure. The participants on average on the course lost weight. This is a contradiction of the positive mean energy balance identified. This is likely due to the large range of total energy balance in the study, 19528.5 kcal. Reasons for this range many include individual factors such as resting metabolic rate, BMI, hydration status, body composition, pre hike fat stores and fitness level. Overall the majority of individuals were able to maintain energy balance throughout the whole test period with a few individuals operating in deficit therefore depending on their fat stores.

NOLS is in the business of educating students how to successfully manage themselves and groups in the mountains (NOLS, 2014). Definitive reasons why energy balance was negative cannot be given from this energy expenditure study as these factors were not tracked and were beyond the focus of this study. There may possible human factors that contribute to the negative energy balance on these days. Day one of hiking trips at NOLS often includes many classes on backpacking tasks from tent set up to

cooking. A novice backpacker with little experience on how to prepare meals on a backcountry stove may contribute to the negative balance on day one. This may be the reason for half of the subjects as this was their first experience participating in NOLS programming. The other half of the subjects had already participated in other NOLS activities for a few weeks, which would have allowed them time to become proficient at cooking. One would assume that by day six proficiency in cooking might be established for many participants, therefore other reasons for energy deficit may need to be considered. Locating food within large backpacks can often provide a challenge for the novice and may be a viable reason for lack of energy intake. Motivation to cook higher calorie foods or multi course meals may also be a contributing factor. There is also the motivation and stress variable that may affect individual's drive to eat resulting in some subjects eating more than others. Timing of the first day's events may also contribute to a lack of time to cook. Many variables may contribute to this negative energy balance on the first day of the back backpacking course. The energy deficit on day one is statistically different from Day 2 and Day 4. Continued analysis of the factors contributing to day one energy deficit should be further examined.

Mean energy balance was also negative on day 6 of the course. Again many reasons could contribute to why this balance was negative. Lack of food rations at the end of a hiking trip may be a reasonable conclusion except that the energy balance returned to positive for day seven. There is also the possibility that on day six there was increased energy expenditure in the form of increased mileage and elevation gained that could not be balanced by food intake. With increased time spent hiking there may be a reduced

time available in the day to cook. This time reduction for a novice backpacker may have resulted in them eating a low calorie quick snack for a meal instead of preparing something with higher calories. Elevation may have also contributed to anorexia and reduced food intake up to 10-50% (Rose et al., 1988). Fatigue and lack of motivation for cooking higher calorie meals could also have contributed to this energy balance deficit. Weather may also have contributed to the inability to cook.

Day 6 is also statistically important, as it is different than Day 2, Day 3, and Day 4. Day 6 brings up some important points with regarding the energy balance for NOLS courses. With the negative down trend toward day 6 without a statistically different value at Day 7 there is the possibility that day 7 is a negative value and the participants will continue to trend negative in the future.

Significance to Nursing

Specific information regarding energy balance for participants in multiday backpacking trips is important to nursing providers for many reasons as discussed above. The specifics of exact energy expended during activities and the exact nutritional intake daily are not as much of a concern for the advanced practice nurse as they will see the averages of this relationship through clinical presentation and weight gain or loss. Understanding the need for participant of these activities to be of a normal weight provided an energy buffer for possible situations of energy deficit that may be encountered on backcountry courses. In this study no participants came to their courses underweight. Many medical providers will be signing medical release forms for their

patients to participate in these programs. Patients who are underweight at the start of these backpacking excursions have a higher risk of reducing their fat stores to a critical level during the trip. Basically the energy balance between stored energy, expended energy and energy intake is more delicate (Tharion et al., 2005). Subjects that have been diagnosed or have behaviors congruent with anorexia and bulimia or other eating disorders may be at a higher risk in energy deficit situations.

Rural Nurse Practitioners are the front line for treating and counseling patients who are participating in rigorous physical activity while living outdoors. Graduates of family physician residencies and nurse practitioner programs provide care 48% and 38% respectively, of the time in rural areas (Edwards et al., 2006). Rural towns are the primary location for staging multiple day backpacking trips. Backpack weight may contribute to injuries, and if pack weight can be minimized through variable pieces such as food weight it is possible that musculoskeletal injuries and traumatic injuries may be reduced. Sprains and strains account for 80% of the injuries during wilderness recreation (Gentile, Morris, Schimelpfenig, Bass, & Auerbach, 1992). Proper nutrition providing for energy balance may also prove for better health and decrease the incidence of gastrointestinal complaints. Nutritional education in primary care is not always a priority because of limited visit time and limited educational materials (Kenner, Taylor, Dunn, Gruchow, & Kolasa, 1999).

