GENDER DIFFERENCES IN OXYGEN CONSUMPTION, FORWARD TRUNK LEAN AND RATING OF PERCIEVED EXERTION DURING LOAD CARRIAGE

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CHAPTER I

INTRODUCTION

From the primitive necessity of transporting oneself from one location to another was born a popular form of recreational activity called hiking. Hiking has also become popular both for itself and as a means to enjoy such wilderness activities as camping and canoeing. In the Unites States, the National Scenic Trail Act of 1968, which made large tracts of land available to the public for recreational use, contributed greatly to the growth of hiking as a pastime. The Scenic Trail Act helped to set up a system of hiking trails that runs throughout the country. While short hikes over mild terrain are easily accomplished, longer hikes through the wilderness require conditioning and special equipment. Hiking boots of sturdy leather-and-rubber construction are essential, and clothing made from such durable materials as denim and wool has given way to polypropylene and synthetic fleece. Sleeping bags, tents, and other equipment are needed for extended hikes. Backpackers require camp stoves, cameras, fishing poles, and other useful items necessary for a camping trip, all of which must be carried while hiking. Carrying items via a backpack has become so popular that it has become the primary means in which children carry their books to and from school (Gimmer, Williams, & Gill, 1999).

The history of load carriage via backpack dates back hundreds, if not thousands, of years. The transportation of load by rucksack (early backpack) has long been used as an exercise in military training programs. Before the 18th century, foot soldiers seldom carried more than 15 kg while on the march, but loads have progressively risen since then (Cureton & Sparling, 1980). This load increase is presumably due to the weight of weapons and equipment that incorporate new technologies to increase protection, firepower, communications, and mobility. The energy cost of walking with backpack loads increases progressively with increases in weight carried, walking speed, or grade. Load carriage can be facilitated by lightening loads, improving load distribution, optimizing load-carriage equipment, and taking preventive action to reduce the incidence of injury. Backpacks may need further consideration for fitting a female; this is based upon the possibility that gender differences may exist.

Most frequently, males and females are given backpacks of the same design despite known gender differences and body size. For example, if a typical female carries a weighted backpack, it will represent a greater load relative to her bodyweight in comparison a male carrying the same weight. This is due to the female's disadvantage in upper body strength and smaller body size. Not considering size and strength of the female may increase the risk of injury. Modern backpacks have advanced designs that are superior in comfort and performance to the earlier and more primitive backpacks. A typical "modern" pack can weigh between 15 and 30 kilograms (when loaded) and needs to be specifically fitted for each individual. During walking there is a considerable amount of swinging, twisting, rising and falling of the arms, legs, torso and head. This increased motion of the body requires that special attention be paid to the fitting of any backpack while transporting weight. A modern backpack is designed to fit properly and accommodate the many different shapes and sizes of the human body (Epstein, Rosenblum, Burstein, & Sawka, 1988).

Statement of Problem

The current research investigates several performance parameters on college-aged males and females. There is an obvious lack in the research focusing on the possibility of gender differences during load carriage. Due to an underrepresentation of female subjects, there is a need for additional exploration into the possibility of gender differences existing during load carriage with respect to metabolic rates, body posture and self-reported ratings of exercise intensities (RPE). The evaluation of the criteria motioned above is critical for the determination of physiological, psychological, and biomechanical differences that may exist between males and females while walking and carrying various weights by backpack.

It is well known that men and women have demonstrated physiological differences during exercise (Bhambhani & Maikala, 2000; Cathcart, Lothian & Greenwood, 1920; Horber, Gruber, Thomi, Jensen, & Jaeger, 1997; Lewis, Kamon, & Hodgson 1986; Martin & Nelson, 1986; Pandorf, Harman, Frykman, Patton, Mello, & Nindl, 2002; Parker, Hunter, Treuth, Kekes-Szabo, Kell, Weinsier, & White, 1996). When male and females are compared during exercise at higher intensities, what was a slight difference becomes even more profound. In addition, it has been shown that females, when compared to males, have physiological disadvantages such as a smaller body size, lower oxygen consumption, decreased upper body strength, altered gait characteristics during axial loading (weight on shoulders), wider hip width (Q angle), increased body fat, different distribution of fat, and hormonal alterations (Bhambhani & Singh, 1985; Cureton, Sparling, Evans, Johnson, Kong, & Purvis, 1978; Cureton & Sparling, 1980; Evans, Winsmann, Pandolf, & Goldman, 1980; Kang, Chaloupka, Mastrangelo, & Hoffman, 2002; LaFiandra, Wagenaar, Holt, & Obusek, 2003; McCardle, Katch, & Katch, 2003; Miller & Stamford, 1987; Smith, Lelas, & Kerrigan, 2002; Sparling & Curreton, 1983). Future research into load transportation by backpack needs further investigation focused upon female subjects. Hopefully, this research may provide information in backpack designs and limitations that may help to provide information that could be used to help and decrease the risk of injury to females.

