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Physiologic Changes Occurring During a 592-mile Hike on the Appalachian Trail

Patricia Gayle Williams
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Patricia Gayle Williams entitled "Physiologic Changes Occurring During a 592-mile Hike on the Appalachian Trail." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Exercise Science.

David Bassett, Major Professor

We have read this thesis and recommend its acceptance:

Edward T. Howley, Eugene C. Fitzhugh

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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A Thesis Presented

For the Master of Science Degree

The University of Tennessee, Knoxville

Patricia Gayle Williams

May 2007

DEDICATED

In Loving Memory of my Grandmother, with whom I watched many sunsets over the mountains.

This is dedicated to my family who gave me a love of the outdoors. This is also dedicated to my niece and nephew, to whom I hope to pass along this same passion. I love you all.

ACKNOWLEDGEMENTS

The author would like to express her thanks and appreciation to several people who helped with this project.

My advisor, Dr. David Bassett: thank you for serving as my major professor and for giving me the idea for this research. Thank you for your knowledge, guidance, and support. Thank you for not giving up on me when my first priority was not my thesis.

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Pam Andrews, our Laboratory Assistant: thank you for your endless help during testing days.

Fellow Graduate Student: Rachel Duckham: thank you for pushing me to get this thesis done and for guiding me through the process.

Thank you to my parents. You all have always supported my decision and told me you were proud of me. Thank you for giving me a love of the outdoors and the freedom to live my passion.

My husband: thank you for supporting me through this lengthy process and for sharing my love of the outdoors.

A special thanks to Dick and Ann Ray for always being interested in my hobbies, showing me another part of the world, and stressing the importance of education.

A very special thanks goes out to the two subjects who enthusiastically participated in this study. Without you this would not have been possible.

ABSTRACT

The purpose of this study was to assess physiologic changes during a 592-mile hike of the Appalachian Trail. The participants included 2 physically active nonsmoking male adults, 23 and 26 years of age. The participants were both experienced backpackers attempting a 592-mile northbound hike of the AT in the summer of 2006. Participants were tested before and after hiking. Participants underwent the following tests: resting BP, resting HR, height and weight, body fat, BMD, lactate threshold, VO_{2peak}, maximal HR, curl-ups, push-ups, and sit-and-reach. Although the hike was ended prematurely after 474 miles, many changes were observed. Body mass, body fat, and girth measurements (except the calf) decreased for both subjects. VO_{2peak} and lactate threshold increased. In conclusion, many positive physiologic changes were seen after hiking 474 miles on the AT. Further research is needed on more diverse subjects attempting the entire trail.

TABLE OF CONTENTS

CHAPTER **PAGE**

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The Appalachian Trail (AT) is a 2175-mile footpath stretching from Springer Mountain, Georgia to Mount Katahdin, Maine. Founded by Benton Mackaye, this wilderness hiking trail crosses 14 states and extends along the crest of the Appalachian Mountains. Every spring, approximately 2000 people start hiking north at Springer Mountain in hopes of reaching Mount Katahdin before the October 15th closing of the park, but only about 15-20 % will complete their journey (1). A smaller number start at Mount Katahdin and hike south to Springer Mountain. These hikers are referred to as thru-hikers, or those that hike the entire trail continuously. Others choose to complete the trail in more than one trip. Known as section hikers, these people may hike a couple of days, a couple of weeks, or possibly a couple of months at a time. A third group of hikers are known as flip-floppers, or those that start at one end and hike for a distance, receive transportation to the opposite end, and hike until they reach their first stopping point. Of those completing the entire trail, section hikers represent 20% of the total, flip-floppers make up 5%, and thru-hikers make up the remaining 75%. To date, almost 9,000 people have hiked the entire AT (1).

According to a 1997 study by Boulware et al., the top reasons for not completing the hike were injury, time limitations, and psychosocial reasons (2). Past research on hiking has focused mainly on medical and social issues, and the studies were prospective in nature (2, 3, 39). Of the studies involving thru-hiking, most limited the study duration to 7 days (4). An exception was a 1985 study by Sparling et al. (5) on physiological changes experienced by an AT hiker. Although the participant completed 1700 miles of the trail, few physiological changes were seen.

Most studies on ultra endurance events focus on medical issues or energy expenditure. Of 6 studies involving adventure races, all focused on medical issues during or after the event (6-11). Several Tour de France studies have compared energy expenditure to energy intake (12-14).

Aerobic exercise, such as hiking, elicits many positive adaptations, such as increases in maximal oxygen uptake (VO_{2max}), lactate threshold (LT), stroke volume, maximal cardiac output, maximal oxygen extraction, insulin sensitivity, and HDL cholesterol. Decreases in resting heart rate and blood pressure have been reported (15-21). Some changes occur after a single bout of exercise while others occur only after weeks of training (22).

Walking is often recommended to achieve health related benefits. Walking is inexpensive, low impact, does not require any new skills, and can be done almost anywhere and at anytime. Depending upon speed and grade, walking has an energy requirement of between 2.5-16.8 METs (23, 24). Walking at a speed of 3.0 mph (a common backpacking speed) on a flat surface has an energy cost of 3.3 METs, but carrying a 30 lb (13.6 kg) load increases the cost to 7 METs. Climbing hills with the 30 lb load raises the energy cost to 8 METs (25-27). Downhill walking at lower gradients requires less energy than walking on a flat surface, but as the negative gradient increases, the energy cost rises (28).

In addition to the changes in grade, hiking on the AT requires greater energy cost than normal walking due to the hiker wearing a backpack. Loads for section hikers vary but usually fall between 25-50 lbs, or 11.4-22.7 kg (1). Heart rate and oxygen consumption increases with a pack (29). As compared to walking at the same speed and grade with no load, Keren showed a 17% increase in heart rate and a 25% increase in VO2 when walking with a 20 kg load at 4 mph on a 5% inclined treadmill (29). Often, the gait is changed when wearing a backpack as well (4).

Many hikers use hiking poles during their journey. In a study by Schwameder (30), hiking poles reduced lower extremity forces while walking down a 25% grade. In a study of uphill walking with a load, poles improved backpacking kinematics, redistributed muscular demand, and improved comfort (31). Poles may also help prevent falls on uneven terrain (31). However, studies disagree on whether the use of poles affects metabolic cost, with some studies showing that they increase it (32, 33), and others showing that they have no effect (31).

Purpose

Past research on hiking has focused mainly on medical and social issues. The studies were prospective in nature. Of the studies involving thru-hiking, most were carried out over 7 days. Therefore, the purpose of this case report is to assess physiologic changes during a 592-mile hike of the Appalachian Trail.

Hypothesis

Based on previous research involving physiologic adaptations to exercise, we hypothesis that:

There will be physiological changes that occur during a 592-mile hike on the AT, such as increases in lactate threshold, VO_{2peak}, bone mineral density, abdominal strength, upper body strength, and flexibility and decreases in weight and % body fat.