For the medical provider this study provided important information regarding the energy balance while participating in backpacking and camping activities. Specifically it is important that providers know that there is a positive energy balance for participants

and it would be unnecessary to add energy stores before a NOLS course if the patient is in the normal weight category.

Study Limitations

This study was primarily limited by a few factors: study length and subject numbers. With a short course length of seven days it is hard to determine if longer courses would continue to have a negative energy balance that continued beyond day 6. This study was also limited by how energy expenditure was calculated through a terrain model for hiking and elevation gain. This study was limited by the energy balance assessment technique. It would be ideal to gather daily pack weight data to provide more accurate calculations of energy expenditure. The study could also be limited by participants inaccurately tracking their food consumption in their diet diary resulting in increased or decreased energy intake.

Future Study Recommendations

Future studies should repeat the procedures here for longer durations. With this extended data set information could be analyzed for changes in energy balance over time but also with regards to the activity that they are participating in. Further analysis of individuals in energy deficit during this study should be done. This analysis will provide more answers to why they may be in deficit during these activities. Other energy expenditure monitoring techniques should be considered. Portable energy expenditure monitoring is recommended for future investigation of energy expenditure on

backpacking trips. Future studies may include using diets that more specifically meet energy needs of participants without creating a surplus. This may allow pack weights to be decreased through reduction in ration weight.

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APPENDICES

APPENDIX A

NOLS HEALTH FORM

NOLS HEALTH FORM

H E A L T H F O R M

For NOLS Office Use Only	☐ Initial Review OK	☐ Detailed Review OK
☐ Check Further	Date ____ / ____ / ____	AO Initials _____

Student's Name _____	Course Code _____	Application ID# _____
(_____) _____	(_____) _____	
Daytime or Temporary Phone (circle one)	Permanent Phone	

Gender	Age	NOLS Grad	Non Grad
--------	-----	-----------	----------

NOLS Expedition Information for the Medical Professional

National Outdoor Leadership School courses are wilderness expeditions, varying in length from eight days to three months. NOLS expeditions operate in remote areas where evacuation to modern medical facilities may take days.

Weather conditions can be extreme depending on the course type. Temperatures may be extremely cold (-40°F) or extremely hot (+100°F). Prolonged storms, high winds, intense sunlight, sudden immersion in cold water and/or high seas are possible.

Physical demands on the applicant may include carrying a backpack weighing between 55-85 pounds over uneven terrain such as snow, rocks, boulders, fallen logs, or slippery surfaces as well as ascending and descending steep mountain slopes. Elevations for backpacking courses range from sea level to 12,000 feet. Peak climbs on mountaineering courses may be as high as 14,000 feet. The India and Denali expeditions may reach elevations of 18,000 feet and 20,000 feet respectively. Physical demands of sea kayaking and river courses require paddling heavily loaded kayaks, canoes or rafts and lifting and carrying boats over uneven terrain.

Living conditions. While participating on a NOLS expedition, students will sleep outdoors, experience long physically demanding days, set up their own camp and prepare their own meals. Each student is expected to take good care of him or herself. On some courses, students may have the option to fast without food, for up to five days.

Water disinfection. NOLS disinfects all wilderness water with iodine, chlorine, chlorine dioxide, or by boiling. Not all of these methods are effective against cryptosporidium. Immunocompromised people may wish to obtain an appropriate water filter for their course.

NOLS is not a rehabilitation program. NOLS is not the place to quit smoking, drinking or drugs or to work through behavioral or psychological problems.

Prior physical conditioning and a positive attitude are a necessity. Students find a NOLS course to be an extremely demanding experience both physically and emotionally.



In the interest of the personal safety of both the applicant and the other expedition members, please consider the questions carefully when completing the health form. A "Yes" answer does not automatically cancel a student's enrollment. If we have any question on the student's capacity to successfully complete the course we will call the student to discuss it.