Purpose of the Study

The purpose of this investigation was to determine several gender differences: standing-resting metabolic rates during load carriage; Rate of Perceived Exertion (RPE), forward trunk lean, and net metabolic costs while walking at 3% grade at 3 miles per hour during load carriage; and RPE, forward trunk lean and net metabolic cost during graded walking at subjects' self-selected speed during load carriage.

Significance of the Study

The addition of extra weight to the human trunk may increase the possibility of injury to the spine. Lovejoy (1988) explains that this may be due to our evolutionary metamorphosis from quadrupeds to bipeds. The spine has transformed from an organ-supporting bridge (non weight-bearing) to an upright weight-bearing column. These limitations to the spine leave us predisposed to back injury in efforts to maintain an upright position (Lovejoy, 1988). Given the anatomical differences between men and women, further research is needed to determine if gender differences in load carriage contribute to an increased amount of risk to the back and spine. Increase in weight during load carriage may result in an even greater risk for back and spine injury to females because of their smaller frame size and lesser overall body strength (Lovejoy, 1988).

Unfortunately, most previous research has been narrowly focused upon male subjects while walking on flat surfaces. However, there are many aspects (other than walking on flat surfaces) to examine between males and females during the carriage of loads by backpack. There is a specific need for further research investigating males and females during graded walking while carrying varying weight via backpack. The discovery of these differences, if any, may result in safer or more appropriate design considerations for the future of load carrying devices worn on the body.

Research Questions

1. Are there significant differences between college-aged males' and females' standing-resting metabolic rates with a grade of 3% among all backpack loads of 0%, 15%, and 30% of body weight [BWT]?
2. Are there significant differences between college-aged males' and females' net metabolic cost or forward trunk lean or rating of perceived exertions (RPE) during walking at a 3% grade and 3 miles per hour among all backpack loads of 0%, 15%, and 30% [BWT]?
3. Are there significant differences between college-aged males' and females' net metabolic cost or forward trunk lean or rating of perceived exertions (RPE) during walking at a 3% grade and a self-selected speed among all backpack loads of 0%, 15%, and 30% [BWT]?

Null Hypotheses

HO_1= There will be no significant differences between college-aged males' and females' standing-resting metabolic rates among all backpack loads of 0%, 15%, and 30% [BWT].

HO_2= There will be no significant differences in college-aged males' and females' net metabolic cost of walking at a 3% grade and 3 miles per hour among all backpack loads of 0%, 15%, and 30% [BWT].

HO_3= There will be no significant differences between college-aged males' and females' net metabolic cost of walking at a 3% grade and self-selected speed among all backpack loads of 0%, 15%, and 30% [BWT].

HO_4= There will be no significant differences between college-aged males' and females' RPE during walking at a 3% grade and 3 miles per hour among all backpack loads of 0%, 15%, and 30% [BWT].

HO_5= There will be no significant differences between college-aged males' and females' RPE during walking at a 3% grade and self-selected speed among all backpack loads of 0%, 15%, and 30% [BWT].

HO_6= There will be no significant differences between college-aged males' and females' forward trunk lean during walking at a 3% grade and 3 miles per hour among all backpack loads of 0%, 15%, and 30% [BWT].

HO_7= There will be no significant differences between college-aged males' and females' forward trunk lean during walking at a 3% grade and a self-selected speed among all backpack loads of 0%, 15%, and 30% [BWT].

Limitations of the Study

1. The subjects in this study did not receive any dietary controls.
2. Pretest anxiety could have resulted in overestimated resting metabolic values.
3. The subjects of this study were selected from a sample of convenience.

Delimitations of the Study

1. All subjects were classified as non-sedentary, as indicated by the Godin Leisure Time Exercise Questionnaire.
2. The results of an investigation using college-aged males and females may not necessarily generalize to a cohort consisting of more heterogeneous fitness levels.
3. In a physical performance investigation, the subjects may respond in a laboratory setting differently than they would respond in a more natural environment.
4. The PAR-Q indicated all subjects were apparently healthy.