CHAPTER 2

REVIEW OF LITERATURE

The primary aim of this study was to assess physiological changes of hiking continuously. In order to do this, it was important to address a number of topics, ranging from the Appalachian Trail, to walking as a form of physical activity, grade walking, walking with a loaded backpack, and walking with poles.

The Appalachian Trail

The Appalachian Trail (AT) is a 2175-mile footpath stretching from Springer Mountain, Georgia to Mount Katahdin, Maine. The trail was founded by Benton MacKaye because "people living in a post war industrial focused society grappling with rising unemployment needed to refocus their attention on leisure time" (34). The trail was finished in 1937 and is maintained primarily by volunteers (35).

With 2/3 of the nation's population living within 550 miles of the trail, the AT is the most popular hiking destination in the US (2, 36). The trail crosses 14 states, and although over 2000 miles in total, is only 1200 miles in straight line distance. This wilderness hiking trail extends along the crest of the Appalachian Mountains, crossing 6 national parks and 8 national forests. Ninety-nine percent of the AT is on public land with the remaining 1% on private land (37). The trail crosses a major road often. The longest stretch on the AT without a crossing is 32 miles, which occurs in the Smoky Mountains (35).

The AT is the nation's longest marked footpath (38). White rectangular blazes (5 cm by 15 cm) on trees or rocks identify the trail. Double blazes are placed by turns or junctions. Blue blazes mark side trails that lead to shelters, water supplies, or vistas (36).

The trail is "not exactly a nice, easy, paved bike path" (35). The terrain is uneven with rocks, roots, and turns. The trail ranges from flat to rolling, to steep climbs that require scrambling up rocks. The single greatest climb is the northern terminus at Mount Katahdin which climbs 4198 feet in 5.2 miles, an average grade of 15.3% (37).

Appalachian Trail Hikers

Every spring, approximately 2000 people start hiking north at Springer Mountain in hopes of reaching Mount Katahdin before the Oct 15th closing of the park, but only 15-20% complete their hike (1). A small number start at Mount Katahdin and hike south to Georgia. Some start at one end and hike to a certain point, then receive transportation to the other end and hike until they reach where they left the trail. Others who are unable or unwilling to spend 6 months on the trail hike the AT in sections, with many taking years to complete the entire trail. Regardless of which method used, the aim is to become a "2000-miler", meaning to have "hiked the entire trail between Springer Mountain in GA and Mount Katahdin in MA". As of 2005, 9000 people have achieved this goal (1).

According to a 1997 study of 280 backpackers hiking longer than 7 days, the top reasons for not completing the hike were injury, time limitations, and psychosocial reasons (2). Musculoskeletal injuries were common, with acute joint pain being the #1 complaint. 11 hikers suffered fractures, with 5 stress fractures, 5 due to falls, and 1 unclassified. The most common illness was diarrhea, which was experienced by 56% of hikers.

Crouse studied successful hikers and section hikers in 1987-88 (39). Of 180 hikers who completed the trail, 82% experienced injuries or illness, with 5% reporting at least 1 lost day of hiking due to injury or illness. 25% sought medical attention and 3 were hospitalized. 62% had extremity or joint pain. Of 10 fractures, 3 were stress fractures, 3 were due to trauma, and 1 was due to overuse. 1 hiker was struck by lightning. 63% had diarrhea at least once. Hikers lost an average of 11.8 lbs (5.4 kg). Their average pack weight was 45.6 lbs (20.7 kg).

The Appalachian Trail Conference (ATC) reports 10% of hikers quit by the end of the 1st week. Reasons for quitting included starting too early, heavy rains or snow, overly ambitious schedule, unexpectedly rugged terrain, overspending budget, poor physical shape, ill-fitting boots and equipment, and no sense of humor. The average hiker spends $3000-$5000 on the trail, plus an additional $1000-2000 on gear before the hike (1). The average hiker is 35 years of age (2).

Although most hikers take 5-7 months to complete their journey, the hike can be done much faster as proven by Andrew Thompson. In 2005, he set a record of completing the trail in 47 days, 13 hours, and 13 minutes. However, unlike most hikers, he was not self supported, with a crew of people helping him along the way (40).

Ultra Endurance Events

Most studies on ultra endurance events (those lasting longer than 6 hours) focus on races lasting less than 24 hours, such as ironman triathlons or ultra marathons. Very few studies examine multi-day events. Adventures races are non-stop and consist of multi-sport disciplines such as running, orienteering, mountain biking, flat-water and whitewater paddling, and rope skills. In studies of expedition length adventure races, which last from 36 hours to 10 days, all 6 studies focused on injuries and illnesses (6-11). Blisters were the most common soft tissue injury (6, 8, 10). In Townes' study of Primal Quest 2002 in Telluride CO, respiratory illness was the most common reason for withdrawal; this was not surprising since the race began at an altitude of over 9500 feet and ascended to over 13,500 feet (8, 9). At Primal Quest 2006 in Moab, Utah, where temperatures reached over 100 degrees F, one athlete suffered from heat stroke (10). After Eco-Challenge 2000 in Borneo, a leptospirosis outbreak occurred (41).

The Tour de France is a 3 week professional bicycle race covering approximately 2,000 miles. Lucia (42) evaluated heart rate response to various stages of the tour and found heart rate depended upon the terrain and role of the cyclist in his team. Heart rate was lowest in the flat stages, higher in the mountains, and highest during the time trials. Westerterp (12) used doubly labeled water to measure daily EE during the tour. Cyclists reached an average daily metabolic rate of 3.4-3.9 or 4.3-5.3 times their basal metabolic rate (BMR). As a comparison, men performing heavy labor have a daily metabolic rate of 4 times BMR. A study by Saris (13) on food intake during the tour found cyclists diet to be made up of 62% CHO, 15% protein, and 23% fat. Sweet cakes were their most important food. Average daily water intake was 6.71 L. Although the cyclists' EE was 7810 kcal/day, their EI was only 5900 kcal/day. In the Tour of Italy, amateur cyclists had an EE of 9,033-12,976 kcal/day (14).

In a similar study on EE, Hill and Davies (43) examined a runner during a 7 month endurance run around Australia. The subject ran an average of 76.74 miles/day and had an average EE of 6321 kcal/day, with a daily water intake of 6.083 L. A sedentary man of similar size would have an average EE of only 2390 kcal/day.

A study by Case (44) examined nutritional intakes of IditaSport participants. Athletes ran, biked, skied, snowshoed, or did a combination of the disciplines for an average of 24.5 hours in Alaska. EE was higher for all disciplines due to the snow and cold weather (event took place in February). The estimated EE for biking was 11,237 kcals, 22,124 for skiing and snowshoeing, and 20,454 for running. The average EI was only 7,373 kcals. Although there was an average weight loss of 1.3 kg, there was no change in % body fat. A urine test revealed ketonuria in 83%, blood in 70% and protein in 92% of the samples.