The applicant is not accepted on the course until the health form has been reviewed and approved by NOLS admissions personnel.

Your detailed comments will expedite our review of this form.

Physician, F.N.P. or P.A.:

Please check YES or NO for each item. Each question must be answered and please **provide date and details for all "yes" answers.**

General Medical History

Does the applicant currently have or have a history of:

- | | | |
|--|------------------------------|-----------------------------|
| 1. Respiratory problems? Asthma? | ☐ YES | ☐ NO |
| • Is the asthma well controlled with an inhaler? | ☐ YES | ☐ NO |

If so, please have the student bring one or more metered dose inhalers (MDI) with them for their course and an aerochamber/spacer is recommended.

What triggers an attack? Last episode? Ever Hospitalized?

- | | | |
|-----------------------------------|------------------------------|-----------------------------|
| 2. Gastrointestinal disturbances? | ☐ YES | ☐ NO |
| 3. Diabetes? | ☐ YES | ☐ NO |

Examiner's specific comments: _____

- | | | |
|---|------------------------------|-----------------------------|
| 4. Bleeding, DVT (deep vein thrombosis) or blood disorders? | ☐ YES | ☐ NO |
| 5. Hepatitis or other liver disease? | ☐ YES | ☐ NO |

Examiner's specific comments: _____

- | | | |
|--|------------------------------|-----------------------------|
| 6. Neurological problems? Epilepsy? | ☐ YES | ☐ NO |
| 7. Seizures? | ☐ YES | ☐ NO |
| 8. Dizziness or fainting episodes? | ☐ YES | ☐ NO |
| 9. Migraines? Medications, frequency, are they debilitating? | ☐ YES | ☐ NO |

6-9. Describe frequency, date of last episode, and severity.

- | | | |
|---|------------------------------|-----------------------------|
| 10. Disorders of the urinary or reproductive tract? | ☐ YES | ☐ NO |
| 11. Any disease? | ☐ YES | ☐ NO |

12. Does this person see a medical or physical specialist of any kind?
(provide name/address)

If "yes" please specify the issue(s)



Questions 13 and 14 Are For Female Students Only:

13. Treatment or medication for menstrual cramps? ☐ YES ☐ NO
 14. Is she pregnant? ☐ YES ☐ NO
 Examiner's specific comments:

Cardiac History:

15. Any history of cardiac illness or significant risk factors, such as known coronary artery disease, hypertension, diabetes, hyperlipidemia, angina, tachycardia, bradycardia, unexplained chest pain or family history of early cardiac death (<50 years old)? ☐ YES ☐ NO

Depending on the applicant's history, risk factors and age, a stress ECG or waiver from their cardiologist may be required.

Examiner's specific comments:

Muscle/Skeletal Injuries/Fractures

Does the applicant currently have or does he/she have a history within the past 3 years of:

16. Knee, hip or ankle injuries (including sprains) and/or surgery? ☐ YES ☐ NO
 • Type of injury or surgery? When did the injury or surgery occur? _____

- Is there full ROM? Full Strength? ☐ YES ☐ NO
 • What is the most rigorous activity participated in since the injury/surgery. Results? _____

Examiner's specific comments: (include date of last occurrence and the effect of the problem on current activity level)



17. Shoulder, arm or back injuries (including sprains) and/or surgery? ☐ YES ☐ NO
 • Type of injury or surgery? When did the injury or surgery occur?

- Is there full ROM? Full Strength? ☐ YES ☐ NO
 • What is the most rigorous activity participated in since the injury/surgery. Results?

Examiner's specific comments: (include date of last occurrence and the effect of the problem on current activity level) _____

18. Any other joint problems? ☐ YES ☐ NO
 Examiner's specific comments: (include date of last occurrence and the effect of the problem on current activity level) _____

19. Head Injury? Loss of consciousness? For how long? ☐ YES ☐ NO
 Examiner's specific comments: (include date of last occurrence and the effect of the problem on current activity level) _____

20. Does the applicant have any physical, cognitive, sensory or emotional condition that would require a special teaching environment? ☐ YES ☐ NO
 If yes, please describe how the condition effects you: _____

Mental Health

Students with a history of psychotherapy that required medication or has included hospitalization or residential treatment, needs to be in a period of stability ranging from six months to two years, depending on the condition, before they will be accepted for a course. Applicants need to be gainfully occupied such as attending school or employed. NOLS is not appropriate for applicants just leaving residential treatment facilities.

