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Acute mountain sickness and rating of perceived exertion on Denali

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ACUTE MOUNTAIN SICKNESS
AND RATING OF PERCEIVED EXERTION ON DENALI

A Thesis

Presented to

The Faculty of the Department of Kinesiology

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Stacy Schroeder, ATC

December 2006

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Abstract

ACUTE MOUNTAIN SICKNESS AND RATING OF PERCEIVED EXERTION ON DENALI

By Stacy Schroeder

The relationship between acute mountain sickness (AMS) and rating of perceived exertion (RPE) in climbers at increasing elevations was the purpose of this thesis. Volunteers responded to two questionnaires at nine specific elevations throughout their ascent of Denali's west buttress. AMS, RPE, and rate of ascent (ROA) were recorded. AMS was evaluated using the Lake Louise Symptom Scoring Questionnaire (LLSSQ). RPE was evaluated using Borg's Rating of Perceived Exertion Scale. Rate of ascent was calculated based on time elapsed between data collection points. Age and gender were also recorded.

Results indicated a significant correlation between AMS and RPE scores across the elevation levels; the scores tended to increase with increasing elevation. AMS and RPE seemed to be consistently related to each other, but *not* to ROA and age. Males tended to have slightly higher AMS and RPE scores than females, and this relationship was not affected by elevation. A significant positive correlation between RPE and AMS suggests that RPE may be used to predict AMS. Future duplicate studies would benefit from a larger sample size with a more balanced representation of both genders.

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To my friends in Santa Cruz – thank you for all the climbing trips, late night sushi, and walks along the ocean which helped clear my head. My sanity has been greatly maintained because of you. I am also grateful for Yosemite – for El Capitan and all the other wild climbing adventures we have shared.

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Chapter 1

INTRODUCTION

Altitude sickness can be a serious problem for people who travel to high elevations. Acute Mountain Sickness (AMS) is treatable and preventable, however the many factors which possibly contribute to the onset of AMS must be understood. Continued research in the field of high altitude medicine may enhance laypersons' working knowledge of prevention of AMS. This thesis makes a small contribution to the body of knowledge on AMS, and may increase interest in the topics contained herein.

Statement of the Problem

At altitudes between 1,500 and 2,500 meters the body begins to experience the effects of reduced partial pressure of oxygen in the atmosphere. The density of oxygen in the air decreases with increasing altitude, causing less oxygen to be available during normal inspiration. The body must therefore work harder to obtain oxygen, which is of concern in non-acclimatized individuals who may develop symptoms of altitude illness. AMS, high altitude pulmonary edema, and high altitude cerebral edema result from subnormal blood oxygen levels. With relatively intense physical activity a greater risk for developing the most common of these altitude-related illnesses, AMS exists. A need is present for practical, in-field assessment tools to help promote responsible recreation at high altitudes.

Increasing mountaineers' awareness of altitude sickness and the associated risk factors may help to decrease the incidence of AMS. Since physical exertion is a significant risk factor for AMS, it follows that monitoring exertion is a necessary component of a proper ascent. Objective clinical measurements of physical exertion are

not always available to climbers in the backcountry. Properly utilizing a simple self-evaluation tool for perceived physical exertion may help to control the onset of AMS.

Purpose of the Research

The purpose of this study was to identify whether a positive correlation between climbers' rating of perceived exertion at a given altitude and severity of acute mountain sickness symptoms exists. Relationships among AMS, RPE, age, gender, and ROA were evaluated in a true field setting as opposed to a simulated altitude chamber.

Explanation of Chapter Contents

This thesis is divided into three chapters, according to the guidelines set forth by the Department of Kinesiology.

Chapter 1 – Introduction

Chapter 1 introduces the completed research project, as detailed in Chapters 2 and 3. This chapter presents the basic statement of the problem and purpose of the research.

Chapter 2 – Journal Article

The entirety of Chapter 2 is a representation of the journal article to be submitted to *Medicine and Science in Sports and Exercise*. This includes abstract, methods, results with imbedded figures, discussion, conclusions, and references as it would be seen in the actual journal upon publication.

Chapter 3 – Extended Support Materials

Finally, Chapter 3 provides all materials presented in the thesis proposal. This has been revised to reflect the completed study, and includes an introduction to the research, literature review, and methods sections.

Summary

This thesis presents the necessity for and the results of a recent study of AMS and RPE in climbers on Denali. Because professional publication is anticipated, a mock-journal article has been completed and is presented in Chapter 2. Further details regarding research design and literature review are contained in Chapter 3.

Chapter 2

JOURNAL ARTICLE

Acute Mountain Sickness and
Rating of Perceived Exertion on Denali

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Acute mountain sickness and rating of perceived exertion on Denali

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ABSTRACT

SCHROEDER, S.; CISAR, C., and KAHANOV, L. The Relationship between Acute Mountain Sickness and Rating of Perceived Exertion on Denali. *Med. Sci. Sports Exerc.*, Vol. XX, No. YY, pp. XXXX-YYYY, 2007. **Objective:** We examined the relationship between acute mountain sickness (AMS) and rating of perceived exertion (RPE) in climbers at increasing elevations. **Design and Setting:** Volunteers responded to two questionnaires at nine specific elevations throughout their ascent of Denali's west buttress. AMS, RPE, and rate of ascent (ROA) were recorded. **Measurements:** AMS was evaluated using the Lake Louise Symptom Scoring Questionnaire (LLSSQ). RPE was evaluated using Borg's Rating of Perceived Exertion Scale. ROA was calculated based on time elapsed between data collection points. Age and gender were also recorded. **Results:** Significant correlations between AMS and RPE scores across the elevation levels existed; the scores tended to increase with increasing elevation. AMS and RPE were consistently related to each other, but *not* to ROA and age. Males tended to have slightly higher AMS and RPE scores than females, and this relationship was not affected by elevation. **Conclusions:** A significant positive correlation between RPE and AMS suggests that RPE may be used to predict AMS. **Key Words:** HIGH ALTITUDE, ALTITUDE SICKNESS, PHYSICAL EXERTION

Acute mountain sickness (AMS) has been defined by the Lake Louise Consensus Group as the presence of headache in an un-acclimatized person who has recently arrived at an altitude above 2500m plus the presence of one or more of the following: gastrointestinal symptoms (anorexia, nausea, or vomiting), insomnia, dizziness, and lassitude or fatigue (19,18). Susceptibility to AMS is affected by factors such as: physical exertion (12, 13,18,19,23), especially within the

early hours of exposure to high altitude (18), rate of ascent (ROA)(1,13,19), and past history of the illness (10,21). Gender and age may also be significant, but this has not been consistently demonstrated.

Symptoms of hypoxemia are a normal element of acclimatizing to higher altitudes. These include such inconveniences as mild headache, shortness of breath, and elevated heart rate, as the body must work harder to obtain oxygen. Other typical responses to hypoxic conditions are fainting, loss

of appetite for proteins and fats (usually at 3,000m -5,500m), and a temporary complete loss of appetite at higher altitudes. All of these symptoms usually resolve within one to two days after arrival at the new altitude (6,13). It is only when these mild discomforts become worse, or when symptoms do not diminish within two days that there is a cause for concern. Untreated altitude illness could become fatal.

Increasing climbers' awareness of altitude sickness and the associated risk factors may help to decrease the incidence of AMS. Since physical exertion is a significant risk factor for AMS, it follows that monitoring exertion is a necessary component of a proper ascent. Objective clinical measurements of physical exertion are not always available to climbers in the backcountry. Properly utilizing a simple tool for self-evaluation of perceived physical exertion may help to control the onset of AMS.

The purpose of this study was to identify whether a positive correlation between climbers' RPE at a given altitude and severity of AMS symptoms exists. At nine various elevations between 2,200m and 6,100m the AMS, RPE, and rate of ascent were examined.

METHODS

A research permit was granted by Denali National Park and Preserve (DNPP). San Jose State University Human Subjects - Institutional Review Board also granted approval for the study.

Subjects. Climbers during the May through July 2001 climbing season on

Denali volunteered for the study. In order to qualify for participation, climbers must have intended to complete the west buttress route, and must have been willing to respond to two questionnaires administered via two-way radio at nine specific elevations throughout their ascent. In the event of radio failure, they must have been capable of filling out a back-up response card, as instructed by the researcher.

Assessment of AMS. The LLSSQ was used to classify AMS throughout the study. This method was deemed appropriate due to its simplicity and ease of administration. AMS symptoms were assigned a score, based on severity. A score of grade 0-3 was assigned to five separate groups of symptoms, based on a description of their intensity. They were: headache, gastrointestinal symptoms, fatigue and/or weakness, dizziness/lightheadedness, and difficulty sleeping. AMS was diagnosed if the subject had a total score of 4 or more. In addition, if the subjects had such symptoms due to an obvious illness other than AMS, an AMS symptom score was not assigned to that symptom. For example, subjects having gastroenteritis would have symptoms of nausea, vomiting, and headache with fever and diarrhea, and would not be categorized as having AMS (12).

Assessment of RPE. Rating of perceived exertion scales have been used to quantify subjective perceptions of physical effort during exercise, and to relate these symptoms to objective findings. The most popular, as well as the most extensively tested and confirmed for reliability and validity is the RPE scale developed by Borg in 1970 (2,3,4,5,7,8,9,15,21).

A high linear relationship has been established between heart rate and Borg's 15-point categorical rating scale. The values from 6 to 20 indicated on this scale correspond to approximately one-tenth of exercise heart rate values, such that a particular value on the scale, e.g., 15, would match approximately a heart rate of 150 beats per minute (5). It has been demonstrated that small variations in intensity can be detected by subjects, even when presented in random order (20).

Procedures. At nine data collection points throughout the west buttress climb, the incidence and severity of AMS for each subject was assessed using the self-administered LLSSQ (17). Subjects also reported their rating of perceived exertion as rated by Borg's original 15-point RPE scale (3,4,5).

Pre-Climb. Volunteers were provided a printed description of the study with researcher contact information and completed a medical history and informed consent form prior to the start of the climb. All personal and medical information was maintained in the strictest confidentiality, and was not shared with anyone outside of the research party. To maintain anonymity, upon volunteering for the study, each person was given an identification number, by which they were referred for all data analyses and reports.

The researcher enlisted volunteers for the first three weeks after arrival at base camp. Because the round-trip time to climb the west buttress can vary from 2 to 3 weeks during "normal" weather patterns, participants were recruited during the initial 3 weeks of the 7-week study to allow ample time for completion of the climb. The remaining

4 weeks were spent collecting data from returning climbers.

The Climb. The study was designed around a typical ascent profile as suggested by Denali guiding companies. The data collection points were: 2,200m (Base Camp); 2,400m (Ski Hill); 2,900m (Upper Kahiltna); 4,000m (just below Windy Corner); 4,300m (The Basin); 4,900m (Ridge Camp); 5,200 (High Camp); 5,500m; and 6,100m (Summit).

While approaching the data collection point and still physically exerting themselves, subjects assessed their RPE. Participants carried with them a copy of the scale, along with full instructions for its use. Key phrases were highlighted so the climbers could quickly review the instructions if necessary, which should have increased the likelihood of proper use of the RPE scale. AMS symptoms were then evaluated.

Scores from both questionnaires were relayed to the researcher stationed at base camp, either by means of two-way citizen band (CB) radios at the data point, or by means of a backup data card which was turned in upon completion of their climb. When recording the data, current position (as indicated by their altimeter), and time of day were noted. The researcher recorded the time passed since the last communication in order to approximate rate of ascent.

Statistical Analysis. A Pearson-product moment was used to correlate AMS score and RPE with altitude and rate of ascent. RPE, AMS score, and ROA at various elevations were analyzed using three one-way analyses of variance (ANOVA). Two one-way ANOVAs were used to analyze the gender effect on AMS and RPE at the nine elevations. The level of statistical

significance for all analyses was set at $P \leq .05$.

RESULTS

Descriptive information is depicted in Table 1. As the climb became harder with increasing elevation physically

weak or sick individuals descended, which is reflected in the number of subjects (N) who completed each data collection point.

TABLE 1. Mean ($\pm$ SE) age, acute mountain sickness score, rating of perceived exertion, and rate of ascent for each elevation.

Meters	N	Age (yr)	AMS	RPE	ROA (m/day)
2200	35	32.6 $\pm$ 1.9	0.7 $\pm$ 0.2	9.1 $\pm$ 0.6	n/a
2400	35	32.6 $\pm$ 1.9	1.2 $\pm$ 0.2	13 $\pm$ 0.5	726 $\pm$ 192
2900	35	32.6 $\pm$ 1.9	1.4 $\pm$ 0.3	12.9 $\pm$ 0.4	650 $\pm$ 132
4000	35	32.6 $\pm$ 1.9	1.9 $\pm$ 0.3	14.2 $\pm$ 0.5	530 $\pm$ 60
4300	34	32.9 $\pm$ 1.9	2.6 $\pm$ 0.3	14 $\pm$ 0.7	1042 $\pm$ 334
4900	30	32.8 $\pm$ 2.0	2.1 $\pm$ 0.3	15.1 $\pm$ 0.5	289 $\pm$ 48
5200	29	32.6 $\pm$ 2.1	3.4 $\pm$ 0.3	15.9 $\pm$ 0.6	723 $\pm$ 48
5500	21	35.9 $\pm$ 2.6	1.7 $\pm$ 0.3	15 $\pm$ 0.6	228 $\pm$ 78
6100	22	34.3 $\pm$ 2.6	2.9 $\pm$ 0.6	16 $\pm$ 0.6	2241 $\pm$ 295

Table 2 summarizes the Pearson correlation coefficients between the variables at the nine elevations. At 2,200m of elevation, there was a significant correlation between AMS and RPE [$r(33) = .56$, $P < .001$]. At 2,400m of elevation, there was a significant correlation between AMS and RPE [$r(33) = .33$, $P = .05$]. In addition, age was significantly correlated with AMS [$r(33) = .40$, $P < .05$]. At 2,900m of elevation, the only significant correlation was between AMS and RPE [$r(33) = .51$, $P < .01$]. At 4,000m of elevation, there was a significant correlation between AMS and RPE [$r(33) = .47$, $P < .01$]. ROA was significantly correlated with RPE [$r(33) = .38$, $P < .05$]. At 4,900m of

elevation, there was a significant correlation between AMS and RPE [$r(28) = .45$, $P < .05$]. At 5,200m of elevation, there was still a significant correlation between AMS and RPE [$r(27) = .46$, $P < .05$]. At 6,100m of elevation, there was a significant correlation between AMS and RPE [$r(20) = .53$, $P < .05$]. All other correlations between the variables at the different elevations were non-significant.