Assumptions

1. All subjects were homogeneous in their activity and fitness levels as indicated by the Godin Leisure Time Activity Level Questionnaire.
2. Subjects rated their RPE as accurately as possible.
3. All subjects reached steady state before measurement of oxygen consumption while walking with each backpack load.
4. All laboratory equipment was properly calibrated during the testing.

Operational Definitions

1. Absolute Load- an amount of weight that is in disregard to an individual's body size.
2. Body mass index (BMI) - is a measure of body mass (weight in kilograms\height in meters squared).
3. Dual Energy X-ray Absorptiometry- is the most accurate and advanced test available for measuring bone mass with excellent resolution and reproducible precision. DEXA test is more sensitive than ordinary x-rays, more accurate than radiograms and can diagnose bone loss at an earlier stage (McCardle, Katch, & Katch, 2003).
4. Kilograms (Kg)- one kilogram equals 2.2 pounds.
5. Metabolic economy- is the amount of energy used to travel a given distance.
6. Metabolism\VO_2- the chemical changes in living cells by which energy is provided for vital processes and activities and new material is assimilated (McCardle, Katch, & Katch, 2003).
7. Net Metabolic Cost- difference between the resting and the exercising energy cost. This reflects the "true" amount of energy that is consumed by a given amount of exercise.
8. Oxygen consumption- is the volume of oxygen consumed by the body each minute during exercise, while breathing air at sea level. Because oxygen consumption is linearly related to energy expenditure, when measuring oxygen consumption, we are indirectly measuring an individual's maximal capacity to do work aerobically (McCardle, Katch, & Katch, 2003).

9. Relative Load- an amount of weight that is in regard to an individual's body size

10. Steady State Exercise- a level of metabolism when the oxygen consumption satisfies the energy expenditure for oxygen transport stabilizes.

CHAPTER II

LITERATURE REVIEW

Introduction

An important human evolutionary feature is our complex brain and our ability to use tools in order to further our existence. However, a third feature that sets humans apart from all other forms of life is termed upright bipedal locomotion.

Other animals are quadrapedal and for good reason. For example, walking upright has it disadvantages, “it deprives us of speed and agility and all but eliminated our capability to climb trees” (Lovejoy, 1988). When humans began to stand upright, significant adaptations occurred in their muscular and skeletal systems. These changes were fundamental in the maintenance of a sustained and upright position during bipedalism. However, these adaptations may not be as dramatic as one might think. There are important differences between our closest cousins, the chimpanzee. While walking on the ground, chimpanzees' can walk in an upright fashion but must use their hands to support their body weight (knuckle walking). The most important difference is that chimpanzees cannot straighten their legs and must, therefore, step with a "waddle" like gate. Also, while walking and only relying on muscle power, free from the use of their arms, the chimpanzees inefficient attempt at bipedalism will "tire them out" in a limited number of steps (Lovejoy, 1988).

Slight evolutionary changes have given us distinct advantages during bipedalism. For instance, thighbones extending from our hips slope slightly inward ensure that the knees are in line with the feet, placing our feet under our center of gravity. We also have hip muscles that contract simultaneously as we step in order to ensure that our hips do not drop to one side during walking. Our feet are well adapted for weight bearing and the arches of the feet serve as shock absorbers. Our spine has a distinct double curve, which aligns the head properly above the torso and in alignment above the feet. The surfaces of the joints in our spinal column are enlarged to support the added weight (Inman, Ralston, & Todd, 1981).

In actuality, we are not perfectly adapted for upright walking. Despite the slight evolutionary advantages we seem to have, our spines are still formed from distant ancestors that carried themselves horizontally. In those creatures, the spine acted like a suspension bridge supporting the organs, this is a configuration that seems more structurally advantageous. Although evolution has seemingly tried to prepare us for bipedalism, these slight advantages to the spine may still subject us to unprecedented amounts of stress and predispose us to back injury and pain (Inman, Ralston, & Todd, 1981).

However, walking upright (in theory) has a few distinct advantages. When humans walk, we are thought to mimic the movement of an energy efficient pendulum. The gravitational potential energy that is present at the end of the arc is transformed into kinetic energy, which goes back to potential energy at the other end of the arc, and so on. When the foot is at the top of its arc, (in front of you) the foot slows to a temporary stop and at this point all kinetic energy is lost. During this very point potential energy (mass x gravitational force x height) is at its apex. As the foot falls, potential energy flows back into kinetic energy. If the pendulum is efficient, the transfer of energy should be almost one hundred percent, with just a bit of energy lost due to air friction and friction in the hip joints from which the pendulum (foot) is hung (Saibene & Minetti, 2003).