21. Has he/she had psychotherapy? ☐ YES ☐ NO
 22. Is he/she currently in treatment or psychotherapy? ☐ YES ☐ NO
 23. Reasons for treatment or counseling?
☐ suicide ☐ ADD/ADHD
☐ substance abuse/chemical dependency ☐ family issues/divorce
☐ eating disorder (anorexia/bulimia) ☐ depression
☐ academic/career ☐ other _____

Please Provide **Specific Dates** and Details of psychotherapy and medications that were prescribed: _____

24. Name and telephone number of psychotherapist?

 Name (_____) _____
 Phone



Allergies

25. Is he/she allergic to any foods? ☐ YES ☐ NO

Describe: _____

26. Are there any dietary restrictions? Please specify. ☐ YES ☐ NO

☐ vegetarian ☐ vegan ☐ other

27. Has he/she had any systemic allergic reactions to insects, bee/wasp stings, or medications involving hives, swelling of face/lips or difficulty breathing? ☐ YES ☐ NO

If appropriate please bring a personal supply of epinephrine, preferably in a pre-loaded autoinjector, and know how to use it.

Examiner's specific comments: _____

28. Any other allergies? ☐ YES ☐ NO

Examiners Specific Comments: _____

29. Water may be disinfected with iodine. Is iodine contraindicated? ☐ YES ☐ NO

Medications

30. Is he/she allergic to any medications? ☐ YES ☐ NO

If yes, please list: _____

31. Does this person plan to take any prescription or non-prescription medications on the course? ☐ YES ☐ NO

NOLS courses travel in remote areas where access to medical care may be one or more days away. The student must understand the use of any prescription medications they may be taking. Written specific instructions are necessary. All Students who are required by their personal physician, psychiatrist or health care provider to take prescription medications on a regular basis must be able to do so on their own and without additional supervision.

Medication Dosage Side Effects/Restrictions Prescribed by? For What Conditions?

If Medication or Condition Changes Prior to Course Start, Please Inform NOLS.

Cold, Heat, Altitude

32. History of frostbite or Raynaud's Syndrome? ☐ YES ☐ NO

33. History of acute mountain sickness, high altitude pulmonary/cerebral edema? ☐ YES ☐ NO

When did the illness occur? _____

34. History of heat stroke or other heat related illness? ☐ YES ☐ NO

Examiner's specific comments: _____



Fitness (please provide details concerning the students exercise regime)35. Does the applicant exercise regularly? ☐ YES ☐ NO

Activity _____ Frequency _____

Duration/Distance _____ Intensity Level ☐ Easy ☐ Moderate ☐ Competitive

Activity _____ Frequency _____

Duration/Distance _____ Intensity Level ☐ Easy ☐ Moderate ☐ Competitive36. Does this person smoke? If so how much? ☐ YES ☐ NO

There is no smoking allowed on NOLS courses. We recommend that applicant quit now.

37. Is this person overweight? Underweight? If so, how much? _____ ☐ YES ☐ NO38. Swimming ability (CHECK ONE): ☐ Non-swimmer ☐ Recreational ☐ Competitive**Physical Examination**A physician, F.N.P. or P.A. must read and fill out pages 1-6. **Physical examination data cannot be more than a year old from the starting date of the NOLS course.** (Please type or print legibly)**NOLS Requires a Tetanus Immunization Within 10 Years of the Start Date of the Course.** Expeditions Outside the U.S. May Require Additional Immunizations. Please refer to your course description for specific information._____/_____/_____
Blood Pressure Pulse Last Tetanus Inoculation Height Weight

General Appearance, Impressions and Comments:

Examiner's Name (_____) Phone_____
Street Address State Zip_____/_____/_____
Physician, F.N.P. or P.A. Signature Date:**By my signature, I attest that the person named on page one of this form is medically cleared to participate on a NOLS course based on the expedition information provided on page 1 of this form along with the background information provided by the applicant and my physical examination of him/her.****Please Return All Six Pages To:** NOLS, 284 Lincoln St. Lander, WY 82520