Figure 1 depicts the average correlation coefficients between each variable. The strongest correlation exists between AMS and RPE (average = 0.43), and there was significantly smaller positive correlations between AMS and age (average = 0.04), and RPE and age (average = 0.05). There was a

negative correlation between AMS and ROA (average = -0.05), between RPE

and ROA (average = -0.14), and between ROA and age (average = -0.01).

FIGURE 1. Average correlation coefficients between each variable

TABLE 2. Summary of the Pearson correlation coefficients at each of the elevations (m).

Meters	AMS-RPE	AMS-ROA	AMS-Age	RPE-ROA	RPE-Age	ROA-Age
2,200	$r = .56^*$	$r = \text{n/a}$	$r = -.09$	$r = \text{n/a}$	$r = .06$	$r = \text{n/a}$
2,400	$r = .33^*$	$r = -.05$	$r = .39^*$	$r = -.20$	$r = -.10$	$r = -.30$
2,900	$r = .51^*$	$r = -.07$	$r = .13$	$r = .01$	$r = .16$	$r = -.12$
4,000	$r = .47^*$	$r = -.25$	$r = .08$	$r = -.38^*$	$r = -.03$	$r = -.06$
4,300	$r = .22$	$r = .01$	$r = .15$	$r = .05$	$r = .19$	$r = .11$
4,900	$r = .45^*$	$r = -.27$	$r = -.01$	$r = -.31$	$r = .09$	$r = -.01$
5,200	$r = .46^*$	$r = .09$	$r = .23$	$r = -.27$	$r = .05$	$r = -.03$
5,500	$r = .31$	$r = .24$	$r = -.15$	$r = .14$	$r = .20$	$r = .04$
6,100	$r = .53^*$	$r = -.06$	$r = -.34$	$r = -.17$	$r = -.20$	$r = .26$

Note. *Significant at $P < .05$.

Figure 2 shows the average correlation coefficients between AMS and RPE throughout the ascent. There was a steady, moderate correlation between AMS and RPE. Figure 3 plots the average AMS symptom score at each elevation. AMS scores were generally higher as climbers reached greater elevations. Figure 4 shows that, like

AMS, average RPE also increased with increasing altitudes.

Figures 5 and 6 summarize the subjective findings with respect to the gender influence on AMS and RPE. Figure 5 shows the AMS scores for males and females across the nine elevations. An analysis of variance with gender and elevation, with AMS as the dependent variable, showed a significant main-effect for gender ($P < .05$). Figure

6 shows the mean RPE scores for males and females across the nine elevations. An analysis of variance with gender and elevation, with RPE as the dependent

variable, again found a significant main-effect for gender ($P < .05$).

FIGURE 2. Average correlation of AMS-RPE at each elevation

FIGURE 3. The trend of AMS score with increasing elevation

FIGURE 4. Changes in RPE with increasing elevation

FIGURE 5. Elevation, gender, and AMS

FIGURE 6. Elevation, Gender, and RPE

DISCUSSION

This study was interested in the possible relationships between AMS, RPE, ROA, age, and gender. Of specific interest was the correlation between AMS and RPE with increasing altitude to determine whether or not RPE may be a useful predictor of the onset of AMS. Because such factors as ROA, age, and gender may influence the onset of AMS, this information was also collected. A significant positive correlation between AMS symptoms and RPE score suggests that monitoring these variables while climbing may help to effectively assess the risk for altitude sickness, and that AMS and RPE may be used in conjunction with other risk factors to determine the need to descend, stay at the current elevation or continue ascending.

As reported in Table 2, the correlations between AMS and RPE demonstrated a consistent pattern across

the different elevations. The AMS-RPE correlations were significant at seven of the nine elevations. For the two non-significant AMS-RPE correlations at 4,300m and 5,500m of elevation, the correlation coefficients were still the highest among all the possible pairs of variables in their respective elevations. Although the correlations between RPE and AMS were somewhat moderate indicating that RPE generally accounted for approximately 11% to 31% of the variability in AMS, the relationships in fact may be considerably higher as the scales used to evaluate RPE (6-20) and AMS (0-3) had a limited range resulting in homogeneous scores.

One possible explanation for the seeming lack of correlation at 4,300m is that the participants may have been lax about doing their data collection as they entered this high camp. Due to either poor radio communication or interest in preserving batteries, all climbers used the back up cards as opposed to the radios at this elevation. In anticipation

of reaching a resting point in potentially windy and snowy conditions, the climbers may not have been focused on the AMS study. They may have reported their AMS and RPE scores retrospectively, after being warm and rested. Therefore, it is possible that perceived physical exertion and AMS symptoms were inaccurately rated. Another possibility is that the climbers were acclimatized at this point.

As for the correlations involving other pairings of the variables, none of the other correlations were significant, except for the correlation between AMS and age at 2,200m of elevation and the correlation between RPE and ROA at 4,000m of elevation. However, unlike the AMS-RPE correlations that were consistently significant, these two correlations were only observed at one of the nine elevations. Interestingly, RPE did not seem to change with ROA. It appears to be primarily a product of AMS in this study.

AMS scores generally tended to increase across the elevations for both males and females. Additionally, males reported slightly higher AMS scores (mean = 2.06) than did females (mean = 1.56). There was no significant interaction between gender and elevation. The lines of best fit do cross at approximately 2,100m, which might simply be the by-product from the different slopes of the two lines. It is unlikely that males would report lower AMS scores than females at lower levels of elevations. In fact, it is possible that the difference in reporting of AMS scores between males and females becomes less pronounced at lower elevations. Worth noting is that the female population is very small.

RPE scores increased across the elevations in all subjects. Males' RPE scores (mean = 13.98) were slightly higher than females' RPE scores (mean = 12.66). This is expected given the earlier findings from the consistent AMS-RPE significant correlations across the elevations, as well as the ANOVA involving AMS, gender, and elevation. This is also supported by previous research indicating that females generally report lower RPE scores than males (11,14,16) in outdoor environments (14). There is no crossover in this analysis, which may support the possibility that gender differences on AMS and RPE do *not* reverse at lower elevations. Because it seems unlikely that AMS and RPE would be significantly different for males and females at zero elevation, gender differences, if any, would probably be more pronounced at higher levels of elevations without trend reversal.

In summary, it has been established that there are significant correlations between AMS and RPE scores across the elevation levels and the scores tend to increase with increasing elevation. AMS and RPE are consistently related to each other, but *not* to ROA and age. Males tend to have slightly higher AMS and RPE scores than females, and this relationship is not affected by elevation. If there *is* an interaction between gender and elevation, the trends of the best-fit lines suggest that the difference may be more pronounced at higher elevations and less pronounced at lower elevations.

CONCLUSIONS

In general, the higher altitude reached, and the greater the physical

exertion involved, the more severe the AMS. A significant positive correlation between RPE and AMS suggests that RPE may be used to predict AMS.

Due to the nature of climbing a mountain such as Denali, the data collection cards may have been difficult to access at the appropriate times due to safety or weather concerns. If the subjects were not able to communicate via CB radio and did not have access to the card at the given altitude, they were asked to think about both their perceived exertion and their AMS symptoms. Once in a more appropriate position they were asked to transfer the information to the data card. This retrospective reporting may have affected the accuracy of the data.

Future duplicate studies would benefit from a larger sample size with a more balanced representation of both genders, and with a greater number of subjects completing the questionnaires at the highest elevations. Examination of the relationship between RPE and AMS scores at both moderate and extreme

altitudes, with greater control of potentially confounding factors would also be of interest. Future research should also consider other factors not included in this investigation which may affect AMS.

Overall, if a climber is able to quantify how hard they feel his or her body is working, given the significant positive correlation between RPE and AMS, then there might be evidence for the use of RPE to control physical exertion, contributing to the prevention AMS. This information could directly benefit future studies involving physical exertion at altitude, contributing to the practical knowledge of prevention so essential to the sport of mountaineering.

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Chapter 3

EXTENDED SUPPORT MATERIAL

Introduction

Introduction to the Problem

Mount McKinley (Denali) is the highest peak in North America. Nestled in the Alaska Range, its slopes culminate at 6,194 meters. Advances in technology and equipment have made travel to these mountain tops more feasible in surroundings otherwise unsuitable for humans. But the ever-present environmental extremes will always pose a risk to those who challenge them. Unpredictable weather patterns, along with the effects of altitude on the body, can be severely debilitating. Therefore, there has been great interest in researching altitude-related illnesses with the intent to educate the mountaineering community about cautious climbing.

Statement of the Problem

At altitudes above 2,400m (and occasionally as low as 1,500m), the body begins to experience the effects of reduced partial pressure of oxygen in the atmosphere. Acute mountain sickness, high altitude pulmonary edema, and high altitude cerebral edema result from subnormal blood oxygen levels. The density of oxygen in the air decreases with increasing altitude, causing less of this crucial gas to be available during a normal inspiration. The body must work harder to obtain oxygen. When physical exertion is added to the equation, there is greater risk for developing the most common of these altitude-related illnesses, AMS.

Physical exertion is a primary factor affecting AMS (Hackett 1993; Roach, Maes, Sandoval, et al., 2000). Other variables influencing the acquisition of AMS are individual susceptibility, rate of ascent, and previous exposure to altitude (Schneider,

Bernasch, Weymann, Holle, & Bartsch, 2002). Dehydration, gender, and age may also be significant, but this has not been definitively proven.

The exact etiology of AMS is unknown, although numerous research studies have provided helpful information regarding associated symptoms, effective treatment options, and possible preventative measures (Austin & Sleight, 1995; Coote, 1995; Evans., Robinson, Horstman, Jackson, & Weiskopf, 1976; Hohenhaus, Nirooman, Goerre, Vock, Oelz, & Bartsch, 1994; Honigman, Read, Lezonne, & Roach, 1995; Kasic, Yaron, Nicholas, Kickteig, & Roach, 1991; & Krasney, 1994). AMS can be fatal if untreated. To promote safe climbing at potentially debilitating altitudes, individuals must be aware of their body's response to physical exertion and acclimatization. This knowledge can help to ensure proper ascent, potentially avoiding altitude sickness. Vardy, Vardy, & Judge (2005) determined that trekkers who were more informed about AMS and its prevention were less likely to have altitude sickness at higher elevations.

Statement of the Purpose

The purpose of this study was to identify whether or not there is a relationship between climbers' ratings of perceived exertion at a given altitude and severity of acute mountain sickness, if present. This study also considered rate of ascent, age, and gender.

Significance of the Problem

Due to the potential seriousness of AMS, it is imperative that climbers have an awareness of its clinical manifestations and knowledge of the management of the illness when present. The best method of treatment is prevention, so there is a need for practical, simple methods of controlling the factors that lead to AMS. One of these

factors is physical exertion. If the effects of altitude and rate of ascent are controlled by proper acclimatization, altering the intensity of work done by the body may be useful in decreasing the symptoms of AMS, if not preventing them all together.

Currently, non-invasive methods used among researchers to identify AMS include a combination of questionnaires and simple clinical examinations (Hackett & Rennie, 1983; Maggiorini, Buhler, Walter, & Oelz, 1990; Sampson, Cymerman, Burse, Maher, & Rock, 1983; Wright, Jones, Fletcher, Mackintosh, & Bradwell, 1985). It is practical to be able to identify AMS and the contribution of potential risk factors such as physical exertion without lengthy questionnaires and without dependence on a clinical examination. This study measured climbers' RPE in addition to their self-administered LLSSQ scores at various elevations. This was an in-field study, conducted in the presence of cold temperatures, fatigue, malnutrition, confined and uncomfortable sleeping conditions, and of course increasing altitude. If a climber is able to quantify how hard they feel his or her body is working in a mountaineering environment, and if there is a significant positive correlation between RPE and AMS, this suggests that RPE may be used to control physical exertion, contributing to the prevention AMS. This information would directly benefit future studies involving physical exertion at altitude, and would contribute to the practical knowledge of prevention so essential to the sport of mountaineering.