The human gait can be compared to a "pendulum." During each step, the foot swings over the ground landing only to pivot on that foot. The leg attached to that foot would then support the body through a forward arc. In effect, the heel strike on the ground in will decelerate the leg because the ground exerts a force on the leg. Continuing to slow down, the foot goes into plantar flexion to the point at which the center of mass is directly over the foot. At that point, the kinetic energy is at a minimum, since the body in motion has decelerated to the greatest possible extent. However, the potential energy is also at its maximum, ready to begin stepping with the opposing foot. Energy is continually transferred from potential to kinetic energy. Again, transference supposedly helps to maximize efficiency during walking with each step. The potential energy is converted to kinetic energy, just as with a traditional pendulum creates acceleration in a forward direction (Heglund, Williams, Penta, & Cavagna, 1995).

If the body were a perfect pendulum, it could convert kinetic and potential energy back and forth without losing energy, and walking would require no energy expenditure at all. Unfortunately, the body is far from perfect. In fact, it is estimated that about 33% of the energy required to create movement is lost with each forward swing of the body through its pendulous arc (Winters, 1979).

When our metabolic cost of transport is compared with those of other animals, humans seem to be very energy inefficient. Birds do not take advantage of a pendulum system and still they utilize less energy per distance traveled than do humans. Another animal for example is a swimming fish. The drag forces acting upon fish are enormous, however, they are still more efficient than humans (McCardle, Katch, & Katch, 2003). So why is it that humans, despite their "built in" pendulum, expend more energy moving than other animals? The differences may lie in a simple comparison between an inanimate pendulum and ourselves. The inanimate pendulum is suspended in air, and its bearing (the point of attachment of the pendulum to some stationary object) does not have the responsibility of sustaining weight. However, a human-pendulum's bearing (the foot) and its attached "arm" (the leg) must expend some energy to support the body above in order to keep it from collapsing. A real pendulum does not have to perform a constant balancing act. (Heglund, et al., 1995). It is easy to understand difference in gait when we are compared to other species, however, differences between men and women becomes a more clouded issue. The following review of literature will focus on the research comparing male and female aspects of expenditure of energy, RPE, walking, running, stature, and body composition.

Gender Difference during Load Carriage

Martin and Nelson (1986) examined the gait of 11 men (mean = 20.8 yrs, 176 cm, 71 kg) and 11 women (mean= 20.9 yrs, 166 cm, 60.8 kg) during walking (4 mph) while carrying five different loads of 9, 17, 29 and 36 kilograms. All walking variables were examined with high-speed cinematography including stride length, stride rate, single leg support, double-support time, swing time and forward trunk inclination. The results of the study revealed that males and females display significantly different patterns of gait across all loading conditions. The females had a smaller step and therefore had a higher step frequency than the men. There were also differences in the walking patterns between men and women when weight was added during walking. Martin and Nelson (1986) noted that the men showed small changes in gait with the heaviest loads while the females displayed much larger differences as those mentioned above. Most importantly, it was concluded that there should be careful consideration when females are given greater load while being compared with male subjects. Martin and Nelson (1986) stated, "a major limitation of past studies of load carrying behavior is that the research has been limited to the study of the responses of men to the additional loads of stress." There has been little research considering the responses of females to the demands of load carrying. These differences in gait characteristics could be from both a physiological and biomechanical standpoint (Martin & Nelson 1986).

Bhambhani and Maikala (2000) compared the biomechanical and physiological responses of healthy men and women during a load carriage. The study focused on the performance of men and women under a load during walking on a treadmill at their self-selected velocity. Men (n=11) and women (n=11) carried 15- kilograms and 20-kilogram loads in random order using a custom-designed load-carriage device. The load was measured in each hand by using a strain gauge. The physiological measurements were recorded using standard procedures and cardiac output was estimated in all three conditions of standing, walking, and during load carriage. Bhambhani and Maikala (2000) found significant gender differences when carrying loads with the arms only and differences between men and women during walking with various loads. Women showed an increase in oxygen consumption when compared to men and exceeded the ventilatory threshold when walking under a loaded condition. Women responded with greater amounts of physiological stress by comparison to men. The male and female comparison was even greater as both genders were put under increasing loads. Bhambhani and Maikala (2000) stated, "these observations suggest that when carrying absolute loads of 15 kg and 20 kg, women are more susceptible to fatigue and are at a greater risk of cardiovascular complications than men." This may be explained by the proportion of weight carried to the size of the individual carrying it.