APPENDIX B

HUMAN RESEARCH PROTECTION
APPROVAL WASHINGTON UNIVERSITY



Human Research Protection Office

Barnes-Jewish Hospital
St. Louis Children's Hospital
Washington University

June 16, 2010

Cara Ocobock
Anthropology
Box 1114

RE: 10-0534

A Comparison of Human Physiological and Morphological Responses to Hot and Cold
Climates with an Emphasis on Energy Expenditure

Dear Ms. Ocobock:

The above-stated protocol was reviewed and approved by the Human Research Protection
Office (HRPO). Following please find specifics of the approval:

Approval Date:	6/9/2010
Date released for accrual:	6/16/2010
Expiration Date:	6/8/2011
Research Risk Level:	Minimal
Type of Review:	Referral to F. B. (Full Board)
Reviewing Committee:	02 NPC
HIPAA Compliance:	Exempt

WU HRPO has eleven duly appointed Committees established in accordance with 45 CFR 46.107 that review protocols for faculty and staff at Washington University School of Medicine, Barnes-Jewish Hospital, and Saint Louis Children's Hospital. The Committees have 20 – 25 members with varying backgrounds to promote complete and adequate review of research activities commonly conducted at WU. The names and qualifications of the members are on file with the Office of Human Research Protections.

The WU HRPO complies with the regulations outlined in 45 CFR 46, 45 CFR 164, 21 CFR 50, and 21 CFR 56. The OHRP Federal Wide Assurance numbers for WU, BJH, and SLCH are FWA00002284, FWA00002281, and FWA00002282 (respectively).

If further information is necessary, please contact the HRPO office at (314) 633-7400.

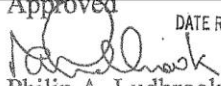
Sincerely,

Lloyd J. Vasquez, Jr., JD

02 NPC Chair

CC: Pontzer, Herman



Approved:  DATE RELEASED FOR SUBJECT ACCRUAL: JUN 16 2010 10 0534

Philip A. Ludbrook, M.D.
Associate Dean and Chairman

HRPO #: _____
(office use only)

 Washington University in St. Louis

8/08
Human Research Protection Office
Box 8089
(314)633-7400
Fax (314)367-3041

"A comparison of human physiological and morphological responses to hot and cold climates with an emphasis on energy expenditure"

Project Director: Cara Ocobock
Faculty Sponsor: Herman Pontzer

OVERVIEW

Brief Background/History

Humans and their ancestors are unique among mammals in that they have been able to inhabit some of the harshest climates on the planet ranging from the sweltering equator to the frigid poles. Finely tuned human thermoregulation is the result of a number of physiological, morphological, and behavioral adaptations working in concert to maintain a constant body temperature despite ecological adversity. Studies on this topic date back to the mid 19th century looking at latitudinal clines in body shape and size; however, few studies have measured and analyzed daily energy expenditure as an interaction among basal metabolic rate, thermoregulation, and activity. Furthermore, there are currently no studies addressing this for acclimatized humans in both hot and cold climates. This study will examine the physiological and morphological changes that accompany acclimatization among students as well as the different metabolic energy expenditures associated with harsh climates. I will collect this data from students participating in the National Outdoor Leadership School (NOLS). This is a program that offers the opportunity for people to learn technical outdoor skills, leadership, and environmental ethics in the wilderness where students undergo rigorous physical activity such as hiking, mountaineering, and kayaking with limited resources. NOLS offers a variety of courses across the globe ranging from one month to one year in duration; this experiment will focus on semester long courses that take place in the Rocky Mountains and the United States Southwest.

Rationale

This study will produce invaluable data and analysis that will greatly improve our understanding of the physiological and morphological interact, and better understand variation in body shape as it relates to climate. The empirical data, both physiological and morphological, collected in this study will provide the building blocks for producing a more tenable model that can better predict the energetic demands experienced by humans in different climates both past and present.

Research Objectives

This study will address the four following questions: 1. How does daily energy expenditure, and its complex interactions, differ between hot and cold climates among resource limited and highly active humans? 2. Which body shapes will confer greater heat dissipation in hot climates and which will confer greater heat retention in cold climates? 3. What is the energetic benefit or cost to particular body shapes in different environments? 4. Which morphological characteristics will provide the most accurate model for predicting daily energy expenditure and what can such a model elucidate about modern human variation?