Approach to the Problem

Aside from the physical demands of mountaineering, the challenge of climbing Denali is particularly unique. Because the peak is positioned at such a high latitude

(63°N), the drop in barometric pressure associated with increasing altitude is more pronounced than it is on other mountains further south. That is, the partial pressure of oxygen is lower at high altitudes near the poles compared with mountains of similar height at lower latitudes. Hackett (1988) illustrated that the barometric pressure at Denali's summit is equivalent to altitudes 300m to 800m higher in the Himalayas, which are situated at 27°N. Therefore, the latitude of Denali puts climbers at more significant risk for suffering the effects of hypoxia, causing them to feel physiologically 'higher' than they really are. The intense weather conditions, including nighttime temperatures of -40° during the summer months and seemingly spontaneous, bellowing storms, subject alpinists to colder conditions than are experienced on Mount Everest.

The increasing popularity of Denali has drawn climbers of all abilities to its routes. A large number of visitors combined with the physiological stress associated with McKinley's extreme hypoxic conditions make this a perfect environment in which to study altitude illness. About 1,000 people attempt the climb each year, approximately 25-30% of whom typically develop acute mountain sickness (Hackett, Roach, Schoene, Hollingshead, & Mills, 1986; Hackett, 1988). This highest point in North America is superior to other mountains on the continent (whose modest elevations are not conducive to producing symptoms of prolonged, severe hypoxia) for research of this nature. In 1988 Hackett appropriately stated that Denali "...provides the highest concentration and largest number of altitude and cold injuries in any civilian population ...it has become a popular volunteer stint for physicians and students interested in mountain medicine." (p. 234).

Using simulated altitude chambers was not considered, primarily because these testing modules eliminate the “real life” component of altitude exposure. Also, the ethical precautions required of such an experiment would be beyond the scope of this study. The objective was to make use of practical in-field tools for the assessment of AMS and RPE, and to identify any significant correlations between the two variables. Responses to two questionnaires were reported at specific altitudes along the West Buttress of Denali, the route taken by 80% of climbers attempting to reach the summit.

Participants were volunteers already registered with Denali National Park and Preserve (DNPP) during the summer 2001 climbing season. Data collection was strictly survey-style, and did not significantly inconvenience the participant. Additionally, to ensure confidentiality of the personal information collected in this study, each climber was assigned a subject number. When analyzing the data, individual results were reported using the subject number without mention of the participants’ names; the information was not shared with anyone outside of the research party.

Hypotheses

At nine various elevations between 2,200m and 6,100m, there will be no relationship between AMS, RPE, and rate of ascent. Neither RPE nor AMS will differ from 2,200m to 6,100m. Gender will have no influence of AMS or RPE.

Delimitations

The volunteers involved in this study had the option of using personal medication that might have significantly altered their symptoms associated with acute mountain sickness. It is common for climbers to take prophylactic and preventative medication to

either prevent AMS or speed acclimatization. If a subject chose to use prescription medication for AMS, they were asked to report its use. Only two subjects reported using acetazolamide (Diamox) or Ginkgo Biloba only once, and they were not excluded from the study. It is also possible that other climbers took medication and did not report its use. This research was limited by personal choices made by the climbers. In no way were the participants encouraged to abandon their intentions or to deny medical treatment for the sake of this study.

Just as medical decisions were not influenced in this study, neither were details regarding rate of ascent. That is, volunteers did not report length of time stayed at each altitude during the expedition. This obviously affects overall rate of ascent measurements, as ROA was calculated based on time passed between data collection points, without separating actual climbing time from time spent at rest points.

Finally, volunteers who lived at high altitudes would not have responded to increasing altitude in the same way a lowland dweller would have, due to chronic adaptations. While on the mountain, there were more acute factors that may have affected the study, such as the considerable variability in amount of sleep attained each night, dietary intake, and actual days of climbing/acclimatization among individuals.

Limitations

Many participants did not complete the entire climb due to altitude illness or other physical limitations, therefore summit data was limited to those healthy enough to have completed the climb. This was reflected in the final results, as subjects having experienced the most intense AMS symptoms descended before reaching the higher and

possibly more significant elevations. This lack of data may have weakened the outcome of the results.

A few subjects climbed multiple routes and two climbers in particular completed bold first-ascents of other peaks before completing the West Buttress route. This obviously affected their AMS scores, as they were well-acclimatized prior to starting the route. As such, these participants may have reported lower AMS and RPE scores than those climbers who ascended according to the expected itinerary. Therefore, there may not have been consistency in the actual ascent profile or recent prior exposure to high altitudes among all volunteers. Additionally, four subjects did not return to base camp after their climb. They descended the north side of the mountain, and their data cards were never submitted.

Another point worth discussing is that some less-experienced mountaineers who were only on Denali for the purpose of climbing the West Buttress had taken only two weeks off work, which created an underlying internal pressure to complete the climb in the time allotted. Some of those who had bad weather delays at the higher elevations chose to descend early, as they did not allow themselves enough time to reach the summit.

In contrast, those who were planning to remain at base camp for the entire climbing season had the luxury of descending and re-starting a climb when personal health and weather were optimal. These subjects would have had time to acclimatize before participating in the study, which may have affected their AMS symptom scores.

Another weakness in the study involved situations where adequate radio communication was lacking and the back-up card was not accessible due to safety or other concerns. In this situation, volunteers were asked to at least *consider* their perceived exertion level and make a mental note of AMS symptoms. At a more appropriate time e.g. a different rest point or even at camp later that day), the participants were asked to do their best to complete the AMS symptom score questionnaire and report their RPE for the collection point that day. While this retrospective reporting may have been slightly inaccurate, all data was accepted. A “good guess” may have been more helpful than absolutely no data at all.

Other limitations of the study included a small sample size (especially for females), and an even smaller population who actually made it to all nine data collection points, subjects’ individual responses to hardship and previous climbing experience which may have revealed differences in ratings of perceived exertion between individuals for a given work load, and length of stay at each altitude. On account of the weather conditions and physical abilities of the individual volunteers, each climber ascended the mountain at slightly different rates. Every time a participant stayed at a given altitude longer than the group before them, they were acclimatizing, which would have theoretically made the next ascent easier than if they had gone up according to the same schedule as the previous group.

Ratings of perceived exertion scores may have been affected by environmental factors as opposed to those tested in laboratory settings. Also, males and females have been shown to report slightly different scores in outdoor situations (Hassman, 1996),

which proved to be a point of significance in this study. Differences in motivation might have been highly variable among individuals, which could also have affected RPE scores.

Another possible source of error involved the amount of sleep deprivation between individuals, which may have altered their overall perception of exertion compared with others who have had more or less sleep. To the best of the author's knowledge, Borg's RPE scale has not been used in mountaineering. Physical exertion may be of slightly different nature in mountaineering than in the situations in which RPE is normally utilized (i.e. cycling and running), although significant alterations in the reliability or validity of the scale were not anticipated.

Cognitive function is known to decrease with increasing altitude (Kramer, Coyne, & Strayer, 1993). It may have been too difficult for the subjects to consider the demands of this study while thinking about matters more immediately pertinent to safe climbing and proper technique. Therefore, it is emphasized again that the study had obvious limitations, but that the climbers were not expected to "give up" their ascent or change any aspect of it for the sake of the research.

Assumptions

Subjects did not have any conditions that would pre-dispose them to developing AMS, and were in appropriate physical condition for climbing Denali. The subjects' use of the RPE scale and AMS symptom questionnaire were the same each time.

Significance of the Study

Recent research has shown that people who are educated about AMS and its prevention are less likely to develop the sickness while at altitude (Vardy, 2005). There

have been studies regarding the intensity of physical exertion with respect to the amount of time spent at a new altitude and the acquisition of AMS. There is a relationship among these variables such that intense exertion too soon after reaching a higher elevation will likely be followed by increased symptoms of AMS (Roach, 2000).

Up to this point, there has not been a study which examines the correlation between rating of perceived physical exertion at high altitude and symptoms of acute mountain sickness. A high positive correlation between the two suggests a potential for preventing AMS by means of monitoring physical exertion using Borg's RPE scale.

Informed visitors to high elevations are able to use the Lake Louise Symptom Scoring Questionnaire to assess level of AMS. While it is necessary to be able to identify AMS symptoms properly, it is also very practical to be able to actually prevent AMS by monitoring the factors associated with its onset. With correct use of the RPE scale, individuals are able to assess their level of physical exertion as a convenient method of gauging their ascent to help avoid developing AMS.

This study confirms the positive correlation between AMS and RPE. These findings contribute to the expanding body of knowledge regarding physical self-awareness during proper ascent at high altitudes. With this information, mountaineers possess a tool that may help them to enjoy their experience without being hindered by exertion-related altitude illness.

Project Completion

Data from this study has been compiled into a journal article for *Medicine and Science in Sports and Exercise* according to the Official Guidelines for Manuscript Submission and Authorship (see Appendices A & B).

Summary

Due to the increasing popularity of mountain recreation, knowledge of altitude-related illnesses and their prevention is essential. Since physical exertion has been shown to affect the onset of acute mountain sickness, it was practical to discover possible methods for preventing AMS by altering exertion. Because RPE is a reliable and valid indicator of exertion, and AMS and RPE are positively correlated, it follows that AMS might be able to be prevented by altering individual RPE.

Review of Literature

This section provides an overview of the nature of acute mountain sickness and the factors associated with its onset and treatment. Also included is a review of the use of ratings of perceived exertion to monitor exercise intensity.

Acute Mountain Sickness

AMS affects about 25% of visitors to moderate elevations of 1,500 to 2,500 meters (Honigman et al., 1993). In 1982, the incidence of acute mountain sickness on Mount McKinley was about 35%. Since then, this number has dropped to approximately 25% of individuals attempting the climb. However, 50% of all climbers will develop a headache higher on the mountain (Hackett, 1988). A thorough understanding of the

symptoms associated with altitude illness is necessary for proper assessment and treatment of affected individuals.

The exact etiology of AMS is not known. Studies have offered theoretical pathophysiological explanations for its onset, and have provided the scientific community with valuable information regarding the symptoms related to AMS. Because of its elusiveness, research has focused on defining the history and symptoms associated with acute mountain sickness, identifying potential methods of diagnosing the illness, and testing specific treatment options (Evans et al., 1976; Garrido, E., Segura, R., Capdevila, A., Rodriguez, F., Javierre, C., & Ventura, J., 1995; Hackett, 1980; Hackett & Rennie, 1979; Maggiorini, Bartsch, & Oelz, 1997; Honigman, Theis, & Koziol-McLain, 1993; Murdock, 1995, Sampson et al., 1983; & Sutton, 1983).

Defining AMS. Acute mountain sickness is a common reaction to exposure to hypoxic conditions, its symptoms usually appearing within 8 to 48 hours after ascent to high altitude (Hackett & Rennie, 1983). In 1992 AMS was defined by the Lake Louise Consensus Group as the presence of headache in an un-acclimatized person who has recently arrived at an altitude above 2,500m plus the presence of one or more of the following: gastrointestinal symptoms (anorexia, nausea, or vomiting), insomnia, dizziness, and lassitude or fatigue.

Signs of “serious AMS” in addition to those that accompany mild AMS are vomiting, headache which is not alleviated with the use of acetaminophen or acetazolamide, dyspnea, and ataxia (Coote, 1995; Hackett, 1980; & Houston, 1992). The same authors reported that a very dangerous sign of serious AMS is *excessive* lassitude,

whereby the individual has generally become apathetic about communicating with others and shows absolutely no concern for their own personal safety. Patients with severe AMS must be very carefully monitored and receive appropriate treatment, because more often than not the sickness will progress to HAPE or HACE.

People who live below 1,000 meters and travel to moderate altitudes (1,800m – 2,900m) will be 3.5 times more likely to experience AMS than those living above this elevation. Additionally, the risk of becoming ill may increase 2.8 times for those who have had AMS in the past (Honigman et al., 1993). Between the ages of 10 and 45 years, AMS occurs most frequently in the youngest individuals, its incidence slowly declining with age. However, after the age of 60 years the risk for acquiring acute mountain sickness may decrease by half (Honigman et al., 1993).

Identifying AMS. Symptoms of hypoxemia are a normal element of acclimatizing to higher altitudes. These include such inconveniences as mild headache, shortness of breath, and elevated heart rate. Other normal responses to increased elevations are fainting, loss of appetite for proteins and fats (usually at 3,000m - 5,500m), and a temporary complete loss of appetite at higher altitudes. All of these symptoms should be gone within 1 to 2 days after arrival at the new altitude (Coote, 1995 & Hackett, 1993). It is only when these mild discomforts become worse, or when they do not diminish within two days that there is a cause for concern.

When assessing someone who may have AMS, it is important to examine not only the clinical manifestations of AMS, but also the affected person's subjective complaints. It is necessary to rule out other sicknesses that are characterized by symptoms similar to

those of AMS. An individual's rate of ascent to higher altitude may contribute significantly to the onset of AMS. Other variables that affect the development of AMS are current altitude and physical exertion; it is possible that cold temperatures, dehydration, age, and previous history of the illness may also facilitate the acquisition of AMS (Hackett, 1980). People who have become sick complain primarily of frontal headache, which is often worse the morning following arrival at altitude. Again, if the headache continues for more than two days, this could be a sign of severe AMS, and descent is likely indicated.

The symptoms associated with AMS can easily be confused with those of other conditions at altitude. In order to identify AMS, these other possibilities must be ruled out. They include dehydration, hypothermia, exhaustion, alcohol hangover, carbon monoxide poisoning, and respiratory or cerebral infectious diseases (Hackett, 1993). If these conditions are actually the cause for the illness, as opposed to AMS, then the symptoms would show no improvement with descent. This lack of symptomatic relief would help differentiate acute mountain sickness from other illnesses.