Parker, Hunter, Treuth, Kekes-Szabo, Kell, Weinsier, and White (1996) revealed more important considerations while testing the energy costs of females during loaded walking. They examined the effects of a total body strength training program on oxygen uptake during a submaximal walk and a weight-loaded walk in healthy women 60-77 years old. They concluded that a reduction in heart rate indicated that strength training may reduce cardiovascular stress during daily tasks in healthy older women. Heart rate during exercise is an important indicator of intensity levels. Heart rate and oxygen consumption have a linear relationship during exercise, as heart rate increases so does oxygen consumption. A consideration in the methodology of all research into load carriage should be that strength-trained females may have a slight advantage during loaded walking when compared with non-strength trained individuals.

Lewis, Kamon, and Hodgson (1986) revealed the physiological differences between men and women. While it is commonly accepted that there are physiological and morphological gender differences, their data suggest that; 1) there are no differences between genders in central or peripheral cardiovascular adaptations to aerobic training; 2) women in general have a reduced oxygen carrying capacity; 3) metabolic responses to exercise may be reduced due to essential sex specific fat of women.

Lewis, Kamon, and Hodgson (1986) concluded that there are no differences in relative increases in VO2max for men and women when they are trained under the same intensity, frequency and duration. Menstrual cycle and mode of training also appears to elicit no important effects. It is important to note little, if any, gender differences remain in the way men and women increase their cardiovascular fitness levels during training.

Horber, Gruber, Thomi, Jensen, and Jaeger (1997) research supports differences in the energy expenditure of females by comparison to males. Four groups of subjects were matched for weight, height, and body mass index (n = 119; 60 women, 59 men). There were differences identified in age (above and below 50 yrs) and gender using dual energy x-ray absorptiometry (DEXA) to assess body composition (bone, lean, fat mass and distribution) and indirect calorimetry to determine resting fuel metabolism. Horber et al. (1997) conclude that aging affects both body composition and fuel metabolism differently between men and women.

Pandorf, Harman, Frykman, Patton, Mello, and Nindl, (2002) examined various speeds that could be traveled by 12 female volunteer soldiers during a loaded walk. The female solders were timed over 3.2 kilometers while carrying loads of 14, 27, and 41 kg, and while traversing an obstacle course with the two lighter loads. Pandorf et al. (2002) concluded that larger subjects were able to carry loads faster than smaller subjects. This was explained because the fixed load makes up greater percentage of the smaller persons body weight.

Body Posture during Loading

Hong and Brueggemann (2000) investigated the amount of weight it would take to induce a trunk forward lean. The sample included school children carrying four different backpack loads of 0%, 10%, 15%, and 20% of bodyweight during a treadmill walk. The measured variables were heart rate, gait pattern (forward trunk lean) and blood pressure. Results of the study indicated that significant trunk lean began near 20% of body weight loading. However, Hong and Brueggemann (2000) suggested that children carry weight in a backpack that equaled no more than approximately 20% their own bodyweight.

Gimmer, Williams, and Gill (1999) investigated the craniovertebral angle of 985 students (ages 12-18) with and without backpack load. The results indicated a significant change in craniovertebral angle across all years when comparing loaded and unloaded backpacks. The change was greater in younger students than in older students which may suggest that craniovertebral angle is an appropriate measure for studies of backpack weight carriage using an adult and not children population.

Gender Specific Differences in Gait

Kerrigan, Todd, and Della-Croce (1998) chose to examine the effect of gender on specific joint biomechanics during gait. Females had significantly greater hip flexion and less knee extension before the foot contacted the ground, greater knee flexion moment in pre-swing and greater absorption of energy at the knee in pre-swing. There was mention of other non-significant differences in gait among genders, however, they were not revealed. Kerrigan, Todd, and Della-Croce (1998) investigated the differences that may exist in females during load carriage. These gender differences may provide new insights into walking dynamics and may be important for both clinical and research studies in the development of separate biomechanical reference databases for males and females.