Perhaps the greatest EE for an event was back in 1911/12 and 1914/16 during the Antarctic sledding expeditions (45). Polar explorers man-hauled sleds for up to 10 hours a day for 159-160 consecutive days. Total caloric expenditure for these expeditions is estimated at 1,000,000 kcals. In comparison, total caloric expenditure for the entire Tour de France is about 168,000 kcals and for the Run Across America is 340,000 kcals. Noakes comments, "Given good health and an adequate food supply to prevent starvation and scurvy, these limits [of human endurance] are set by the mind, not by the body" (45).

Aerobic Exercise Adaptations

Aerobic exercise, such as hiking, evokes many positive physiological adaptations, such as increases in the following: maximal oxygen uptake, lactate threshold, stroke volume, maximal cardiac output, maximal oxygen extraction, insulin sensitivity, and HDL cholesterol. Decreases in resting heart rate and blood pressure have been reported (15-21). Some changes occur after a single bout of exercise while others occur only after weeks of training (22).

If training is not continued, a detraining effect occurs. After 12 days of no training, VO_{2max} decreases by 7%. Lactic acid concentration in the blood increases for the same submaximal work rate, meaning LT shifts to the left and lactate accumulation occurs at a lower exercise intensity than before (46).

Aerobic exercise consists of structured physical activity. Physical activity is "bodily movement produced by skeletal muscles that requires energy expenditure at a level to produce healthy benefits" (47). Regular physical activity helps reduce the risk of heart disease and lowers the risk of developing diabetes. It is associated with a decreased risk of colon cancer and helps prevent high blood pressure and reduce blood pressure in persons with elevated levels. Regular physical activity may also increase lean muscle and decrease fat (48). In addition, physical activity, especially weight bearing activities such as walking, may also enhance bone mineral density (BMD), which helps prevent osteoporosis (49-52). Although a study by Lord (53) showed no improvement in bone mineral density, physical activity still decreased fracture risk, due to the improvements in quad strength and postural sway.

Physical Activity Prevalence and Recommendations

Although physical activity has been shown to evoke many positive health benefits, 40% of Americans are sedentary (48). Healthy People 2010, a health promotion and disease prevention agenda that was designed as a road map for improving the health of all people living in the US by the year 2010, hopes to change this by listing physical activity as one of the top 10 health indicators. The objective is to increase the number of adults who regularly, preferable daily, perform moderate-intensity physical activity for at least 30 minutes per day. This is in accordance with the American College of Sports Medicine (ACSM) and Center for Disease Control (CDC) guidelines for health (23). By 2010, Healthy People 2010 hopes to increase this number from 20% to 30% (54, 48).

Walking as Physical Activity

Walking is reported as the nation's most popular leisure time physical activity. Hippocrates wrote "walking is man's best medicine" (15). It is inexpensive, accessible, does not require any special skills or equipment and is an effective exercise for weight loss and maintenance (54, 55, 22). In a study by Thompson, women who walked more that 10,000 steps per day had a lower percent body fat than those that walked less than 6,000 steps per day (56).

Walking may also help maintain bone mineral density (BMD). In the Nurses Health Study by Feskanich (50), women who walked 4 hours per week or more had a 41% lower risk of hip fractures that sedentary controls. A study by Turner (51) showed that walking was a significant variable for reducing the risk of osteoporosis. In this study, 3310 women aged 50 and over were interviewed about their physical activity. Walking, along with bicycling, aerobics, and dancing, was a moderate predictor for positive bone density. Puntila (49) showed a smaller loss of lumbar bone mineral content among walkers and joggers as compared to sedentary women. Harada (57) showed an increase in femoral neck BMD as well as lumbar BMD with walking.

Walking provides some of the same health benefits of vigorous physical activity, such as decreased risk of type II diabetes, decreased blood pressure, decreased risk of cardiovascular events, and increase in HDL cholesterol. However, as compared to vigorous physical activity, walking has a lower risk of injury and sudden death (15, 19, 20, 55, 58). Most people who walk for exercise do so on a regular basis, and walking programs have lower dropout rates than more vigorous exercise programs (59). Walking is an equal opportunity activity; it is as prevalent for low income families as high income families. This is important since those with lower socio-economic status usually engage in less physical activity (59).

Energy Cost of Walking

The energy cost of walking depends on speed, body weight, and whether walking on a horizontal surface or up and down a grade (23, 60). Walking at a normal speed of 3 mph on level ground will increase the body's energy requirement to 3 times the resting level (from 1 MET resting to 3.3 METs walking) (61). The energy cost of walking increases linearly for speeds ranging from 2-3.5 mph and curvilinearly from 3.5-5.0 mph (60, 62). Most normal weight adults choose a walking speed that minimizes energy cost per a given distance, which is 3 mph (62).

Males usually expend more energy walking due to their greater weight (60, 62). When walking at a normal speed, a 100 kg person has twice the energy cost as compared to a 50 kg person (23).

The type of terrain influences the energy cost of walking. The softer the surface, the greater the penetration of the foot, so the higher the energy cost. For example, loose sand requires twice the energy of a blacktop surface and 3.5 cm (1.4 in) deep soft snow requires 4 times the energy. The increase in energy required is due to a combination of more muscle mass recruitment, added lift work, and more forward stooping posture (25).

Grade Walking

Walking up or down a grade changes the energy cost of walking. As the incline increases, the energy cost of walking increases (28). The oxygen cost of grade walking is computed as the sum of the oxygen cost of horizontal walking, the oxygen cost of the vertical component, and the resting metabolic rate (23). Walking up a slope with an 8%

grade (a common grade for the AT) requires twice the energy expenditure compared to walking at the same speed on level ground (23). Walking at a 15% uphill grade requires 3 times the energy required to walk on level ground (63). Women have higher energy cost than men at high gradients, due possibly to smaller size, different body mass distributions, and greater movement of the upper limbs (63).

Energy expenditure is less for gentle downhill grades than for level walking (28, 64). However, after a point, the energy cost increases due to the braking component or the act of "resisting gravity to maintain a walking rhythm" (64). This point is variable depending on the individual's walking characteristics and walking speed but occurs between -6% and -15% grades (64).

Walking with a Backpack

Not surprisingly, wearing a backpack increases energy expenditure. As compared to walking at the same speed and grade with no load, Keren (29) showed a 17% increase in heart rate and a 25% increase in VO_2 when walking with a 20 kg load at 4 mph on a 5% inclined treadmill. In a study by Epstein (65) where subjects walked at 6.4 km/hr (4 mph) with and without a 20 kg backpack load, VO_2 increased from 43% of VO_{2max} without the load to 53% VO_{2max} with the load. Soule (66) showed that increasing the backpack load increases energy expenditure, although to not the same extent as increasing the speed. At 3.2 km/hr (2 mph), subjects worked at 35% VO_{2max} with a 35 kg backpack and 45.9% VO_{2max} with a 70 kg backpack. However, when the backpack load stayed the same (at 35 kg) and walking speed increased to 6.4 km/hr (4 mph), oxygen uptake increased to 73% VO_{2max}.

Another study by Lyons (67) showed that increasing load carriage from 20-40 kg increased metabolic and cardiovascular demands more than when increasing load carriage from 0 to 20 kg.