Absolute diagnosis of AMS is challenging. A systematic questionnaire can be used to confirm the onset and gauge the severity of acute mountain sickness. These tools make use of patient complaints and may incorporate findings from clinical examination. The Environmental Symptoms Questionnaire (ESQ-III) (Hackett & Rennie, 1983; & Sampson, Cymerman, Burse, Maher, & Rock, 1983) has been widely used to assist in the differential diagnoses of various altitude illnesses, including AMS. Despite its acceptance among researchers (Sampson & Kobrick, 1980; & Wright, Jones, Fletcher,

Mackintosh, & Bradwell, 1985), the lengthy format of this questionnaire, its dependence on a clinical exam, and its incorporation of HAPE and HACE variables makes it a moderately inconvenient method of strictly assessing AMS (Hackett & Rennie, 1983). The recently-developed Lake Louise Questionnaire (see Appendix C), on the other hand, provides a reliable, valid alternative to the ESQ-III (Bartsch, Muller, Hofstetter, Maggiorini, Vock, & Oelz, 1992). The self-reported LLSSQ is comparable to previously-utilized AMS symptom scoring procedures. This scoring system is the result of extensive collaboration on the behalf of respected high-altitude scientists, and was created for the purpose of practical self-administration. When comparing traditional scoring methods, clinical evaluation, and the Lake Louise score, Bartsch et al. (1992) found that "...the sensitivity and specificity in identifying subjects who report reduced activity or feel sick at high altitude is comparable between the Lake Louise score, the clinical score, and the AMS-C score of the ESQ."

It is important to understand that anyone can be affected by this illness, regardless of level of physical fitness or gender (Honigman, et al., 1995). Even if somebody is acclimated at a given altitude, they are still susceptible to developing the illness upon ascending to a higher elevation. Hackett and Rennie (1983) observed that mild and moderate AMS was tolerated better by people in good physical condition, as compared to their unfit counterparts. "Persons struggling into camp each day because of their poor conditioning will often find even mild AMS unbearable, and will descend, whereas more fit individuals might "tough it out" (p. 137). Being physically fit will enable the person to enjoy the hard work, but it will not reduce their chance of getting AMS.

Milledge, Beeley, Broome, Luff, Pelling, and Smith (1991) supported the practice of a slow ascent to prevent (or lessen) the symptoms of altitude illness, specifically confusion. They noted that a change in altitude first affected the centers of the brain that controlled judgment, perception, and reflexes. It was shown that climbers at 18,500 feet had more difficulty learning and retaining the ability to perform perceptual and memory tasks. They also performed most tasks more slowly than the control group, which was performing the same tasks at sea level. However, the researchers reported that because the climbers had ascended slowly, these deficits occurred with only mild symptoms of altitude illness (Houston et al., 1992). These results are a noteworthy adjunct to the current study relating physical exertion and rate of ascent to AMS symptoms in which confusion and difficulty with task completion may have occurred.

Management and prophylaxis. “Since AMS is easily preventable and is simple to treat early on, the ideal management of AMS is based on early recognition, proper assessment, and intervention before progression to serious illness.” (Hackett & Rennie, 1983, p. 136) If AMS is not treated there is great risk for advancement to its potentially fatal forms of high altitude cerebral edema or high altitude pulmonary edema (Hackett & Rennie, 1983; Sutton, 1983).

The quickest, most effective way to alleviate the uncomfortable symptoms associated with AMS is to descend. It is generally recommended that the person retreat to just below the altitude at which they began to feel ill. Conservative guidelines suggest a standard descent of about 1,800 meters, and for that person to stay at the lower altitude until all symptoms have subsided (Ward, Milledge, & West, 1995). However, Hackett et

al. (1980) reported that if a descent of 300m is initiated when symptoms first become apparent, complete recovery from acute mountain sickness is likely.

If an AMS sufferer continues to ascend, the severity of the condition will increase significantly. If the individual remains at the current elevation, AMS will most likely resolve itself, but it can take almost twice as long than if they would have descended appropriately.

When AMS is cured, regardless of its severity, an individual may attempt a rational ascent as long as they remember their body's reaction to the altitude and adjust accordingly. The key for treating AMS is to prevent it in the first place. Slow, graded ascent is essential, and the use of acetazolamide has been shown to not only provide relief from AMS, but sometimes to prevent it all together (Evans, et al., 1976).

Saito et al. (1999) reported on the cerebral effects of acute exposure to reduced-oxygen environments in trekkers at high altitude:

Given that abrupt physical overwork induces headache and mountain sickness in unacclimatized subjects, the temporary acute cerebral hypoxia observed during exercise in the present study might be a fundamental cause of acute mountain sickness. A gradual increase in workload, which induces an adequate cerebral hyperemic response and prevents tentative cerebral hypoxia, may be an effective prophylaxis against high-altitude disorders. This concept is widely accepted among high altitude climbers as a fundamental rule for safe climbing (p. 280).

Since physical exertion has an effect on the onset of AMS, the use of rating of perceived exertion to control exercise intensity may be of value in helping an individual assess their current vulnerability to AMS, potentially aiding in its prevention. This self

monitoring of RPE may contribute to a simple alternative to expensive and often unavailable clinical tests for AMS.

Rating of Perceived Exertion

Borg's RPE scale. Perceived exertion is a subjective perception of the overall effects of exercise. This rating...“integrates various information, including the many signals elicited from the peripheral working muscles and joints, the central cardiovascular and respiratory functions, and the central nervous system. All of these signals, perceptions, and experiences are integrated into a configuration or ‘Gestalt’ of perceived exertion” (Borg, 1982, p. 377) so that a specific perception, such as muscle fatigue or shortness of breath, does not have a proportionally greater influence on overall rating of exertion.

Ratings of perceived exertion scales have been used to quantify subjective perceptions of physical effort during exercise, and to relate these symptoms to objective findings (Carton & Rhodes, 1985). The most popular, as well as the most extensively tested and confirmed for reliability and validity, is the RPE scale developed by Borg in 1970 (see Appendices D & E). A high linear relationship has been established between heart rate and Borg's RPE scale. The values from 6 to 20 indicated on this scale correspond to approximately one-tenth of exercise heart rate values, such that a particular value on the scale, e.g., 15, would match approximately a heart rate of 150 beats per minute (Borg, 1982). Verbal expressions of effort such as “very light” and “very, very hard” correspond to various levels of intensity. Borg later created a 10-point measure of RPE, which has also been used in clinical testing. However, Borg (1982) still

recommends that the original 15-point scale be used over the 10-point category-ratio scale for most applied studies of perceived exertion.

Borg's original RPE scale has been proven to be reliable and valid (Borg, 1970, 1974; Dunbar, Robertson, Baun, Blandin, Metz, Burdett, & Goss; Eston & Williams, 1988; Skinner, Hustler, Bergsteinova, & Buskirk, 1973), independent of exercise intensity (Stamford, 1976), and variations in protocol (Morgan & Borg, 1980). Further supporting the research that Borg's scale is both valid and reliable is a study done by Skinner, Hustler, Bergsteinova, and Buskirk in 1973, which demonstrated that small variations in intensity could be detected by the subjects, even when presented in random order.

RPE has a close positive correlation ($r = 0.8$ to 0.9) with physical fatigue factors such as heart rate and maximal oxygen consumption (Pandolf, 1982). Therefore, RPE is a dependable indicator of work intensity, independent of these clinical measurements. Morgan and Borg (1980) reported that perceptions alone predicted maximal oxygen consumption with less error than by heart rate alone. Noble, Maresh, and Ritchey confirmed these findings in 1981. Similarly, Eston et al. (1987) indicated that:

...the rating of perceived exertion was at least as good a predictor of exercise intensity as heart rate in both the graded exercise test and effort production test...RPE may be used to predict relative metabolic demand, especially at higher workloads and could be a useful medium for controlling intensity of effort during vigorous exercise...(p. 154)

Perception of effort during work has been attributed to both physiological and non-physiological factors. The body's response to exercise and an individual's

subsequent perception of exertion due to physiological stress are affected by both local and central primary sensory cues. Various contributions from local factors (e.g. lactate accumulation and muscle or joint strain) and central factors (e.g. sensations from cardiopulmonary system, such as heart rate, oxygen uptake, and respiratory rate), in addition to psychometric determinants, account for RPE (Borg, 1982; Morgan, & Pollock, 1977; Pandolf, 1978). During low levels of activity, local factors have a greater influence on RPE than central factors, whereas during more intense exercise, central factors contribute more significantly to ratings of perceived exertion (Borg, 1982; Cafarelli, 1982; & Robertson, 1982).

In 1973, Morgan found that only 66% of variance in RPE was due to physiological factors. Psychometric and personality variables, such as motivation, also affect one's level of perceived exertion. In 1973 Morgan found that extroverts had a higher pain tolerance than introverts, and their reported RPE scores were significantly different at a given work intensity. With respect to environment, Jackson, Dishman, LaCroix, Patton, and Weinberg (1981) found that physiological and psychological components of exercise performance contribute differently to RPE in a field setting compared to a laboratory environment.

Other external cues have been studied for their relative contribution to overall RPE. Martin (1981) examined sleep deprivation and found that after 30 hours without sleep, there was no difference in reported RPE during self-determined work intensity on a treadmill. Koller, Starter, Palmer, Doctor, and Mandell (1966) disagreed, stating that RPE may be affected in this state due to the anxiety, depression, confusion, and fatigue

associated with sleep loss. Additionally, in 1973 Morgan suggested that neurotics and depressives may lack the ability to accurately rate perceived exertion, but concluded that 'normal' subjects are capable of consistently identifying differences in workload (Morgan, 1973).

Differences in rating behavior have been reported between males and females (Frazier & Fatis, 1980), and between exercise performed in the laboratory as compared to exercise performed in the field (Hassman, 1996). In this evaluation of gender and exercise environment, the female subjects reported significantly lower RPEs than the male subjects at comparable heart rates during an outdoor run test, while only minor differences in RPE were reported during a laboratory cycle test. The factor(s) that cause this discrepancy between the genders during outdoor activities is not fully understood. Additionally, high altitude may affect the dominance of certain physiological cues when reporting RPE (Young, Pandolf, & Cymerman, 1981). At lower elevations, local factors have a greater effect on perceived exertion, whereas at higher elevations RPE is affected more by central factors (Forster, 1984).

Summary

Acute Mountain Sickness can be a threat to anyone ascending to higher altitudes. When climbers increase sleeping altitude too quickly, or if they exceed their bodies' physical capabilities at high elevations, severe headache and other crippling symptoms may develop. The incidence of AMS is not disputed, therefore its prevention, if possible, would be of great interest to mountaineers. There are a myriad of variables that contribute to the development of acute illness. Generating more awareness of one of

these significant factors, physical exertion, may help to reduce the onset and/or severity of altitude sickness. A practical, inexpensive, easily administered assessment of physical exertion and corresponding AMS symptom severity may prove useful to climbers in the field.

Mild physical activity on days of “rest” during the expedition will likely improve acclimatization. On the other hand, intense physical activity, as is characteristic of ascent days, may contribute to the onset of acute mountain sickness (Hackett, 2001; Roach, Maes, Sandoval, Roberts, Icenogle, Hinghofer-Szalkay, et al., 2000). Borg’s Rating of Perceived Exertion scale provides an objective tool for the measurement of the overall intensity of physical activity. Its values correlate highly with heart rate, which elevates as oxygen demand increases with greater workloads.

From one perspective, the incidence of AMS seems to be declining due to increased awareness of potential causes and knowledge of its clinical manifestations. This is probably true among the more experienced climbers. However, with the ever-increasing popularity and accessibility of high-risk sporting adventures, there are more novices than ever attempting feats that are quite challenging for their relatively unprepared bodies and minds. In these cases, the less-informed individuals are stricken with acute mountain sickness quite readily. For this reason, research of this nature is needed.

Procedures

Subjects

Climbers during the May through July 2001 climbing season on Mount McKinley's West Buttress route were selected for participation in the study. Because DNPP is a governmental institution, confidential personal information is not disclosed. Therefore, complete lists of registered climbers were not able to be obtained from the Park.

Once permits were obtained (see Appendices F, G, & H) and specific dates of the study established, the researcher sent a letter to each of the 7 authorized Denali guiding companies (see Appendices I & J). The purpose was to inform them of the study taking place on the mountain that year and to ask for their cooperation if their clients chose to participate in the research.

Individuals flying with K2 Aviation, the air taxi service that transported climbers from Talkeetna to Denali base camp, or who learned of the study while at base camp, had the opportunity to participate. In order to qualify for participation, climbers must have intended to complete the West Buttress Route, and must have been willing to respond to two questionnaires administered via two-way radio at nine specific elevations throughout their ascent. In the event of radio failure, they must have been capable of filling out a back-up response card with the appropriate symptom scores, as instructed by the researcher.

Subjects were physically healthy, with a strong background in all aspects of mountaineering and self-reliance demanded of a climber attempting to summit Denali. A

brief medical questionnaire was obtained from the volunteers prior to leaving base camp. This information on personal medication, health conditions, and previous altitude experience could contribute to the discussion of individual variance with respect to incidence and severity of AMS. Subjects who had taken acetazolamide, a drug proven to be effective in the prevention and treatment of AMS (Chow, Browne, Heileson, Wallace, Anholm, & Green, 2006), were not excluded from the study.

Methods

At nine data collection points throughout the West Buttress climb, the incidence and severity of acute mountain sickness for each subject was assessed using the self-administered Lake Louise Symptom Scoring Questionnaire (LLSSQ) (Roach, Bartsch, Hackett, & Oelz, 1992). Subjects also reported their rating of perceived exertion as rated by Borg's original 15-point RPE scale (Borg, 1973, 1974, & 1982).