Smith, Lelas, and Kerrigan (2002) revealed that women exhibited significantly more pelvic obliquity range that did males (coronal-plane rotation of the pelvis). Gender differences were found between men and women with women having greater pelvic obliquity and less vertical center of mass displacement (COM). It is unclear if these differences are from gender, social or cultural effects. It is possible that women use greater pelvic motion in the coronal plane to reduce their vertical COM displacement and, thus, conserve energy during walking. Since the weight of the upper body is placed downward through the pelvis, control of pelvic motion is vital to maintaining whole body balance in the coronal plane. An increase in pelvic obliquity motion may be advantageous from an energy standpoint, but it is also associated with increased lumbosacral motion, which may have an increased risk for low back pain.

LaFiandra, Wagenaar, Holt, and Obusek, (2003) examined differences in gait dynamics while loaded with 40% of the subjects' body weight and revealing a decrease amount of pelvic rotation when carrying weight. They concluded that women display shorter stride lengths and higher stride frequencies when carrying a backpack. This is a result of decreased pelvic rotation. During unloaded walking, increases in pelvic rotation contribute to increases in stride length with increasing walking speed. The decreased pelvic rotation during load carriage requires an increased hip extension to compensate. However, the increase in hip extension is insufficient to fully compensate for the observed decrease in pelvis rotation, requiring an increase in stride frequency during load carriage to maintain a constant walking speed. This is suggestive of significant changes in the gait dynamics with loads of up to 40% of body weight.

Epstein, Rosenblum, Burstein, and Sawka (1988) examined a limit for weight that should be added to a subject while walking. Six aerobically trained subjects were tested while walking for 120 minutes on a treadmill at a speed of 1.25 $m.s^{-1}$ and 5% grade with a backpack load of 25 and 40 kg alternately. The study revealed that when loads are increased there was an increase in the amount of physical fatigue. This is an important consideration during testing under heavy loading conditions. Therefore, when subjects are under heavy loading conditions, the amount of walking should be in proportion to the unloaded condition.

Gender Difference in RPE during Exercise

Glass, Whaley, and Wegner (1991) revealed that there are gender differences. The differences were in the ratings of perceived exertion (RPE) at predetermined relative heart rate between two treadmill protocols and steady state exercise in a field setting. Thirty healthy male (N = 15) and female (N = 15) volunteers were maximally tested using the standard Bruce and a modified Balke (3.0 mph with 2.5% grade each two minutes) protocols. All subjects completed a field exercise trial consisting of an 800-m run. During the field trial, an investigator paced each subject to an individualized target heart rate (75% maximal heart rate reserve) calculated from the treadmill tests. During the last 50 m of the field trial, RPE values were recorded. Comparisons of the rating of perceived exertion at the target heart rate (RPE at THR) were made and there were significant gender x trials interaction for RPE at THR, with males reporting significantly higher values during the treadmill tests as compared to the females.

In contrast, O'Connor, Raglin, and Morgan (1996) examined the perceived exertion scale (RPE) and perceived dyspnea (RPD) during progressive arm ergometry to be somewhat different between 60 male and female subjects. The subjects completed a battery of questionnaires followed by progressive arm ergometry to exhaustion. Heart rate, minute ventilation, RPD and RPE were obtained during the last 30 seconds of every two-minute stage of the exercise test. The female group had significantly higher RPE (overall and local), RPD, minute ventilation, and heart rate than did the male group during exercise at absolute workloads. At each workload, both state anxiety and body awareness were significantly related to RPE and RPD in the male but not in the female sample. The results show that elevated trait anxiety is associated with dyspnea during arm ergometry and that gender differences in psychological correlates of perception during arm exercise, but the authors shed no light on why the gender differences may exist.

Robertson, Moyna, Millich, Goss, and Thompson (2000) determined the perception of exertion (RPE) for the overall body, chest, legs, and arms in 9 male and 10 female subjects by comparing absolute and relative oxygen uptake and heart rate. Subjects were compared during several different exercise modes including treadmill walking (weight bearing), simulated ski (partial weight bearing), and cycle (nonweight bearing) exercise. For each exercise mode, overall body, chest, legs, and arms RPE were higher in the female than in males when compared at submaximal absolute VO2. RPE did not differ between males and females at mode specific relative VO2. Differences in chest, legs, and arms RPE's were not found between females and male subjects when comparisons were made at both absolute and relative HR. RPE did not differ between gender when comparisons using the relativized VO2 and HR reference criteria at higher exercise intensities.

Energy Expenditures Focused on Males

The earliest studies of this type investigated the physiological responses of men only, because at this earlier time in history women were not allowed to serve in the armed forces. This left an interesting mark upon the history of energy expenditure of load transportation during walking. Due to the vast amount of research that was being done on males, the females were vastly underrepresented. As time passed and more research was completed, the females were continually left out of the research because all of the previous research into energy expenditure during transport was completed using only males.