Wearing a backpack causes changes in walking gait. In a 7-day backpacking trip through the Grand Canyon (4), the subject, while wearing a 20 kg load, walked uphill with little side to side or vertical motion and using only deliberate linear steps. During downhill walking, he took deliberate side to side steps and increased vertical motion thru more bending of the knees.

At speeds above 8.5 km/hr (5.27 mph), it is more economical to run than to walk (68). Wearing a 20 kg backpack decreases the speed at which this occurs to 7.7 km/hr (4.8 mph) (29).

Caloric expenditure increases when walking with a backpack. Devo's hikers expended 408-702 kcals/hr depending upon difficulty of terrain (4). Sparling's AT hiker expended an estimated 312 kcals/hr during the hike (5).

However, Patton (69) showed that predicted values may underestimate the actual metabolic cost of prolonged backpacking. In his study, 15 male subjects walked at 12 km (7.4 miles) with loads of 31.5 kg, 49.4 kg and 0 kg. In the unloaded condition, VO_2 remained constant throughout the trial, which was expected. However, with the 31.5 and 49.4 kg loads, VO_2 increased throughout the trial (i.e. VO_2 drift). During the final minute of the trial, actual VO_2 values were 10-16% higher than the predicted values. The 49.4 kg load elicited a higher VO_2 than the 31.5 kg load. A similar study by Epstein (65) found an 8.8% increase in VO_2 during a 2-hour inclined treadmill walk with a 40 kg load. No change in VO_2 over time was seen during the same walk with a 25 kg load.

Hiking with Poles

Increasing numbers of hikers and backpackers are now using hiking poles. Hiking poles have been more prevalent in Europe but are now being used more in the US (31). Manufacturers of hiking poles claim that using poles reduces impact forces on the lower extremities by as much as 21% (70) and pole users say they reduce the pain of sore knees and swollen feet (31).

Studies disagree on whether hiking poles change the energy cost of walking. Studies of unloaded level walking with exerstriders and power poles (both similar to hiking poles) found an increase in energy expenditure which they attribute to the increased recruitment of the arm muscles (32, 33). However, Knight and Caldwell (31) examined the effects of poles on uphill backpacking, and found no change in VO_2 when comparing the use of poles to no poles. They speculate that the use of hiking poles may have caused a decrease in the activity of the leg muscles by shifting some work to the arms.

In the same study (31), poles caused a change in gait kinematics. With poles, the stride length was 6.7 % longer and stride frequency was 6.3% less. The knee was straighter upon heel strike.

The use of hiking poles decreases forces on the lower extremities. A study by Wilson-Effect (71) found the use of hiking poles increases walking speed while decreasing the knee joint reaction forces. During the study, subjects carried no load and walked on a level platform at a self-selected speed.

During downhill walking with a 7.6 kg backpack, the use of poles reduced external and internal loads on several knee joint structures (30). In a study of loaded downhill walking with subjects carrying 25% of their body weight, pole use decreased ground reaction forces (GRF) and decreased combined muscle use by 13.7% (72).

In two related studies by Abendroth-Smith (70, 73), college-aged students and seasoned adult hikers walked downhill without backpacks. Pole use in the college-aged subjects did not significantly change peak GRF, vertical forces, or braking forces (70). However, with the seasoned adult hikers, pole use decreased GRF and braking forces (73). Although these changes were small, they would be significant over time.

Jacobson (74) compared lateral stability with and without poles while balancing on a stability platform with and without a 15 kg backpack. The stability platform simulates loose alpine terrain and unstable log bridges that backpackers may encounter while hiking. In all conditions, balance time was greater when not wearing a load. This was due to the center of gravity shifting higher when wearing a backpack, which caused a decrease in balance. With a load, using 2 poles improved balance as compared to using no poles or only 1 pole. Without a load, using either one or two poles improved balance.

Summary

Past research on long distance hiking has focused mainly on medical and social issues, and most were prospective studies. Most studies on ultra endurance events focused on medical issues or energy expenditure. Aerobic exercise elicits many positive health benefits. The energy cost of walking varies depending upon speed and grade. Walking with a backpack requires greater energy cost. Many hikers use hiking poles to improve comfort and help prevent falls.

CHAPTER 3

MANUSCRIPT

Abstract

PURPOSE: The purpose of this study was to assess physiologic changes during a 592-mile hike of the Appalachian Trail.

METHODS: The participants included 2 physically active nonsmoking male adults, 23 and 26 years of age. The participants were both experienced backpackers attempting a 592-mile northbound hike of the AT in the summer of 2006. Participants were tested before and after hiking. Participants underwent the following tests: resting BP, resting HR, height and weight, body fat, BMD, lactate threshold, VO_{2peak}, maximal HR, curl-ups, push-ups, and sit-and-reach.

RESULTS: Although the hike was ended prematurely after 474 miles, many changes were observed. Body mass, body fat, and girth measurements (except the calf) decreased for both subjects. VO_{2peak} and lactate threshold increased.

CONCLUSION: In conclusion, many positive physiologic changes were seen after hiking 474 miles on the AT. Further research is needed on more diverse subjects attempting the entire trail.

Introduction

The Appalachian Trail (AT) is a 2175-mile footpath stretching from Springer Mountain, Georgia to Mount Katahdin, Maine. Founded by Benton Mackaye, this wilderness hiking trail crosses 14 states and extends along the crest of the Appalachian Mountains. Every spring, approximately 2000 people start hiking north at Springer Mountain in hopes of reaching Mount Katahdin before the October 15th closing of the park, but only about 15-20 % complete their journey (1). A smaller number start at Mount Katahdin and hike south to Springer Mountain. These hikers are referred to as thru-hikers, or those that hike the entire trail continuously. Others choose to complete the trail in more than one trip. Known as section hikers, these people may hike a couple of days, a couple of weeks, or possibly a couple of months at a time. A third group of hikers are known as flip-floppers, or those that start at one end and hike for a distance, receive transportation to the opposite end, and hike until they reach their first stopping point. Of those completing the entire trail, section hikers represent 20% of the total, flip-floppers make up 5%, and thru-hikers make up the remaining 75% (1). To date, almost 9,000 people have hiked the entire AT (1).

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Many AT hikers use hiking poles during their journey. In a study by Schwameder (30), hiking poles reduced lower extremity forces while walking down a 25% grade. In a study of uphill walking with a load, poles improved backpacking kinematics, redistributed muscular demand, and improved comfort (31). Poles may also help prevent falls on uneven terrain (31). However, studies disagree on whether the use of poles affects metabolic cost, with some studies showing that they increase it (32, 33), and others showing that they have no effect (31).

Purpose

Past research on hiking has focused mainly on medical and social issues. The studies were prospective in nature. Of the studies involving thru-hiking, most limited the study duration to 7 days. Therefore, the purpose of this case report is to assess physiologic changes during a 592-mile hike along the Appalachian Trail.