Pre-Climb. A complete proposal and application for a research permit was submitted to DNPP. After obtaining the permit in the spring of 2001, the superintendent of the Park, local rangers, and Denali guiding companies were informed of the upcoming study. San Jose State University HS-IRB approved the proposed study.

All potential volunteers were given a packet of information which included a cover letter (see Appendix K), informed consent form with researcher contact information (see Appendix L), pre-trip medical questionnaire (see Appendix M), and research design and instructions sheet (see Appendix N). The packets were handed out to climbers as they checked in for their flight with K2 Aviation. On arrival at the 2,200m base camp, the climbers were able to identify the researcher's tent so that they could ask

questions and volunteer for the study. At base camp additional packets were handed out to interested climbers who had not yet learned of the study. The researcher helped prospective volunteers to become familiar with the forms and tools to be used throughout the expedition.

The researcher enlisted volunteers for the first three weeks after her arrival at base camp. Because the round-trip time to climb the West Buttress can vary from two to three weeks during “normal” weather patterns, subjects were only recruited during the initial three weeks of the seven-week study to allow ample time for completion of the climb. The remaining four weeks were spent collecting data from returning climbers.

All personal and medical information was held in the strictest confidentiality, and was not shared with anyone outside of the research party. In addition, upon volunteering for the study, each person was given an identification number by which they were referred for all data analyses and reports.

The Climb. The study was designed around a typical ascent profile as suggested by Denali guiding companies. The data collection points were: 2,200m (Base Camp); 2,400m (Ski Hill); 2,900m (Upper Kahiltna); 4,000m (just below Windy Corner); 4,300m (The Basin); 4,900m (Ridge Camp); 5,200 (High Camp); 5,500m; and 6,100m (Summit).

While approaching the data collection point and still physically exerting themselves, subjects assessed their RPE. AMS symptoms were then evaluated.

Scores from both questionnaires were relayed to the researcher stationed at base camp, either by means of two-way citizen band (CB) radios at the data point, or on a backup data card (see Appendix O) which was turned in upon completion of their climb.

When recording the data, current position as indicated by their altimeter, and time of day were noted. The researcher recorded the time passed since the last communication in order to calculate the approximate rate of ascent.

In the event of radio failure subjects documented their AMS and RPE scores on the backup data card made specifically for each elevation. This prefabricated instrument enabled climbers to simply circle the value corresponding to their reported scores using a mini pencil provided by the researcher. Climbers carried lightweight, bound set of 10 cards – one for each data collection point.

Due to the nature of climbing a mountain such as Denali, the backup data cards may have been difficult to access at the appropriate times due to safety or weather concerns. If the subject was not able to communicate via CB radio and did not have access to the card at the given altitude, they were asked to think about both their perceived exertion and their AMS symptoms. Once in a more appropriate position they were asked to transfer the information to the data card.

Instrumentation

Technology. The researcher was equipped with a base station CB radio, as well as a hand-held 5-watt unit for communication with the climbers. Solar panels were used to generate power for the radios. In the absence of sunlight for a significant amount of time, lawnmower batteries were used as a back-up power source. The researcher did not rely on Park resources or base camp rangers for communications or other logistical support.

Each climber carried a Citizen Band radio (5 watt portable unit), appropriate for communicating across long distances and in harsh weather conditions. In addition, the participants possessed an altimeter by which to measure current elevation.

RPE. Rating of perceived exertion was reported according to Borg's 15-point scale. The participants carried with them a copy of the scale, along with full instructions for its use (see Appendices D & E). Key phrases were highlighted, so that the climbers could quickly review the instructions if necessary. This was intended to increase the likelihood that the RPE scale was used properly.

AMS. The Lake LLSSQ was used to classify acute altitude illness throughout the study. This method was deemed appropriate due to its simplicity and ease of administration. AMS symptoms were assigned a score, based on severity. A score of grade 0-3 was assigned to five separate groups of symptoms, based on a description of their severity. They were headache, gastrointestinal symptoms, fatigue and/or weakness, dizziness/lightheadedness, and difficulty sleeping. AMS was diagnosed if the subject had a total numeric score of 4 or more. In addition, if the subjects had such symptoms due to an obvious illness other than AMS, an AMS symptom score was not assigned to that symptom. For example, subjects with gastroenteritis would have symptoms of nausea, vomiting, and headache with fever and diarrhea, and would not be categorized as having acute mountain sickness (Hackett & Rennie, 1976). Because this design was not inconvenient or excessive in length, and there was no invasive clinical examination component to determining the presence of AMS, compliance with the study was high.

Research Design

The following itinerary was created with the help of certain guiding companies' proposed ascent plans. The actual day a team reached a specific data-collection point was arbitrary. Approximate days were given, but the actual landmark (elevation) was most significant.

Days 1 and 2 – Climbers traveled from Talkeetna (sea level) to Base Camp (2,200m). The climbers organized their gear and were flown into the Kahiltna Glacier. As previously stated, any climbers flying with K2 Aviation were given a complete “Altitude Sickness Study” informational packet as prepared by the researcher.

Base camp was established at the Kahiltna glacier. To avoid altitude illness, only light physical activity was to be performed on this and the second day. Climbers typically spent these days reviewing glacier travel and crevasse rescue, sled rigging, rope management, and camp site procedures. This day was useful for subject familiarization with the format for reporting the data to the base camp researcher. Climbers interested in volunteering were verbally instructed on the use of the RPE scale and LLSS, familiarized with the pocket cards, and given the opportunity to ask questions regarding what was expected of their participation in the research. Activity at base camp sufficed for the first data collection point.

Day 3 – Carried supplies to camp 1. This was a moderate carry of about 9 miles round-trip, returning to base camp at the end of the day. As of this point in the trip, they were beginning to practice the “climb high, sleep low” technique, for better acclimatization (Hackett, 1993). This ascent to the base of Ski Hill (2,400m) marked the

second data collection point. If any problems were encountered, they were addressed once the team was back at base camp.

Day 4 – Moved remaining supplies and established camp 1. Data was not collected during this second arrival at 2,400m. This was an acclimatization day.

Day 5 – Hauled loads up to the site of camp 2, near Kahiltna Pass. Depending on weather, snow conditions, and team strength, several options existed for camp sites between 2,700m and 3,500m. This was a moderately difficult carry over a round-trip of 7-9 miles, with 600 to 900m of elevation gain. This was data collection day #3; at the upper Kahiltna (2,900m), the onset of mild AMS in some climbers was expected.

Day 6 – Moved everything to camp 2. As with days 3 and 4, this was the second time climbers reached a particular elevation point, and data was not collected. AMS and RPE scores were assessed during the initial exposure to the new altitude, and not on subsequent exposures.

Day 7 – Hauled loads to just below Windy Corner (4,000m). There was steep snow climbing up Motorcycle Hill during this four mile round trip. Climbers were expected to have increased incidences of altitude sickness on this data collection day #4.

Day 8 – Moved camp to either 3,800m or all the way to the Basin at 4,300m. This was strenuous, and actual elevation attained varied among groups depending on weather and physical ability. Data collection #5 took place at the Basin.

Day 9 - 10 – Took it easy. Climbers either moved camp from 3,800m to 4,300m or descended to the Windy Corner Cache to bring everything up to 4,300m. There may have actually been a discrepancy in data collection points here, as some climbers may

have hiked all the way to 4,300m on the first day, going back for supplies the next day, while others may have stopped at 3,810m and continued to 4,300m the second day.

Day 10 – Rest day. At 4,300m acclimatization was important. The climbers went down to Windy Corner to retrieve any remaining food. They slept at this altitude of 4,300m for approximately 3 nights, but were active during the day to promote proper acclimatization.

Day 11 – Climbed up the Headwall to 4,900m. If the climber was capable, they were to continue on to 5,200m. They were to gather supplies and return to 4,300m. Climbing up the Headwall with a heavy pack was considered one of the most strenuous days of the trip. It was steep, the load debilitating, and the air thin. Data collection #6 was taken at Ridge Camp.

Day 12 – Moved camp to either 4,900m or 5,200m. Once again this decision was dependent on weather and team strength. Data collection #7 was taken at High Camp.

Day 13 – Returned to 16,100' to gather supplies, or move camp to 5,200m. No Data was collected.

Day 14 – Summit day. This was an eight to twelve hour round trip climb. Symptoms of hypoxia could potentially be severe, and AMS was likely present. The data collection points (#8 and #9) included Denali Pass (5,500m) and the Summit Ridge (6,100m). This was the final data collection day.

Descent – This took one to two days. Climbers returned to base camp at 2,200m. Because most participants ended up using the backup data collection cards at the majority of the elevation points, they submitted their raw scores to the researcher at this time.

They were thanked for their participation and given a logo T-shirt for their efforts. They were also given follow up information if they were interested in knowing the results of the study.

Day 18-22 – extra. These days were built in at the end of the trip to account for any bad weather days and/or a second summit attempt. For example, if flying conditions prevented them from traveling to base camp from Talkeetna, or if a storm hit at the 4,300m camp, they would still have enough time for a proper acclimatization and successful summit.

Statistical Analysis

Pearson-product moment correlations were used to correlate AMS and RPE scores with altitude and rate of ascent. RPE, AMS score, and ROA at various elevations were analyzed using three one-way analyses of variance (ANOVA). Two one-way ANOVAs were used to analyze the gender effect on AMS and RPE at the nine elevations. The level of statistical significance was set at $P < .05$.

Audience

The results of this data collection were discussed in a final written thesis. This will be available to the general public. Professional publication is also anticipated.

Summary

Climbers during the summer 2001 season on Denali volunteered for the Altitude Sickness Study. They responded to two questionnaires regarding AMS symptoms and RPE while moving through each of nine pre-determined elevations during their ascent. The researcher was stationed at the 2,200m base camp recruiting volunteers and

recording data. The participants were given a T-shirt following their arrival back at base camp, regardless of their final elevation attained or total contribution to the study. The results were calculated and discussed in a formal written thesis and made available to the general public.

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SUBMISSION REQUIREMENTS

Manuscripts that do not comply with the following requirements and directives for process, style, and format will not enter the peer-review process.

5. Manuscripts shall be submitted electronically via Editorial Manager® (www.editorialmanager.com/msse). Detailed information regarding registration and use of Editorial Manager® is found on the site. *Hard-copy submissions will not be accepted by the Editorial Office and will be discarded.*

6. Authors submitting manuscripts for review shall also submit:

- a. Completed mandatory submission form
- b. Copyright transfer/dual-submission statement signed by all authors
- c. Manuscript submission fee (Non-ACSM member corresponding authors only)

Letter of permission to reprint figures or tables (if applicable)

MANUSCRIPT STYLE POLICIES

7. The manuscript file must be in a document format, *not* PDF format. The manuscript shall be formatted so that it is set in Times Roman font with 12-point font size, has margins of 1 inch (all sides), and is double-spaced throughout. Typical manuscript length is approximately 20 pages including references, but excluding tables and figures. Do not put figures and tables in the manuscript file. Submit all figure and table files separately from the manuscript text file. Do not use Microsoft Word for figure formatting. Figures shall be submitted in .tiff or .eps format.

8. Paragraphs should be numbered; for example, “***Paragraph Number 1*** The subjects of this study...” Paragraph numbers serve as an effective method for relaying reviewer comments back to the author. Begin paragraph numbering with the first paragraph in the Introduction and end before the References section. Do not use an automatic paragraph numbering option, as titles, subtitles, abstracts, etc., should not be numbered.

9. Revised Manuscripts

Authors submitting revised manuscripts shall adhere to the above requirements and submit through Editorial Manager® (www.editorialmanager.com/msse).

When returning a revised manuscript, author point-by-point responses to reviewer comments must be a separate document.

10. Blind Reviews

All reviews are “open,” with the author identities known to the reviewers.

HUMAN AND ANIMAL EXPERIMENTATION POLICY STATEMENTS

Failure to comply with the guidelines that follow and to guarantee such conformance by a statement in the manuscript will result in rejection of the manuscript.

11. Studies and case reports involving the use of human subjects shall conform to the policy statement regarding the use of human subjects and written informed consent as published by *Medicine & Science in Sports & Exercise*[®]. All studies involving animal experimentation shall be conducted in conformance with the policy statement of the American College of Sports Medicine on research with experimental animals as published by *Medicine & Science in Sports & Exercise*[®].

12. Policy Statement Regarding the Use of Human Subjects and Informed Consent

By law, any experimental subject or clinical patient who is exposed to possible physical, psychological, or social injury must give written informed consent prior to participating in a proposed project. Informed consent can be defined as the knowing consent of an individual or his legally authorized representative so situated as to be able to exercise free power of choice without undue inducement or any element of force, fraud, deceit, duress, or other form of constraint or coercion.

The Editorial Board of *Medicine & Science in Sports & Exercise*[®] requires that all appropriate steps be taken in obtaining the written informed consent of any and all human subjects employed by investigators submitting manuscripts for review and possible

publication. In most cases, written informed consent should be obtained by having the subject read a document (an Informed Consent Form) presenting all information pertinent to the investigation or project and affixing a signature indicating that the document has been read and consent given to participation under the conditions described therein. The document should be written so that it is easily understood by the subjects and provided in a language in which the subjects are fluent.