1. Courses

* 1. What is your NOLS course code and starting date?

(e.g. WRW 7/21/10)

2. What is your birthdate?

Date MM DD YYYY
 / /

* 3. During my NOLS course I experienced stress from:

	No stress		Some stress		Lots of stress	
the high level of physical activity	☐	☐	☐	☐	☐	☐
the high level of exposure to heat	☐	☐	☐	☐	☐	☐
the high level of exposure to cold	☐	☐	☐	☐	☐	☐
conflict with others	☐	☐	☐	☐	☐	☐
a lack of sleep	☐	☐	☐	☐	☐	☐
a lack of rest days	☐	☐	☐	☐	☐	☐
hunger for food	☐	☐	☐	☐	☐	☐
food choices	☐	☐	☐	☐	☐	☐
illness	☐	☐	☐	☐	☐	☐
an injury	☐	☐	☐	☐	☐	☐
fear of injury	☐	☐	☐	☐	☐	☐

Other (please specify)

4. These stressors detracted from my enjoyment:

- ☐ the high level of physical activity
☐ the high level of exposure to heat
☐ the high level of exposure to cold
☐ conflict with others
☐ a lack of sleep
☐ a lack of rest days
☐ food stress
☐ illness
☐ an injury
☐ fear of injury

Please explain how the most significant stressor detracted from your enjoyment.

Approved

Philip A. Ludbrook

Philip A. Ludbrook, M.D.
 Associate Dean and Chairman

DATE RELEASED FOR SUBJECT ACCRUAL: JUN 16 2010

Information Regarding an Optional Voluntary Research Project:

A comparison of human physiological and morphological responses to hot and cold climates with an emphasis on energy expenditure

The National Outdoor Leadership School would like to inform you of an optional voluntary research opportunity being conducted at NOLS sites. What follows, is a description of a research project looking at metabolic energy expenditure in different climates being conducted by Cara Ocobock, a graduate student, and Dr. Herman Pontzer from the Department of Anthropology at Washington University in St. Louis and in cooperation with the National Outdoor Leadership School. The purpose of this study is to determine which body types use less metabolic energy, as measured through heart rate monitors and doubly labeled water, in hot climates and which use less in cold climates. This study will also look at the relationship between course enjoyment and stress caused by physical activity, diet, and climate during the NOLS experience.

This is an optional research opportunity. Your participation in this study is voluntary and you may choose not to participate or withdraw at any time. Choosing to not participate in this study will NOT affect your NOLS experience. If you choose to participate in this study, you may withdraw from it at any time without penalty.

If you choose to participate in this study, you will be asked to:

1. Take part in a series of physical measurements which include recording your height, weight, percent body fat, muscle mass, skin fold thickness, and measurements of your limbs and torso.
2. Wear a heart rate monitor and accompanying data logging device while on the NOLS course.
3. Provide urine samples for analysis of stress hormones every three days.
4. Take part in a series of step tests and basal metabolic rate measurements which include wearing a light mask while expired air is collected. **What are Step Tests:** Step tests will consist of you walking and running on a treadmill or up and down stairs. You will be wearing the heart rate monitor and the open-flow mask to collect the air you expire while taking part in the step tests. This allows us to calibrate your individual heart rate level to the amount of oxygen you consume and carbon dioxide you expel. We do this so that we can better estimate your metabolic rate from data collected by the heart rate monitors while you are on course.
5. Complete surveys pertaining to the stress levels you experience during a NOLS course.
6. You may also be asked to be part of a small subset of subjects asked to take part in a doubly labeled water portion of this study, if so, you will be asked to drink a small dose of doubly labeled water and provide urine samples for analysis. **What is Doubly Labeled Water:** Doubly labeled water is a harmless form of water that weighs more per ounce than regular tap water. Your body uses water to breakdown food and turns it into energy, any excess water is excreted as urine. Once you have ingested a dose of doubly labeled water, it, as well as any water you ingest afterwards, will be used like regular water to metabolize food and also be excreted in urine. The urine samples collected during this study will be analyzed for the ratio of doubly labeled water to regular water as determined

by the weight difference of the two forms of water. That ratio will tell us how quickly you are using water, and, therefore, your metabolic rate.