Pimental and Pandolf (1979) mentioned that previous studies; Bobbert, 1960; Cotes and Meade, 1960; Durnin and Passmore, 1967; Givoni and Goldman, 1971; Goldman and Impetro, 1962; Margaria, Cerretelli, Aghemo & Sassi, 1963; Workman and Armstrong, 1963 were limited in there scope based upon, ranges of speed, grade, load. They did not make provisions for the different types of walking surfaces; for not eliminating the effects of external load and subjects weight separately (ie. calculating the energy cost per unit total weight instead of separation the weight of the body from the external load). However, there was no mention of gender differences.

Pimental and Pandolf (1979) used eight fit male subjects (mean = 24yrs, 176 cm, 79kg) who stood and walked at speeds of $0.5 m \cdot s^{-1}$ (1.12 mph) or $0.5 m \cdot s^{-1}$ (2.01 mph) throughout various grades ranging from -10% and 25%. The subjects were given a 25 kg and 40 kg backpack load. Pimental and Pandolf (1979) had earlier found no significant differences among heart rates and energy expenditure (across all ten conditions) while standing. While only standing with loads of 25 kg to 40 kg increased energy expenditure, it was not to the point of significance. However these earlier differences may have been due to a greater amount of subjects (greater statistical power) or from using heavier loads of 0 to 50 kgs. Finally, Pimental and Pandolf (1979) determined that a load had a greater effect on energy expenditure while standing than did grade. They found that in standing conditions the changes to load and or grade affected energy expenditure only slightly.

Studies, such as the ones mentioned above, have focused on males, leaving a much unknown about women and energy expenditure during weighted backpack standing and walking. There are important aspects for future studies into the energy expenditure of walking, regardless of gender. The external weight that is to be loaded to the body must take in account the subjects body weight. This was a careful consideration into the development of methods for this study.

Unloaded Walking and Running

Bhambhani and Singh (1985) examined the metabolic costs and gait patterns of walking and running at self-selected and comfortable speeds in males (n=12) and females (n=12). Total oxygen consumption was used to determine the metabolic cost, and the analysis of gait was conducted during walking and running distances of one km (.621 miles). There were no significant differences in metabolism between males and females during walking. However, there did not seem to be differences in analysis of gait (vertical lift per stride or total vertical lift per km of distance run) between genders. In both sexes, the gross and net energy costs of running were significantly greater than walking. No significant gender difference was observed in the gross or net metabolic cost of walking.

During running, the gross and net metabolic costs were significantly higher in females than in males. Bhambhani and Singh (1985) stated, "It was hypothesized that this sex difference was due to the cumulative effect of several factors which were biomechanical and metabolic in nature."

Falls and Humphrey (1976) revealed variations during walking and running seen in women. The energy cost of level walking and level and grade running was determined in seven active women. The speeds of interest were four to eight km/hr (2.48-4.9 mph) walking and eight to 14.5 km/hr (4.9- 9 mph) running. Falls and Humphrey (1976) concluded that oxygen consumption and energy cost values were similar to those previously reported for men at equivalent walking and running speeds. They also indicated that women, when walking and running are similar in comparison of energy expenditure.

Kang, Chaloupka, Mastrangelo, and Hoffman, (2002) also investigated gender differences when comparing men and women. Kang et al. (2002) revealed various differences in biomechanical and physiological differences in gradient walking in men and women. Both men (n=11) and women (n=11) took part in four experiments consisting of eight minutes treadmill walks gradients of 0 %, 5 %, 10 % and 15%. The subjects were also measured for body fat, height, lean body mass, and weight to hip ratios. During exercise, each subject was videotaped for the analysis of gait on such factors as step frequency and step length and ranges of motion of the shoulder, hip and knee during a walking cycle. This analysis was performed with a motion analysis, a similar instrument that was used in the current study.

Kang et al. (2002) concluded that women had higher percentages of body fat, but were shorter in stature, and body mass, lean body mass. However, the relative oxygen consumption (measured per kilogram per minute) and heart rate were similar between men and women at 0% and 5%, but greater in women than men at 10 % and 15 % grade. Men and women are most similar in energy levels at rest and these differences become increasingly apparent as exercise intensity increases.