Investigators are requested to consider the following items for inclusion in an Informed Consent Form as appropriate to the particular project:

- a. A general statement of the background of the project and the project objectives.
- b. A fair explanation of the procedures to be followed and their purposes, identification of any procedures that are experimental, and description of any and all risks attendant to the procedures.
- c. A description of any benefits to be reasonably expected and, in the case of treatment, disclosure of any appropriate alternative procedures that might be advantageous to the subject.
- d. An offer to answer any queries of the subject concerning procedures or other aspects of the project.
- e. An instruction that the subject is free to withdraw consent and to discontinue participation in the project or activity at any time without prejudice to the subject.

- f. An instruction that, in the case of questionnaires and interviews, the subject is free to deny answer to specific items or questions.
- g. An instruction that, if services or treatment are involved in the setting or context of the project, they will be neither enhanced nor diminished as a result of the subject's decision to volunteer or not to volunteer participation in the project.
- h. An explanation of the procedures to be taken to ensure the confidentiality of the data and information to be derived from the subject. If subjects are to be identified by name in the manuscript, permission for same should be obtained in the Informed Consent Form or obtained in writing at a later date.

If the subject is to be videotaped or photographed in any manner, this must be disclosed in the Informed Consent Form. The subject must be advised as to whom will have custody of such videotapes or photographs, who will have access to the tapes or photographs, how the tapes or photographs are to be used, and what will be done with them when the study is completed.

The informed consent document shall not contain any exculpatory language or any other waiver of legal rights releasing, or appearing to release, an investigator, project director, or institution from liability. At the bottom of the form, provision shall be made for the signature of the subject (and/or a legally authorized representative) and the date. It is generally advisable to precede this with a statement to the effect that the subject and/or representative have read the statement and understand it. In the case of minors,

one or both parents should sign (as appropriate). For minors of sufficient maturity, signatures should be obtained from the subject and the parent(s).

The Editorial Board endorses the Declaration of Helsinki of the World Medical Association as regards the conduct of clinical research. Physicians are expected to comply with the principles set forth in this declaration when research involves the use of patients. In the case of psychological research, investigators will be expected to comply with the principles established by the American Psychological Association. These principles are presented in the publication, “Ethical Principles in the Conduct of Research with Human Participants” (American Psychological Association, Washington, D.C., 1982). The use of subjects should be approved by an ethics committee prior to the investigation and shall be stated in the Methods section of the submitted manuscript.

It will not be necessary for an author to describe in the manuscript the specific steps that were taken to obtain informed consent, to ensure confidentiality of results, or to protect the privacy rights of participating subjects. It will be satisfactory for the author to indicate that, “Written informed consent was obtained from the subject,” or by similar wording. It will be understood by the editors that such a statement indicates the author’s guarantee of compliance with the directives presented above.

MANUSCRIPT PREPARATION

12. **Language**

English is the language of the publication. Authors who speak English as a second language are encouraged to seek the assistance of a colleague experienced in writing for English language journals. Authors of accepted manuscripts who cannot meet

the Journal's standard English usage are encouraged to seek assistance from the publisher, Lippincott Williams & Wilkins, who provides rewriting services for a fee.

13. Authors are encouraged to use nonsexist language as defined in the *American Psychologist* 30:682–684, 1975, and to be sensitive to the semantic description of persons with chronic diseases and disabilities, as outlined in an editorial in *Medicine & Science in Sports & Exercise*®, 23(11), 1991. As a general rule, only standardized abbreviations and symbols should be used. If unfamiliar abbreviations are employed, they should be defined when they first appear in the text. Authors should follow *Webster's Third New International Dictionary* for spelling, compounding, and division of words. Trademark names should be capitalized and the spelling verified. Chemical or generic names should precede the trade name or abbreviation of a drug the first time it is used in the text.

14. **Previously Published Material**

Medicine & Science in Sports & Exercise® will accept only original, unpublished illustrations and tables, except in the cases of review articles, symposia, and meta-analyses. Authors of review articles, symposia, and meta-analyses papers who do use previously published material shall obtain prior written permission to reprint from the publisher holding the copyright and be able to provide a quality original to the Editorial Office for publication. It also is customary that written permission from the original authors be requested and received. The statement “used by permission” must appear in the caption of the figure or table with complete reference citation. Permission to reprint, if required, must accompany the manuscript at the time of submission.

15. Order of Manuscript

An original investigation should contain the following items and satisfy the given specifications.

a. Title Page

1. Title of no more than 85 characters, including spaces. Do not use a complete sentence as a title.
2. Full names of the authors—Only those investigators who contributed substantially or who had a primary role in the research represented in the manuscript should be listed as authors. Manuscripts listing more than six (6) authors should provide justification. The Editor-in-Chief reserves the right to request that the author list be reduced.
3. Institutional affiliation of each author clearly identified; linked to each author by use of superscript numbers
4. Corresponding author name, mailing address, telephone, fax, and e-mail information
5. Running title of no more than 45 characters, including spaces

b. Abstract

1. Limit of 275 words, including numbers, abbreviations, and symbols
2. Structure states purpose, methods, results, and conclusion

3. Reference citations are not permitted

c. Key Words

1. Four (4) to six (6) words following the abstract
2. Should not repeat terms or phrases from the title

d. Introduction

1. State clearly the purpose and hypothesis of the study
2. Provide relevant references
3. Do not exhaustively review the subject

e. Methods

1. Present subject information
2. Describe the experimental subjects and their controls
3. Insert “written informed consent” statement or animal-use statement and ethics committee approval statement (required) (see “Human Animal Experimentation Policy Statements”)
4. Identify the methods, apparatus, and procedures employed with sufficient details to allow others to reproduce the results
5. Provide references for established methods and statistical procedures

6. Provide rationale for use and include a description of possible limitations for utilized methods not well known
7. Denote statistical significance when appropriate and include detailed statistical analyses, mathematical derivation, or computer programs in an appendix

f. Results

1. Present findings of the study in the text, tables, or figures
2. Do not include the same data in tables and figures

g. Discussion

1. Emphasize the original and important features of the study and avoid repeating all the data presented within the results section
2. Incorporate the significance of the findings and the relationship(s) and relevance to published observations
3. Provide only those conclusions that are supported by the study

h. Acknowledgments

1. Identify funding sources
2. Identify external reviewers, if any

16. Conflict of Interest

Authors are required to state in the acknowledgments all funding sources, and the names of companies, manufacturers, or outside organizations providing technical or equipment support. In particular, authors should:

- a. Disclose professional relationships with companies or manufacturers who will benefit from the results of the present study
- b. State that the results of the present study do not constitute endorsement of the product by the authors or ACSM

Failure to disclose such information could result in the rejection of the submitted manuscript.

17. References

The format for references is that which has been adopted by the United States National Library of Medicine and employed in *Index Medicus*. For those not included in *Index Medicus*, adhere to the form established by the American National Standard for Bibliographic References. The reference list shall be in alphabetic order, rather than in the order of citation, and numbered. All references shall appear in the text. Examples of the types of references are as follows:

1. Books

- a. American College of Sports Medicine. *Guidelines for Exercise Testing and Prescription*. Philadelphia, PA: Lea and Febiger, 1986, pp. 158–161.

- b. Paffenbarger, R. S., R. T. Hyde, and A. L. Wing. Physical activity and physical fitness as determinants of health and longevity. In: *Exercise, Fitness, and Health*. C. Bouchard, R. J. Shephard, T. Stephens, J. R. Sutton, and B. D. McPherson (Eds.) Champaign, IL: Human Kinetics, 1990, pp. 33–48.
2. **Doctoral Dissertations**—Crandall, Craig. Alterations in human baroreceptor reflex regulation of blood pressure following 15 days of simulated microgravity exposure. *Doctoral Dissertation*. University of North Texas HSC, Dept. of Physiology, Fort Worth, Texas, August 1993.
3. **Government Reports**—U.S. Department of Health and Human Services. *Healthy People 200: National Health and Disease Prevention Objectives* (full report, with commentary). Washington, DC: Department of Health and Human Services, Publication 91:50212, 1991, pp. 91–125.
4. **Journal Articles**—Blair, S. N., N. M. Ellsworth, W. L. Haskell, M. P. Stern, J. W. Farguhar, and P. D. Wood. Comparison of nutrient intake in middle-aged men and women runners and controls. *Med. Sci. Sports Exerc.* 12:310–315, 1981.
5. **Software Manuals**—SAS Institute. SAS/STAT Software: *The PHREG Procedure, Version 6*. Cary, NC: SAS Institute Inc., 1991, 1054 pp.
6. **Conference Proceedings**—Conference proceedings can be used only if the publication has an ISBN or ISSN number. This information must accompany the

reference—Matthie J. R., P. O. Withers, M.D. Van Loan, and P. L. Mayclin. Development of a commercial complex bio-impedance spectroscopic (CBIS) system for determining intracellular water (ICW) and extracellular water (ECW) volumes. *In Proceedings of the 8th International Conference on Electrical Bio-impedance*. Kuopio, Finland: University of Kuopio, Finland, ISBN: 952-90-3999-9, pp. 203–205, 1992.

7. **Abstracts**—An abstract can be cited when it is the only source of information.

Note: In-text reference citations shall be baseline in parentheses, not superscripts [e.g., (14,15), not ^{14,15}]. Internet sources, Master of Science theses, personal communications, or other unpublished material are not acceptable as references. There should not be more than 30 references for original investigations. Review articles are limited to 50 references. All book references require page numbers. Examples to follow for corporate authors, chapters, editors, center publication, etc., can be observed in the *British Medical Journal* 1:1334–1336, 1978. Journal abbreviations should follow the abbreviations of Index Medicus published by the Library of Congress. Use of et al.—If fewer than seven (7) authors are listed, all should be mentioned. When seven or more authors are named, list only the first three.

a. Figure Captions

1. Provide a caption for each figure
2. List captions together following references section

TECHNICAL GUIDELINES

18. Terminology and Units of Measurement

To promote consistency and clarity of communication and to avoid ambiguity, it is directed that authors use standard terms generally acceptable to the field of exercise science and sports medicine.

The units of measurement shall be *Système International d'Unités* (SI). Permitted exceptions to SI are heart rate—beats per min; blood pressure—mm Hg; gas pressure—mm Hg. Authors should refer to the *British Medical Journal* 1:1334–1336, 1978) and the *Annals of Internal Medicine* (106:114–129, 1987) for the proper method to express other units or abbreviations. When expressing units, authors must locate the multiplication symbol midway between lines to avoid confusion with periods; for example, mL·min⁻¹·kg⁻¹.

The basic and derived units most commonly used in reporting research in this Journal include the following:

mass—gram (g) or kilogram (kg); force—newton (N); distance—meter (m), kilometer (km); temperature—degree Celsius (°C); energy, heat, work—joule (J) or kilojoule (kJ); power—watt (W); torque—newton-meter (N·m); frequency—hertz (Hz); pressure—pascal (Pa); time—second (s), minute (min), hour (h); volume—liter (L), milliliter (mL); and amount of a particular substance—mole (mol), millimole (mmol). Selected conversion factors: 1 N = 0.102 kg (force); 1 J = 1 N·m = 0.000239 kcal = 0.102 kg·m; 1 kJ = 1000 N·m = 0.239 kcal = 102 kg·m; 1 W = 1 J·s⁻¹ = 6.118 kg·m·min⁻¹.

19. Sample Size

Authors should justify the adequacy of their sample size by providing calculations regarding the power of their statistical tests. While there are different approaches that authors may take in performing these calculations, the text by Cohen (1988) is recommended as an appropriate starting point. (Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*, 2nd Ed. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers, 1988.)

20. Formulas and Equations

Simple in-text formulas and equations should be presented in a single line:

$M = (a + b)/(x + y)$. More complex equations should be set displayed, and, if referenced in text, shall have an equation number:

$$\dot{V}O_{2(t)} = A_1(1 - e^{-(t-\delta_1)/\tau_1}) + A_2(1 - e^{-(t-\delta_2)/\tau_2})$$

All unusual characters must be accompanied by a definition or explanation.

21. Figures

Medicine & Science in Sports & Exercise[®] accepts electronic file artwork only.

Captions are required for all figures and shall appear on a separate manuscript page.

22. Electronic Artwork Guidelines

- a. Do not submit artwork that is embedded in a text file from a word-processing program.

- b. Lettering (symbols, letters, and numbers) should be between 8 and 12 points, with consistent spacing and alignment. Font face may be serif (Times Roman) or sans serif (Arial).
- c. Line width should be $\frac{3}{4}$ point or greater.
- d. Any extra white or black space surrounding the image should be cropped. Ensure that subject-identifying information (i.e., faces, names, or any other identifying features) is cropped or blacked out.
- e. Artwork should be submitted in final size and should be cropped and rotated as it will appear in the final printed piece.
- f. Color images should be scanned in CMYK (cyan, magenta, yellow, black) mode. Do not submit any figures in RGB (red, green, blue) mode. Submit color figures only if color publication is intended. Color publication incurs additional charges (see Manuscript Submission Fees & Page Charges).
- g. Black-and-white line art should be saved at a resolution of at least 1200 dpi (dots per inch). Photographs, CT scans, radiographs, etc. should be saved at a resolution of at least 300 dpi. Combination photo–line art and grayscale images should be saved at 600–900 dpi. Images saved at 72 dpi are not acceptable for printed publications.

- h. Each figure should be saved as a separate file without captions. Submit figures separate from the accompanying text file. Any figure with multiple parts should be sent as one file with each part labeled the way it is to appear in print.
- i. Files should be saved as and submitted in .tiff or .eps format—jpeg, .gif, or files downloaded from the Internet are not acceptable due to low resolution.