The course you are participating in offers the unique opportunity of exposure in two different climates over an extended period of time; either hot and temperate or cold and temperate. This allows us to see how your energy use differs in these different climates. For this project, you will be asked to take part in four different data collection bouts. The first will occur before you embark on your course and will consist of the oxygen consumption and body measurements; this will last 2 hours. The second bout will occur at re-supply stations along the NOLS course, after you have been on the course and in a particular climate (for example the temperate climate) for two weeks and consist of urine sample collection and survey completion; this will last 20-30 minutes. This second bout of data collection will occur every three days for a week. The third bout will occur two weeks after you have entered a new climate (for example the cold climate) on your course. This third bout will be conducted in the exact same manner as the second bout. The final bout will occur once the NOLS course is complete and will consist of the oxygen consumption and body measurements as well as survey completion and final urine sample collection; this will last 2 hours. Please see the chart which demonstrates how the research timeline fits within the NOLS course.

Sample Timeline

Time	Before Course	Week 1 (temperate climate)	Week 2 (temperate climate)	Weeks 3-4 (temperate climate)	Several Weeks Elapse for semester course & climate change	Week 10 (hot or cold climate)	Week 11 (hot or cold climate)	Weeks 12-13 (hot or cold climate)	After Course Week 16
NOLS schedule	NOLS Orientation	Embark on Course	Regular Course	Re-ration		Regular course	Regular Course	Re-ration	NOLS De-briefing
Data collection	Bout #1			Bout #2				Bout #3	Bout #4

Risks associated with this study:

There are no additional risks associated with this study outside of the risks known for participating in a NOLS course. All urine samples provided for analysis will be assigned a number so that your name remains confidential.

Benefits to your participation in this study:

1. You will receive all of your data such that you can view how your metabolism and body changed before, during, and after the NOLS course.
2. You will have access to the final, generalized results of this study so that you may review how body shape, body size, and climate impact metabolic energy use. Given that each course is only a small part of the larger study, we may not be able to give you the final, general results until the study is complete.

All data collected will be kept confidential to protect your privacy. Your participation in this study will contribute to our understanding of how body shape and size interact with physiology. Furthermore, it will

linked code will be in a laboratory notebook which is kept in a locked cabinet in the laboratory in the Department of Anthropology at Washington University which is also locked. In rare instances, a researcher's study must undergo an audit or program evaluation by Washington University or an external oversight agency (such as the Office for Human Research Protection or the Food and Drug Administration). This may result in the disclosure of your data as well as any other information collected by the researcher. If this were to occur, such information would only be used to determine whether the researcher conducted this study properly and adequately protected your rights as a human participant. Importantly, any and all auditors would maintain the confidentiality of any information reviewed by their office(s).

Contact Information

If you have any questions or concerns about this study, or feel that you have been harmed in any way by your participation in this research, please contact Cara Ocobock 734-819-6108 or Herman Pontzer 314-935-5292. If you wish to talk with someone not associated with the research, or if you have questions about your rights as a research participant, please call Dr. Philip Ludbrook, Executive Chair of Washington University's Human Research Protection Office, at 314-633-7400 or 1-800-438-0445.

I have read this consent form and have been given a chance to ask questions. I agree to participate in the research study described above titled, A comparison of human physiological and morphological responses to hot and cold climates with an emphasis on energy expenditure. I will receive a signed copy of this form for my records.

Signature of Research Participant

Date

Printed Name of Research Participant

Signature of person obtaining consent

Date

Printed Name of person obtaining consent

This form is valid only with the Human Research Protection Office's current stamp of approval.

WASHINGTON UNIVERSITY MEDICAL CENTER HSC	
Protocol Approved	<u>JUN 09 2010</u>
Approval Terminates	<u>JUN 08 2011</u>
<i>Federal regulations permit no grace period</i>	
Date Released For Subject Accrual	<u>JUN 16 2010</u>

APPENDIX C

ACTIVITY LOG

Name:

Activity Journal

Date:

[illegible]

Date:

[illegible]

APPENDIX D

FOOD LOG

Name:

Food Journal

Date:[illegible]

Date:

[illegible]