Hypothesis

Based on previous research involving physiologic adaptations to exercise, we hypothesis that:

> There will be physiological changes that occur during a 592-mile hike on the AT, such as increases in lactate threshold, VO_{2peak}, bone mineral density, abdominal strength, upper body strength, and flexibility and decreases in weight and % body fat.

Methods

Participants

The participants included 2 physically active nonsmoking male adults, 23 and 26 years of age. The participants were both experienced backpackers attempting a 592-mile northbound hike of the AT in the summer of 2006. They were recruited via word-of-mouth from the University of Tennessee student body.

Testing Protocol

Testing was performed in the Applied Physiology Laboratory inside the Health, Physical Education, and Recreation (HPER) Building at the University of Tennessee. Testing was conducted before the participants began their hike and after completion of their hike. Before the participants began testing, they were asked to read and sign an informed consent form approved by the University of Tennessee Institutional Review Board (Appendix A). They completed a health history questionnaire (Appendix B) to assess their health status and ensure the participants had no contradictions to exercise. Participants were encouraged to ask questions concerning the study and the informed consent form.

The following protocol was used for pre and post hike testing. Both participants had abstained from exercise for 12 hours prior to testing, and they refrained from eating for 4 hours prior to testing. Participants underwent the following tests:

1. Resting BP was measured using a stethoscope and a blood pressure cuff (23).

2. Resting HR was measured using a Polar heart rate monitor (model A1, Kempele, Finland).

3. Height and weight were measured to determine body mass index (BMI). BMI was calculated by dividing the weight in kilograms by the height in meters squared (23). Girth measurements were taken at the chest, shoulder, waist, hip, arm, thigh, and calf (47).

4. Body fat was measured using the Bod Pod chamber (a machine that measures % body fat). Participants were asked to remain still for 2 one-minute trials while body volume was determined (75).

5. Bone mineral density (BMD) was measured using DXA, which uses a low dose radiation beam. During the 20-min procedure, participants were required to wear a swimsuit (76).

6. Lactate threshold (the point at which lactate starts accumulating in the blood) was measured by obtaining several drops of blood from the fingertip, several times during a graded exercise test (GXT). This test was only performed on one participant. During this test, the participant wore the same backpack loaded with the same estimated weight as when hiking on the AT, a load of 30 lbs (13.6 kg). After a 5-10 minute warm-up period, the treadmill was set at 3.7 mph at 0% grade. Every 3 minutes, the grade increased 2% until the participant reached a very strong effort (on a scale of 0-10, with 0 being no effort and 10 being a maximal effort, he reached an 8) (77).

7. Peak oxygen uptake (VO_{2peak}), or the greatest amount of oxygen taken in and used in 1 minute, was measured using the TrueMax 2400 Metabolic Measurement System, which measured the amount of oxygen and carbon dioxide expired during exercise. The participants wore a Hans Rudolf breathing valve (model 5330, Kansas City, Missouri). Participants also wore a nose clip to prevent nasal breathing. During this test, participants wore the same backpack as in the previous test. The test started at a speed of 3.7 mph at 0% grade, and the grade increased every minute until participants were unable to continue. The participant's peak oxygen uptake was considered the highest volume of oxygen recorded.

8. Maximal HR was measured at the end of the VO_{2peak} test. The participant wore the same Polar heart rate monitor as during the resting heart rate measurement. Heart rate

was measured each minute of the exercise test. The participant's maximal heart rate was considered to be the highest heart rate recorded during the test.

9. Curl-ups- To assess abdominal muscular endurance, a curl-up test was given. For this test, participants lay supine with knees bent at 90°, arms at sides with fingers touching a piece of masking tape. A second piece of masking tape was placed 11 cm beyond the first. The participant performed slow controlled curl-ups to lift the shoulder blades off the mat and slides fingers to 2^{nd} piece of tape. Each curl-up was performed in tune with a metronome set at 40 beats per minute (or 20 curl-ups per minute). The participant performed as many curl-ups as possible without pausing, up to a maximum of 75 (47).

10. Push-ups- To assess upper body muscular strength and endurance, the push-up test was used. Participants performed the standard push-up test with hands shoulder-width apart, back straight, and head up. The participant lowered the body until the chin touched the mat or the chest touched the fist of the investigator. While maintaining a straight back, the participant pushed up to a straight-arm position. The participant continued until reaching the point of exhaustion or not being able to maintain proper form. The participant's score was the total number of push-ups performed (47).

11. Sit and reach test -To test flexibility of the low back and hip joint, a sit-and-reach test was performed. The participant sat on a mat with both legs extended. A sit and reach box was placed against the sole's of the feet. The participant reached forward as far as possible with hands placed on top of each other. The distance from the starting position to the final outstretched position was measured. The participant then repeated the test 2 times. The largest number observed during the three trials was recorded (47).

Hiking Protocol on the AT

Participants began hiking on May 22nd at Appalachian Gap, Hwy 17, Long Trail Vermont and ended on June 29th in Monson Maine. They covered a total distance of 474 miles of the AT during this 39 day period (4 of which were rest days), an average of 13.5 miles per day. Pack weight, including food and water, was approximately 30 lbs (13.6 kg). Poles were used for the entire hike by subject A and for the first 200 miles by subject B. Although their original goal was to hike 592 miles, the hike was ended prematurely when one hiker injured his big toe. At this point, the non-injured hiker chose to end his hike as well. Subjects were scheduled to hike until July 15 and return for post-hike testing 3 days later. However, due to the hike ending early, 18 days elapsed between hike termination and post-hike testing.

Results

Resting blood pressure was higher post-hike for subject A, while subject B had a lower systolic but higher diastolic (Table 1). Resting heart rate decreased for subject A, but increased for subject B. Weight decreased for both subjects by 4.1 kg and 7.1 kg (A and B, respectively). Body fat decreased 6% for A and 5.6% for subject B. BMD remained essentially the same. For both subjects, girth measurements decreased at all sites except the calf, which did not change.

Lactate threshold increased from 63% to 66% pre-test VO_{2peak} for subject A (Subject B was not tested). VO_{2peak} increased 4.4 ml/kg/min for A and 11.3 ml/kg/min for

Table 1: Physiological Changes in Response to Backpacking 474 Miles on the AT. (N=2)