Compression programs, such as WinZip, may be used to compress large .tiff or .eps files into a .zip file before uploading it to Editorial Manager®.

23. Tables

- a. Tables must be typed double-spaced and should be designed to fit a one-column width (3¼ inches) or a two column width (7 inches).
- b. Each table shall have a brief caption; explanatory matter should be in footnotes below the table.
- c. The table shall contain means and the units of variation (SD, SE, etc.) and must be free of nonsignificant decimal places.
- d. Abbreviations used in tables must be consistent with those used in the text and figures. Definition symbols should be listed in the order of appearance, determined by reading horizontally across the table and should be identified by standard symbols.

Appendix B. Authorship Form – MSSE Manuscript Submission

<u>Criteria \ Author's Last Name</u>	<u>Schroeder</u>	<u>Cisar</u>	<u>Kahanov</u>
<u>Significant Manuscript Writer</u>	X		
<u>Significant Manuscript Reviewer</u>	X	X	X
<u>Concept and Design</u>	X		
<u>Data Acquisition</u>	X		
<u>Data Analysis and Interpretation</u>	X	X	X
<u>Statistical Expertise</u>	X	X	

Appendix C. Lake Louise Acute Mountain Sickness Self-report Questionnaire

“A diagnosis of AMS is based on a recent gain in altitude, at least several hours at the new altitude, and the presence of headache and at least one of the following symptoms: gastrointestinal upset (anorexia, nausea, or vomiting), fatigue or weakness, dizziness or lightheadedness and difficulty sleeping. A score of three points or greater on the AMS Self-report questionnaire....constitutes AMS.” (Roach et al p. 334, 1993)

1. Headache.	0 No headache
	1 Mild headache
	2 Moderate headache
	3 Severe headache, incapacitating
2. Gastrointestinal symptoms.	0 No gastrointestinal symptoms
	1 Poor appetite or nausea
	2 Moderate nausea or vomiting
	3 Severe nausea & vomiting, incapacitating
3. Fatigue and/or weakness.	0 Not tired or weak
	1 Mild fatigue/ weakness
	2 Moderate fatigue/ weakness
	3 Severe fatigue/ weakness, incapacitating
4. Dizziness/ lightheadedness.	0 Not dizzy
	1 Mild dizziness
	2 Moderate dizziness
	3 Severe dizziness, incapacitating
5. Difficulty sleeping.	0 Slept as well as usual
	1 Did not sleep as well as usual
	2 Woke many times, poor night's sleep
	3 Could not sleep at all

Appendix D. Instructions for the use of Borg's RPE scale

During all climbs, particularly those on which you will be exposed to a higher altitude for the first time, I want you to pay close attention to how hard you feel the work rate is. This feeling should represent your total amount of exertion and fatigue, combining all sensations and feelings of physical stress, effort, and exhaustion. Don't concern yourself with any one factor such as leg pain, shortness of breath, or exercise intensity, but try to concentrate on your *total*, inner feeling of exertion. Don't underestimate or overestimate, just be as accurate as you can.

(Adapted from Borg & Ottoson, 1986)

Appendix E. Borg's Scale for Ratings of Perceived Exertion

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

Appendix F. Scientific Research and Collecting Permit

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Scientific Research and Collecting Permit

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<p align="center">SCIENTIFIC RESEARCH AND COLLECTING PERMIT</p> <p align="center">Grants permission in accordance with the attached general and special conditions</p> <p align="center">United States Department of the Interior National Park Service</p> <p align="center">Denali NP & PRES</p>	<p>Study#: DENA-00638</p> <p>Permit#: DENA-2001-SCI-0002</p> <p>Start Date: MAY-20-2001</p> <p>Expiration Date: JUN-30-2001</p> <p>Coop. Agreement #:</p> <p>Optional Park Code: permit no. 646</p>
<p>Name of principal investigator Name: Stacy Schroeder Phone: 650.949.7782 Email: schroe39@yahoo.com</p>	
<p>Name of institution represented: San Jose State University</p>	
<p>Additional investigator(s):</p>	
<p>Project title: The Relationship Between Acute Mountain Sickness and Rating of Perceived Exertion in Climbers on Mount McKinley</p>	
<p>Purpose of study At altitudes above 8,000 feet, the human body must adapt to the reduced partial pressure of oxygen in the atmosphere. Acute mountain sickness (AMS) may result from subnormal blood oxygen levels, especially when the hypoxic exposure is associated with physical exertion. This illness can affect anyone at any time, and can be fatal if untreated. To promote safe climbing at debilitating altitudes, individuals must be aware of their body's response to physical exertion and acclimatization. This knowledge can help an individual gauge their ascent, potentially avoiding altitude sickness. The purpose of the current study is to identify whether or not there is a relationship between climbers' ratings of perceived exertion (RPE) at a given altitude and severity of acute mountain sickness (if present).</p> <p>Due to the potential seriousness of AMS, it is imperative that climbers have an awareness of its clinical manifestations. There is a need for practical, simple methods of controlling the factors that lead to AMS. It is possible that altering the intensity of work being done by the body may decrease the symptoms of the altitude illness, if not preventing them all together. Invasive clinical measurements of physiological symptoms are not only expensive, but are also often unavailable in the field. Individuals need to be accountable for their body's response to the altitude, and should have a convenient method by which to assess their progress. Knowledge of the RPE and AMS scales may help to reduce the incidence of AMS, thereby promoting the practice of safe and responsible climbing. Novice climbers will particularly benefit from the results from this study, although anyone interested in mountaineering will gain insight about the nature of altitude illness.</p> <p>Denali provides an ideal setting in which to conduct altitude-related research, not only for its relative ease of accessibility, but also for its popularity among mountaineers. With over 1,000 individuals attempting the West Buttress Route annually, the potential subject population is appealing. The high altitude and extreme latitude characteristic of Denali create challenging environmental stressors - an aspect of climbing that should not be eliminated when conducting field-related research. Physiological exertion and severity of acute mountain sickness will be evaluated in the presence of cold, fatigue, malnutrition, and sleep deprivation, unlike many studies conducted in environment chambers. In addition to the immediate educational benefits attained, this altitude sickness research will provide useful information for future studies on Denali.</p>	
<p>Locations authorized The researcher (Study) will remain at the 7,000' base camp of Denali for the duration of the study. Climbers on the West Buttress Route will have the opportunity to participate in this survey-based data collection at various altitudes throughout their climb. Sites will be administering a questionnaire via CB radio to the subjects during the ascent. The approximate elevations are (in feet) 7,000; 7,900; 9,600; 13,000; 14,300; 16,100; 17,200; 18,000; and 20,000.</p>	
<p>Transportation method to research site(s) The researcher will be flying into base camp by means of an air taxi. She will establish camp on the glacier where she will reside for approximately 6 weeks.</p>	

https://science.nature.nps.gov/servlet/Coord_printPermit?id=DENA-2001-SCI-0002

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Scientific Research and Collecting Permit

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Collection of the following specimens or materials, quantities, and any limitations on collecting
N/A

Name of repository for specimens or sample materials if applicable

Specific conditions or restrictions (also see attached conditions)

Flight time related to project (in minutes or hours) should be reported at end of project. Flight times to report are those that weren't on a commercial flight that would have occurred whether researcher was on it or not. Flight time should be estimated separately for time spent over wilderness and non-wilderness.

Recommended by park staff (name and title): _____	Reviewed by Collections Manager: YES _____ NO _____
Approved by park official: _____ Title: _____	Date approved: _____

I Agree To All Conditions And Restrictions Of this Permit As Specified.
(Not valid unless signed and dated by the principal investigator)

Paul S. Sorenson
(Principal investigator's signature)

7 May 01
(Date)

THIS PERMIT AND ATTACHED CONDITIONS AND RESTRICTIONS MUST BE CARRIED AT ALL TIMES WHILE CONDUCTING RESEARCH ACTIVITIES IN THE DESIGNATED PARK(S)

Appendix G. General Conditions for Scientific Research and Collecting Permit

United States Department of the Interior National Park Service

1. Authority

The permittee is granted privileges covered under this permit subject to the supervision of the superintendent or a designee, and shall comply with all applicable laws and regulations of the National Park System area and other federal and state laws. A National Park Service (NPS) representative may accompany the permittee in the field to ensure compliance with regulations.

2. Responsibility

The permittee is responsible for ensuring that all persons working on the project adhere to permit conditions and applicable NPS regulations.

3. False information

The permittee is prohibited from giving false information that is used to issue this permit. To do so will be considered a breach of conditions and be grounds for revocation of this permit and other applicable penalties.

4. Assignment

This permit may not be transferred or assigned. Additional investigators and field assistants are to be coordinated by the person(s) named in the permit and should carry a copy of the permit while they are working in the park. The principal investigator shall notify the park's Research and Collecting Permit Office when there are desired changes in the approved study protocols or methods, changes in the affiliation or status of the principal investigator, or modification of the name of any project member.

4. Revocation

This permit may be terminated for breach of any condition. The permittee may consult with the appropriate NPS Regional Science Advisor to clarify issues resulting in a revoked permit and the potential for reinstatement by the park superintendent or a designee.

5. Collection of specimens (including materials)

No specimens (including materials) may be collected unless authorized on the Scientific Research and Collecting permit.

The general conditions for specimen collections are:

- a. Collection of archeological materials without a valid Federal Archeology Permit is prohibited.
- b. Collection of federally listed threatened or endangered species without a valid U.S. Fish and Wildlife Service endangered species permit is prohibited.
- c. Collection methods shall not attract undue attention or cause unapproved damage, depletion, or disturbance to the environment and other park resources, such as historic sites.
- d. New specimens must be reported to the NPS annually or more frequently if required by the park issuing the permit. Minimum information for annual reporting includes specimen classification, number of specimens collected, location collected, specimen status (e.g., herbarium sheet, preserved in alcohol/formalin, tanned and mounted, dried and boxed, etc.), and current location.
- e. Collected specimens that are not consumed in analysis or discarded after scientific analysis remain federal property. The NPS reserves the right to

designate the repositories of all specimens removed from the park and to approve or restrict reassignment of specimens from one repository to another. Because specimens are Federal property, they shall not be destroyed or discarded without prior NPS authorization.

- f. Each specimen (or groups of specimens labeled as a group) that is retained permanently must bear NPS labels and must be accessioned and cataloged in the NPS National Catalog. Unless exempted by additional park-specific stipulations, the permittee will complete the labels and catalog records and will provide accession information. It is the permittee's responsibility to contact the park for cataloging instructions and specimen labels as well as instructions on repository designation for the specimens.
- g. Collected specimens may be used for scientific or educational purposes only, and shall be dedicated to public benefit and be accessible to the public in accordance with NPS policies and procedures.
- h. Any specimens collected under this permit, any components of any specimens (including but not limited to natural organisms, enzymes or other bioactive molecules, genetic materials, or seeds), and research results derived from collected specimens are to be used for scientific or educational purposes only, and may not be used for commercial or other revenue-generating purposes unless the permittee has entered into a Cooperative Research And Development Agreement (CRADA) or other approved benefit-sharing agreement with the NPS. The sale of collected research specimens or other unauthorized transfers to third parties is

prohibited. Furthermore, if the permittee sells or otherwise transfers collected specimens, any components thereof, or any products or research results developed from such specimens or their components without a CRADA or other approved benefit-sharing agreement with NPS, permittee will pay the NPS a royalty rate of twenty percent (20%) of gross revenue from such sales or other revenues. In addition to such royalty, the NPS may seek other damages to which the NPS may be entitled including but not limited to injunctive relief against the permittee.

6. Reports

The permittee is required to submit an Investigator's Annual Report and copies of final reports, publications, and other materials resulting from the study. Instructions for how and when to submit an annual report will be provided by NPS staff. Park research coordinators will analyze study proposals to determine whether copies of field notes, databases, maps, photos, and/or other materials may also be requested. The permittee is responsible for the content of reports and data provided to the National Park Service.

7. Confidentiality

The permittee agrees to keep the specific location of sensitive park resources confidential. Sensitive resources include threatened species, endangered species, and rare species, archeological sites, caves, fossil sites, minerals, commercially valuable resources, and sacred ceremonial sites.

8. Methods of travel

Travel within the park is restricted to only those methods that are available to the general public unless otherwise specified in additional stipulations associated with this permit.

9. Other permits

The permittee must obtain all other required permit(s) to conduct the specified project.

10. Insurance

If liability insurance is required by the NPS for this project, then documentation must be provided that it has been obtained and is current in all respects before this permit is considered valid.

9. Mechanized equipment

No use of mechanized equipment in designated, proposed, or potential wilderness areas is allowed unless authorized by the superintendent or a designee in additional specific conditions associated with this permit.

10. NPS participation

The permittee should not anticipate assistance from the NPS unless specific arrangements are made and documented in either an additional stipulation attached to this permit or in other separate written agreements.

11. Permanent markers and field equipment

The permittee is required to remove all markers or equipment from the field after the completion of the study or prior to the expiration date of this permit. The superintendent or

a designee may modify this requirement through additional park specific conditions that may be attached to this permit. Additional conditions regarding the positioning and identification of markers and field equipment may be issued by staff at individual parks.

12. Access to park and restricted areas

Approval for any activity is contingent on the park being open and staffed for required operations. No entry into restricted areas is allowed unless authorized in additional park specific stipulations attached to this permit.