Test	Subject A Pretest (5/19)	Posttest (7/18)	Change	Subject B Pretest (5/17)	Posttest (7/18)	Change
resting BP (mmHg)	120/70	126/82	"+6/+12"	130/75	122/84	"-8/+9"
resting HR (beats/min)	83.0	75.0	-8.0	77	80	3
height (in)	70.0	70.0	0.0	71.5	71.5	0.0
body mass (kg)	93.0	88.9	-4.1	102.0	94.9	-7.0
BMI (kg/m²)	29.4	27.1	-2.3	30.7	28.9	-1.8
chest (in)	41.0	39.0	-2.0	43.0	40.0	-3.0
shoulder (in)	46.0	45.0	-1.0	52.0	48.0	-4.0
waist (in)	37.0	33.5	-3.5	39.0	36.5	-2.5
hip (in)	44.0	41.0	-3.0	44.0	41.0	-3.0
arm (in)	12.5	12.0	-0.5	14.5	13.0	-1.5
thigh (in)	24.5	24.0	-0.5	25.0	24.0	-1.0
calf (in)	16.0	16.0	0.0	17.0	17.0	0.0
% Body Fat	23.1	17.0	-6.1	24.3	18.7	-5.6
BMD (g/cm²)	1.45	1.45	0.00	1.37	1.42	0.05
LT (% pre-test V02peak)	63.0	66.0	3.0	n/a	n/a	n/a
VO2peak (ml/kg/min)	47.0	51.4	4.4	39.4	50.7	11.3
max HR (beats/min)	200	195	-5.0	201	204	3
curl-up	26	30	4.0	15	18	3
push-up	14	20	6.0	21	20	-1
sit and reach (in)	21	22	0.5	20	20	0

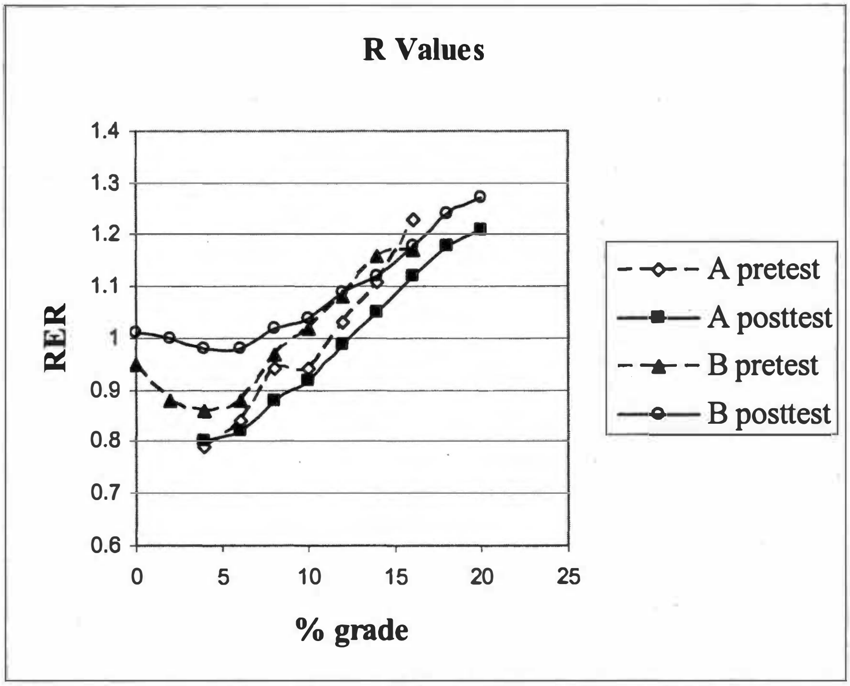

Figure 1. Changes in RER in Response to Backpacking 474 Miles on the AT. (N=2)

B. R values decreased slightly post-test for subject A, while varying for subject B (Figure 1). Abdominal strength increased in both subjects. Subject A had an increase in upper body endurance while subject B had a very slight decrease. Flexibility did not change (only a very slight increase for subject A).

Discussion

There were many physiologic adaptations that occurred over the course of this 474-mile hike on the AT. Unlike in Sparling's hiker study (5), the present study found major changes in body weight, % body fat, and VO_{2peak}. However, Sparling's subject was well-conditioned before the hike, had a higher pre-test VO_{2max}, and had a lower % body fat as compared to the subjects in the present study. Although our subjects were physically active, they did not participate in any structured program before beginning their hike. In addition, individuals with a lower VO_{2max} (our subjects as compared to Sparling's subject) typically show the largest percent change as a result of training (78).

In this study, both subjects decreased body fat by approximately 6% and lost body weight. This was probably due to the increase in caloric expenditure through hiking. Although there was no record of caloric intake, subjects reported eating well on the trail and consuming additional calories whenever they passed through towns. Perhaps as a result of the decreased subcutaneous and visceral body fat, girth measurements (except for the calf) decreased for both subjects as well.

BMD remained essentially unchanged. However, both subjects had high (99^{th} and 100^{th} percentile of age and gender-matched norms) pretest values for BMD.

The increase in LT in subject A was expected due to the increased number of mitochondria and capillaries in the muscle, which increases the muscle's respiratory capacity, as a result of thru-hiking (79). Along with the increase in the respiratory capacity, there is an increased utilization of fat and less use of carbohydrates, as shown by the RER value, which is slightly lower posttest for subject A (79). Although we had expected a lower RER in subject B as well, this was not the case.

Resting heart rate decreased for subject A, but subject B had a slight increase in resting heart rate. This is surprising since endurance training usually lowers resting heart rate (15). Maximal heart rate increased by 3 beats/min for subject B but decreased for subject A. This is not uncommon, since maximal heart rate changes very little with training (16). Although resting blood pressure increased slightly for subject A, both pre- and posttest values were in the normal range. Subject B had a decrease in systolic blood pressure from high normal pretest to normal posttest, which is expected since blood pressure should decrease as a result of training (15).

The increase in abdominal muscle endurance in both subjects could be due to a combination of the increased use of these muscles during their activities of daily living on the trail (like setting up camp each night), the activity of hiking with a loaded backpack over uneven terrain, and a daily regimen of sit-ups and push-ups. Both subjects reported they wanted to improve their pre-test score in these exercises. Although both were successful in increasing the number of sit-ups, only subject A increased the number of post-test push-ups. Sit-and-reach scores remained essentially the same for both subjects.

Limitations

Due to subject A injuring his big toe (due to trauma, not overuse), the hike was ended prematurely after 80% of the originally scheduled distance had been covered. The physiologic changes observed may have been even greater after 592 miles. Although some studies show a leveling off of $VO_{2\ max}$ after only a few weeks of training, others show that VO_{2max} continues to increase over several years of training (80).

Subjects were scheduled to hike until July 15th and return for post-test hiking on July 18th. With only 3 days in between completion and testing, the detraining effects and weight change should have been minimal. Instead, there was a time period of 18 days between hike termination and testing. Therefore, at post-hike testing, many physiologic adaptations were quickly returning to pre-hike values. A study by Coyle (81) showed that $VO_{2\ max}$ decreased by 7% after 12 days of de-training. Also in Coyle's study, lactic acid increased at the same submaximal work rate as well. As mentioned earlier, Sparling (5) showed a 3 kg increase in body weight, 7 days after the cessation of hiking.

More testing needed to be done on both subjects. As stated earlier, only 1 subject underwent a LT test. Because HDL cholesterol was the only physiologic variable that improved in Sparling's hiker (5), a lipid profile test could have been done to assess HDL cholesterol changes. Doppler echo-cardiography could have also been done to assess changes in the heart volume.

Stricter controls on diet and physical activity levels prior to testing should have been enforced to more accurately evaluate the influences of training on RER. Many factors affect RER, including pre-exercise diet, pre-exercise physical activity levels, pre-exercise muscle glycogen concentrations, training state, and exercise intensity (82). Along with having stricter controls, muscle glycogen levels should also have been measured.