13. Notification

The permittee is required to contact the park's Research and Collecting Permit Office (or other offices if indicated in the stipulations associated with this permit) prior to initiating any fieldwork authorized by this permit. Ideally this contact should occur at least one week prior to the initial visit to the park.

14. Expiration date

Permits expire on the date listed. Nothing in this permit shall be construed as granting any exclusive research privileges or automatic right to continue, extend, or renew this or any other line of research under new permit(s).

15. Other stipulations

This permit includes by reference all stipulations listed in the application materials or in additional attachments to this permit provided by the superintendent or a designee. Breach of any of the terms of this permit will be grounds for revocation of this permit and denial of future permits.

Appendix H. Human Subjects-Institutional Review Board Approval

San José State
UNIVERSITY

Office of the Academic
Vice President
Associate Vice President
Graduate Studies and Research

To: Stacy Schroeder
880 Whitehall Avenue
San Jose, CA 95128

From: Nabil Ibrahim,
AVP, Graduate Studies & Research

Date: May 10, 2001

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

"The relationship between acute mountain sickness and rating of perceived exertion in climbers on Mount McKinley."

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Nabil Ibrahim, Ph.D., immediately. Injury includes but is not limited to bodily harm, psychological trauma and release of potentially damaging personal information. This approval is in effect for one year, and data collection beyond May 9, 2002 requires an extension request.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at
(408) 924-2480.

The California State University

Appendix I. Authorized Guide Services for Denali

- Rainer Montaineering
- Alaska-Denali Guiding, Inc.
- National Outdoor Leadership School (NOLS)
- American Alpine Institute
- Alpine Ascents International
- Mountain Trip

Appendix J. Letter to Guides

March, 2001

American Alpine Institute
1515 12th Street
Bellingham, Washington 98825

Dear (Name of guide):

Hello! I am a graduate student at San Jose State University, researching acute mountain sickness (AMS) on Denali and its relationship to physical exertion. The data is to be collected in May and June, 2001 from volunteer climbers who are registered with a guide company such as yours. I am preparing to climb the mountain in two years, so it is with extreme excitement and anticipation that I pursue this opportunity to conduct my study on Mount McKinley this summer. I am seeking your support, hoping you will be willing to allow your clients to participate if they so choose.

The purpose of the current study is to identify whether or not there is a relationship between climbers' ratings of perceived exertion (RPE) at a given altitude and the severity of acute mountain sickness symptoms (if present). These variables will be measured by means of simple questionnaires at nine various altitudes throughout the expedition. I will remain at base camp during the study, maintaining communication with the climbers via CB radio, administering the oral survey and charting the responses. This study will lay the foundation for future research. Considering the proposed data-collection points, climbers will be asked to respond to the questions approximately once a day, or once every two days. Each response will take about 3 minutes. Of course, the volunteers will be permitted to drop out at any time, if they no longer wish to participate. The design of the study ensures that there will be minimal interference with the group's activities. In addition, there is no clinical exam or otherwise invasive component to the assessment of AMS.

The research protocol will be reviewed and approved by the Institutional Review Board-Human Subjects at San Jose State University prior to beginning data collection. Again, consent will be voluntarily obtained from each subject participating in the study prior to the climb. Of course, strict confidentiality of all responses is maintained.

Enclosed you will find the questions that will be asked of the participants, as well as the proposed itinerary for obtaining the information. Previous researchers on Denali have had overwhelming cooperation with volunteer-based altitude-related studies, so I anticipate eager responses. I would like you to send you more detailed information regarding the specific parameters of the study. Your cooperation with this research would be greatly appreciated. Please seriously consider this opportunity, and return the pre-paid response card indicating

your intentions. If you have any questions, you may contact me directly. Thank you for your attention and your time.

Sincerely,

Stacy Schroeder, ATC, WEMT
Assistant Athletic Trainer, Foothill College

Appendix K. Letter to Prospective Subjects

March, 2001

Hello fellow mountaineer! You will soon be in Alaska, climbing North America's greatest peak. This will be an exhilarating challenge, both mentally and physically. I too, will be on Denali, but for slightly different reasons. I am a graduate student at San Jose State University, and will be conducting my thesis research on Mount McKinley this summer. You and your teammates may develop symptoms of acute mountain sickness (AMS), which I would like to document throughout the expedition.

The purpose of the current study is to identify whether or not there is a relationship between climbers' ratings of perceived exertion (RPE) at a given altitude and the severity of AMS symptoms (if present). These variables will be measured by means of a brief questionnaire at nine varying altitudes throughout the climb. I will remain at base camp during the study, maintaining communication with you by means of a CB radio, administering an oral survey and charting the responses. Based on the proposed timeline for the West Buttress route climb, you will be passing about one data collection point each day, or one every two days.

I am asking for volunteers to participate in this study. I have obtained approval from both the Denali National Park and Preserve and have the cooperation of the Talkeetna Ranger Station. Your climbing guide has also agreed to help out. All I need now are willing subjects! I am asking you to respond to an oral questionnaire, which will require about 3 minutes of your time. It will not interfere with the regular activities of your team. Of course, this is strictly voluntary and you are free to drop out at any time, with no consequences.

Enclosed you will find the questions that will be asked of you, as well as the proposed itinerary for obtaining the information. I would like to send you more detailed information regarding the specific parameters of the study. If this sounds like something in which you would be interested in participating, please indicate your consent on the pre-paid response card. Your cooperation with this research would be greatly appreciated. If you have any questions, please don't hesitate to contact me. Thank you for your attention and your time.

Sincerely,

Stacy Schroeder, ATC, WEMT
Assistant Athletic Trainer, Foothill College

HOME: 408.286.6703
WORK: 650.949.7324
CELL: 408.857.5189
Schroe39@yahoo.com

Appendix L. Agreement to Participate in Research

Responsible Investigator: Stacy Schroeder, ATC, WEMT

Title of Protocol: The Relationship Between Acute Mountain Sickness and Rating of Perceived Exertion

1. I have been asked to participate in a research study investigating the relationship between acute mountain sickness symptoms and physical exertion.
2. I will be asked to report my feelings of physical exertion as well as any symptoms of acute mountain sickness (AMS) at nine elevations throughout the ascent. I will be asked to contact Stacy at base camp as I approach the desired data collection point (i.e. without stopping to rest), at which time she will administer a brief oral questionnaire about my exertion and sickness symptoms as I continue to climb. I will also indicate the approximate elevation at which I am responding to the questions.
3. **RISKS:** There are no foreseeable risks associated with participation in this study.
4. **BENEFITS:** By contributing to the current research on acute mountain sickness, I am helping scientists to better understand the illness. This information will help to establish the significance of a relationship between physical exertion and acute mountain sickness, with potential implications for prevention.
5. **ALTERNATIVE PROCEDURES:** In case of radio failure, back-up data sheets will be used to record the necessary information at the collection points. I will carry a bound set of 10 weather-resistant sheets. I will use a writing utensil to record the appropriate data directly on the sheet, instead of communicating with Stacy at base camp. As I approach the designated collection point, I will retrieve the small notebook from my pocket and place an "X" in the boxes that correspond to my current physical exertion and AMS symptoms. If it is not possible to retrieve the notebook as I approach the collection point, I will be asked to at least *think about* my current rating of perceived exertion and AMS. At the next most convenient moment, I will pause to pull out the data sheets and record, to the best of my knowledge, the AMS and RPE information.
6. **RESULTS:** The results of this study may be published, but no information that could identify me will be included.
7. **COMPENSATION:** I will receive a T-shirt for my participation.

Initials _____

8. **QUESTIONS ABOUT THE RESEARCH:** Any questions about the research may be directed to Stacy Schroeder, principle investigator. During the study she will reside at base camp. After July 14th she can be reached at 408.857.5189. Complaints about the research may be presented to the Thesis Chairman, Dr. Craig Cisar, at 408.924.3018. Questions about research, subjects' rights, or research-related injury may be presented to Nabil Ibrahim, Ph.D. Associate Vice President for Graduate Studies and Research, at 408.924.2480.

9. **NO PENALTY FOR DROPPING:** I may drop out of the study at any time, with no penalty. No service of any kind, to which I am otherwise entitled, will be lost or jeopardized if I choose not to participate in the study. In addition, if I feel that my safety or comfort may be put at risk by taking the time to complete the questionnaire at a given elevation, I can refuse to take part in the survey at that elevation, and will still be able to participate in the survey at other elevations. In addition, I am not being asked to refuse medical treatment for illnesses. If I choose to take medication for the treatment or prevention of altitude illness, I am free to do so. However, I will be asked to report usage of medications to Stacy so that my data may be analyzed appropriately.

10. **VOLUNTARY CONSENT:** All consent given is voluntary. I may refuse to participate in the study or any part of the study. If I decide to participate in the study, I am free to withdraw at any time without prejudice to my relations with San Jose State University, Denali National Park and Preserve, or any other participating institutions.

11. I have received a signed and dated copy of the consent form.

- The signature of a subject on this document indicates agreement to participate in the study.
- The signature of the researcher (Stacy Schroeder) on this document indicates agreement to include the above named subject in the research and attestation that the subject has been fully informed of his or her rights.

Signature

Date

Signature

Date

Appendix M. Pre-Trip Medical Questionnaire

SUBJECT # 00

Please complete this medical questionnaire as thoroughly as possible, as your responses will contribute to the understanding of AMS. All information will be kept confidential. Again, thank you for your willingness to volunteer in this study. See you back at Base Camp!

1. When was your most recent trip to high altitude (above 7,000')?

MONTH(s) _____ DATES _____ YEAR _____

2. How many days did you stay at elevation? _____

3. To what extent were you physically active during that time?

_____ Mild physical activity

_____ Moderate physical activity

_____ Heavy physical activity

4. Climbing history (if extensive, feel free to just list a few)

DATE

LOCATION

1. _____
2. _____
3. _____
4. _____

5. Have you ever experienced any symptoms of altitude illness (Check appropriate symptoms)?

Headache with:

_____ Loss of appetite, nausea, or vomiting

_____ Fatigue or weakness

_____ Dizziness or light-headedness

_____ Difficulty sleeping

_____ Confusion

_____ Staggering gait

6. If you've experienced some of these symptoms, how have you treated yourself?

- _____ Rest at the same altitude until symptoms subsided
- _____ Descent
- _____ Over-the-counter medications (i.e Tylenol, Advil, Immodium AD)
- _____ Prescription medications (i.e. Acetazolamide [Diamox] or Dexamethazone [Decadron])
- _____ Paying more attention to nutritional / fluid needs

7. Have you ever had any other medical complications at altitude (including orthopaedic limitations) that prevented you from climbing or severely impeded your progress? If yes, please briefly explain.

8. What is your age? _____

9. What is your gender? _____

Thank you!

Stacy Schroeder, ATC, WEMT

CELL: 408.857.5189

EMAIL: schroe39@yahoo.com

Appendix N. Climbers' Instruction Sheet

Thank you for volunteering to be part of this acute mountain sickness study! I want to re-iterate that all personal information collected will be viewed solely by the researching team, and will not be shared with anybody else. In addition, your participation should not significantly affect your ascent in any way. Please do not feel that you must sacrifice your comfort or safety to be part of this study. The following information outlines your role as a subject.

Design of the Study

Along the West Buttress Route, there are nine specific elevations (listed below) at which you will respond to an oral survey, which takes approximately 3 minutes to complete. These are familiar landmarks, and you will know that you are coming upon them. *As you approach* the pre-determined elevation (i.e. without stopping to rest), you will contact me (Stacy) at base camp over your CB radio (we will discuss certain channels to use). I will then tell you to continue moving while I ask you a few questions about your physical exertion level and your feelings of altitude sickness, if any. These questionnaires are attached.

Back-Up Plan

In the event of failed radio communication, you will be asked to record the information yourself, on pre-fabricated data collection cards. You will carry a set of 10 bound cards – one for each of the desired elevations. I know that certain weather or safety circumstances may prevent you from accessing the cards at the appropriate time, so I understand if you decide that you cannot use the data collection card. However, I do ask that, if you are unable to reach me on the radio and you decide that you will not use the data card, you at least *consider* your physical exertion level and AMS symptoms at the data collection point. Then, when you are able to pull out the card or contact me on

the radio, you can do your best to remember the information, even though you may not be currently physically exerting yourself.

Medications

Certain medications such as Acetazolamide and Dexamethasone are known to enhance acclimatization or reduce symptoms of acute mountain sickness. Your decision to take medications will *not* affect your ability to volunteer in the study. I only ask that you report the usage of any drugs so that your data may be analyzed appropriately. This research is not meant to inconvenience you or your team. I am not asking you to sacrifice your enjoyment of the ascent for the sake of this study.

Dropping out of the Study

As the Informed Consent Form indicates, you are free to drop out of the study at any time, without consequences. Any and all information collected from you will be appreciated.

Data Collection Points

1. Base camp (7,200')
2. Base of Ski Hill (7,900')
3. Near Kahiltna Pass (9,500')
4. Just below Windy Corner (13,000')
5. The Basin (14,200')
6. Ridge Camp (16,100')
7. High Camp (17,200')
8. Denali Pass (18,000')
9. Summit Ridge (20,000')

Appendix O. Back-Up Data Card for Climbers

TIME		AMS			
12	:00	HEAD	0	DIZZY	0
1	:05		1		1
2	:10		2		2
3	:15		3		3
4	:20	GI	0	SLEEP	0
5	:25		1		1
6	:30		2		2
7	:35		3		3
8	:40	WEAK	0		
9	:45		1		
10	:50		2		
11	:55		3		