The present study had a limited sample size (N=2), due to the difficulty of recruiting subjects. A greater diversity of subjects would have been desirable. Both subjects in the present study were young, male, and physically active. It would be interesting to compare the adaptations occurring in young versus old, and male versus female subjects.

Also, it would be interesting to compare caloric expenditure with caloric intake. This could be determined by having the subjects record daily distance, time walked, pack weight, temperature, terrain, and caloric intake.

Our subjects had similar physiologic changes because they hiked together. They covered the same distance each day, split the pack weight almost evenly, and had similar caloric intakes since they shared food. It would be interesting to compare physiologic adaptations of non-solo hikers to solo hikers.

This study had originally tried to recruit subjects attempting a northbound hike of the entire AT. Hikers would be tested pre-hike, after completion of 271 miles, and post-hike. To our knowledge, no other study has reported changes experienced during an entire hike of the AT. However, due to time constraints and lack of availability of hikers, the study was changed to a 474-mile hike on the AT. Further research is needed on hikers attempting the entire trail.

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APPENDICES

Appendix A:

Informed Consent

INFORMED CONSENT FORM

Project Title: Physiological adaptations to hiking the Appalachian Trail
Investigator: Patricia Williams
Address: The University of Tennessee
Department of Exercise, Sport, and Leisure Studies
1914 Andy Holt Ave.
Knoxville, TN 37996
Telephone: (865) 974-8768

Purpose

You are invited to participate in a research study. The purpose of this study is to measure physical fitness changes in response to a 2175-mile thru-hike of the Appalachian Trail. If you give your consent, you will be asked to perform the below tests. You will be tested three times: (1) before starting your thru-hike at Springer Mountain, GA, (2) after reaching Hot Springs, NC, and (3) after completion or termination of your thru-hike. The testing will take approximately 4-6 hours on each of 3 separate days. To determine your health status, you will be asked to complete a health history questionnaire. This questionnaire will be completed before testing begins. If a serious medical condition is found, you will be excluded from the study and advised to see your physician. On the night prior to testing, you will be provided a room at the Campus Day's Inn. During this time, you are not to exercise and to sleep as you normally would.

For the pre-and post-hike testing, you will report to the Applied Physiology Lab at the University of Tennessee (located in HPER building, 1914 Andy Holt Ave.) following an overnight fast for the following tests:

1. Resting blood pressure will be measured using a stethoscope and a blood pressure cuff.
2. Resting heart rate will be measured using a heart rate monitor.
3. Lipid Profile- A 5-ml blood sample will be drawn from a vein in your forearm.
4. Height and weight will be measured. Girth measurements will also be made.
5. Your bone mineral density will be measured using DXA, which uses a low dose radiation beam. During the 20-min procedure, you will be required to wear a swimsuit.
6. Body fat- You will be placed in the Bod Pod chamber (a machine that measures % body fat) and asked to remain still for 2 one minute trials while body volume is being determined. You will be able to breathe normally and see your surroundings.
7. Lactate threshold (the point at which lactic acid starts accumulating in the blood) will be measured by obtaining several drops of blood from your fingertip, several times during a graded exercise test (GXT). During this test, you will wear the same backpack loaded with the same estimated weight as when hiking on the AT. After a 5-10 minute warm-up period, the treadmill will be set at 3.7 mph at 0% grade. Every 3 minutes, the grade will increase 2% until you reach a very strong effort (on a scale of 0-10, with 0 being no effort and 10 being a maximal effort, you reach an 8).
8. Peak oxygen uptake (VO_{2peak}), or the amount of oxygen taken in and used in 1 minute, will be measured using a metabolic measurement system. You will wear a breathing valve, which measures the amount of oxygen and carbon dioxide you expire during

exercise. You will also wear a nose clip to prevent nasal breathing. During this test, you will wear the same backpack as in the previous test. The test will start at a speed of 1.7 mph at 0% grade, and the grade and speed will increase every 3 minutes until you are unable to continue.

9. Curl-ups- For this test, you will lie supine with knees bent at 90°, arms at sides with fingers. You will slowly curl-up to lift the shoulder blades off the mat. Each curl-up is performed in time with a metronome set at 40 beats per minute (or 20 curl-ups per minute). You will perform as many curl-ups as possible with out pausing up to a maximum of 75.

10. Push-ups- Males will perform the standard push-up test with hands shoulder-width apart, back straight, and head up. Females will perform the modified push-up test with legs together, lower leg in contact with mat, ankles plantar-flexed, back straight, hands shoulder-width apart, and head up.

11. Sit and reach test -This test will be used to assess flexibility of the low back and hamstrings. You will sit on a mat with your back against the wall and both of your legs extended. A sit and reach box will be placed against the sole's of your feet. You will reach forward as far as possible with hands placed on top of other.

Intermediate-Point testing

After the initial testing, you will travel to Springer Mountain, Georgia, which is the southern terminus of the Appalachian Trail (AT), to begin hiking. You will contact the tester upon your arrival in Hot Springs, N.C., which is 271 miles from the start of the AT. You will then be transported by car to the University of Tennessee, where all of the physiological and performance tests (but not the bone mineral density or blood sample) will be repeated.

Upon completion of testing, you will be transported back to Hot Springs, NC where you will resume hiking. You will continue hiking until completion of the AT at Mount Katahdin, after which you will return to UT (on your own) for final testing. You are asked to arrive at UT no later than 3-5 days after completion of the trail. The same tests administered at the outset of the study will be repeated.

You will inform the tester if your hike is terminated prematurely. If you are able to perform the final tests, you will return to UT within 3-5 days and final testing will be conducted at this point.

Cost

You will incur no additional expense by participating in this study except the cost of traveling between your home and UT for pre and post testing. Gasoline from UT to Hot Springs will be paid for by the Department of Exercise, Sport, and Leisure Studies. The department will also pay for the room at the Day's Inn and meals while at UT for testing.

Data obtained while hiking the AT

You will keep a daily log with total mileage and approximate hours hiked each day. You will also estimate pack weight based on gear weight and amount of food being carried. Pack with gear will be weighed before the hike begins. Estimated weight of food each day will be calculated. Based on the amount of days of food that is being carried on a given day, this is the estimated weight of the pack. You will also record any prescription or over-the-counter medications taken. You will also be asked to periodically record your food intake.

Potential Risks

The risks of maximal exercise in a healthy population are low. These risks include muscular soreness, musculoskeletal injuries, shortness of breath, dizziness, and in rare cases, sudden death. If you experience any abnormal feeling during this study such as chest pain or severe breathlessness, you should let the investigators know.

Risk associated with each test:

1. Height, weight, and girth: none
2. Blood Pressure: none
3. Resting heart rate: none
4. Bod Pod: none except for privacy issues since you will be wearing a swimsuit. To protect privacy, you will be provided with a robe to wear until you step in the chamber.
5. Bone mineral density: The DXA scan does require exposure to low-dose radiation. The radiation exposure is small; roughly equivalent to the radiation exposure of a round-trip transcontinental plane ride. The DXA machine is only operated by individuals certified by the State of Tennessee.
6. Peak oxygen uptake: According to the ACSM, the risk of death during or immediately after an exercise test is less than or equal to 0.01%, with the risk of an acute MI during this time being less than or equal to 0.04% (5). The risk of suffering an exertion-related heart attack is almost 50 times lower in people who exercise >5 times per week as compared to sedentary persons (6).
7. Fingertip blood sampling: Possible risk of infection. All necessary precautions will be taken (tester wears gloves, alcohol is used on finger, waste disposed of according to OSHA guidelines).
8. Maximal heart rate: none
9. Abdominal endurance: Risk of muscular soreness and musculoskeletal injuries; however, minimal risk with adequate warm-up and proper screening of participants.
10. Pushup test: same as #9.
11. Sit-and-reach test: same as #9; subject will be instructed to stretch only to the point of slight discomfort, not to the point of pain.
12. Blood sample: Risk of hematoma and infection; however, OSHA guidelines will be followed and the blood sample will be drawn by a trained professional; therefore, risk of infection is minimal.

In the event that a serious medical condition is found after completing the questionnaire or the testing, you will not participate in the study and be referred to your personal physician.

There are many risks involved in hiking the AT. However, because you plan on hiking the AT, regardless of whether or not you participate in this study, the study presents no additional hiking-related risks, except the risk of an automobile accident while being transported to and from the trail. The driver, Patricia, has a clean driving record and will be driving a well-maintained 2002 Subaru Forester. All rules of the road will be obeyed.

Benefits of Participation
From the results of your tests, you will be given a report of the following by Patricia: your body fat percentage, your bone mineral density, your peak oxygen uptake, your maximum heart rate, your lactate threshold, your muscular strength and endurance, your flexibility, and your lipid profile. After completion of this study, you will be able to observe the changes of your test values while you were hiking. You will have the opportunity to discuss these changes with Patricia.

Confidentiality
The information obtained from these tests will be treated as privileged and confidential and will consequently not be released to any person without your consent. However, the information will be used in research reports and presentations; however your name and other identity will not be disclosed. All of your data, this form, and your health history questionnaire will be kept in a locked file cabinet in HPER 317 for 3 years following the study.

Emergency Medical Treatment
The University of Tennessee does not automatically offer compensation or reimbursement for medical claims. In the unlikely event that physical injury is suffered during the course of this research study, or if you have questions regarding this policy, notify Patricia Williams at (865) 974-8768.

Contact Information
If you have questions at any time concerning the study or the procedures, (or you experience adverse effects as a result of participating in this study,) you may contact Patricia Williams. If you have questions about your rights as a participant, contact Research Compliance Services of the Office of Research at (865) 974-3466.

Right to Ask Questions and to Withdraw
You are free to decide whether or not to participate in this study and are free to withdraw from the study at any time.

Before you sign this form, please ask questions about any aspects of the study, which are unclear to you.

Consent

By signing, I am indicating that I understand and agree to take part in this research study.

______________________________ ____________________

Your signature Date

______________________________ ____________________

Researcher's signature Date

Appendix B:

Health History Questionnaire

HEALTH HISTORY QUESTIONNAIRE

NAME____________________________ DATE_______________________

DATE OF BIRTH___________________ AGE________________________

ADDRESS____

____

PHONE NUMBERS (HOME) _______________ (WORK)_______________

Email address: ____

When is the best time to contact you? ________________________

Please answer the following questions. This information will only be used for research purposes and will not be made public. Please answer the following questions based on physical exercise in which you regularly engage. **This should not include daily work activities such as walking from one office to another.**

1. Do you regularly exercise? Yes/No If yes, please describe.

____

____

2. On average, how many times per week do you engage in exercise?

   0_____ 1_____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____

3. On average, how long do you exercise each time?

   0-19 minutes_____ 20-40 minutes _____ more than 40 minutes _____

4. How long have you been exercising at this level?

   Less than 6 months __________
   6-12 months __________
   1-2 years __________
   3 or more years __________

MEDICAL HISTORY

Past History:
Have you ever been diagnosed with the following conditions? Please check the appropriate column.

	Yes	No	Don't know
Rheumatic Fever	( )	( )	( )
Heart Murmur	( )	( )	( )
High Blood Pressure	( )	( )	( )
Any heart problem	( )	( )	( )
Lung Disease	( )	( )	( )
Seizures	( )	( )	( )
Irregular heart beat	( )	( )	( )
Bronchitis	( )	( )	( )
Emphysema	( )	( )	( )
Diabetes	( )	( )	( )
Asthma	( )	( )	( )
Kidney Disease	( )	( )	( )
Liver Disease	( )	( )	( )
Severe Allergies	( )	( )	( )
Orthopedic Problems	( )	( )	( )
Hyper- or Hypothyroidism	( )	( )	( )
HIV, Hepatitis, or other blood-borne disease	( )	( )	( )
Heparin Sensitivity	( )	( )	( )

Present Symptom Review:
Have you recently had any of the following symptoms? Please check if so.

Chest pain	( )	Frequent urination	( )
Shortness of breath	( )	Blood in urine	( )
Heart palpitations	( )	Burning sensations	( )
Leg or ankle swelling	( )	Severe headache	( )
Coughing up blood	( )	Blurred vision	( )
Low blood sugar	( )	Difficulty walking	( )
Feeling faint or dizzy	( )	Weakness in arm	( )
Leg numbness	( )	Significant emotional problem	( )

Do you smoke? Yes/No   If yes, how many per day? __________

Are you taking medications? Yes/No
If yes, please describe: ____
On average, how many alcoholic drinks do you consume per week? __________
Can you walk 5 miles continuously without pain or discomfort? ____________

OTHER INFORMATION

Whom should we notify in case of emergency?

Name ______________________________

Address ______________________________

Phone# ______________________________

I have been given the opportunity to ask questions about any of the above items that were unclear and I have answered all questions completely and truthfully to the best of my knowledge.

SIGNATURE ______________________________ DATE __________

VITA

Patricia Williams was born on the 27th of December 1974 in Maryville, Tennessee. At age 12, she started competing in local running races. After graduating high school, she joined the United States Marine Corps where she worked as a supply clerk. During this time, she lived in Cherry Point, North Carolina for three years and Iwakuni, Japan for one year. She continued her love of competitive sports by representing the USMC on the triathlon team. In 1996, she returned to her home town of Maryville to pursue a Bachelor's Degree in Exercise Science, which she received from the University of Tennessee in 2002. She switched from the sport of triathlon to adventure racing, competing at both the national and international level. In 2004, Patricia entered the graduate program in Exercise Science, with a concentration in Exercise Physiology at the University of Tennessee. She served as a Graduate Teaching Assistant in the department of Physical Education. In the spring of 2007, she received a Master of Science degree with a concentration in Exercise Physiology.