Energy Expenditure and Stature

Censi, Toti, Pastore, and Ferro-Luzzi (1998) investigated the energy differences between short and tall men during loaded walking. Forty-six young men were chosen based upon their height and assigned to the group of short, S (n = 25, mean stature = 1.65 +/- 0.03 m) or of tall, T (n = 21, mean stature = 1.87 +/- 0.04 m). Body composition was estimated by underwater weighing and basal metabolic rate was measured with a Douglas bag during treadmill walking. Body composition for the tall men was 20% higher than it was for the short men. The energy cost of walking was 27% higher in the taller men than in short men. However, 9% and 5% lower when standardized for body weight (BW) and fat free mass (FFM) respectively. The differences disappeared when expressing the energy cost of walking as net cost per kg FFM. In conclusion, tall subjects showed a lower metabolic per pound than did the shorter subjects. This may be due to the proportion of metabolically active organs that make up a greater percentage of proportion to the short men's weight. Censi, et al. (1998) revealed significant overestimates BMR of both short and tall people, but there is no simple explanation of this observation. The energy cost of walking is less affected by stature when correcting for fat free mass (Censi, et al., 1998)

Energy Expenditure Body Composition

Metabolic rate is altered by factors such as muscle mass, hormones. The muscle an individual possesses the more calories they expend during both rest and exercise. Therefore, estimating the amount of muscle mass was an important characteristic to consider. Westerterp and Goran (1997) measured metabolism and body fat (indirectly with a doubly labeled water technique) of 290 healthy adult male subjects. In females, no relationship was found between physical activity and body fat. The confounding research of Westerterp and Goran (1997) concluded that males showed an inverse relationship between body composition and metabolism, whereas no such relationship was apparent in females.

The meta-analysis by Carpenter, Poehlman, O'Connell, and Goran, (1995) investigated the influence of body composition, resting metabolic rate (RMR), and sex on variation in total energy expenditure (TEE). When TEE was adjusted for RMR, there was no significant correlation between TEE and body fat, and females had a significantly lower TEE than males. Carpenter, Poehlman, O'Connell, and Goran (1995) also indicated a need for more research for the development of prediction models for total energy expenditure in adults.

Ferraro, Lillioja, Fontvieille, Rising, Bogardus, and Ravussin (1992) investigated the difference between men and women's (235 healthy male and female subjects) metabolic rates in comparison to body composition. Women were found to have an increased amount of body fat when compared to men. Sedentary energy expenditure is approximately 5-10% lower in females compared with males after adjusting for differences in body composition, age, and activity.

Loading Limbs during Walking

Miller and Stamford (1987) compared the energy cost of males and females while adding ankle and hand weight at various walking and running speeds. They found that there were no gender differences when adding weights to the limbs (wrist and ankle). Intensity of effort and energy cost per minute and per mile was increased when weight was added during walking. However, there was a greater increase in oxygen consumption when weights were added to the arms instead of the ankles regardless of speed. During non-weighted walking, the energy cost (kcal/mile) was significantly greater at 4 mph compared with 2 and 3 mph. The slower speed showed no distinct gender differences. It is important to note that a difference in energy was only seen during walking at higher speeds and without weights. In conclusion, walking at 4 mph with ankle and hand weights was comparable to running at 4 mph. This indicates that there is no difference between males and females when adding only weight to either the arms or the legs.

Energy Expenditure and Backpack Designs

Kirk and Snider (1992) investigated eleven females walking on a treadmill at a speed of 3.13 mph. The grade of the treadmill alternated every 15 minutes between 0% and a 3% grade. On separate days the subjects carried either internal or external frame backpacks, with weight equaling approximately 33% of their bodyweight. There we no significant differences found for cardiovascular, metabolic or perceptual between the two backpack conditions. However, changes to grade had significant effects to oxygen consumption, heart rate and minute ventilation regardless to which pack was used. It was concluded that different backpack frame designs produced no significant differences in metabolic rates. Regardless of backpack design the measure of oxygen consumption will be free from error having to do with the types of backpacks used.

The study by Kirk and Snider (1992) was similar to the current research. Forward trunk lean is another variable investigated of interest. Forward trunk lean is critical for the determination of increased loading. As the weight increases the load (backpack) shifts the body's center of gravity posteriorly. In order for the body to regain its balance the trunk must lean forward to adjust to the changing center of gravity produced by the backpack. Without this forward trunk lean it would be impossible to maintain balance while walking. This forward trunk lean will increase the metabolic cost of walking because it will take more muscles to maintain posture while walking. (Chansirinukor, Wilson, Grimmer, & Dansie, 2001) An increase in metabolism will increase the amount of calories it takes to walk a given distance. Increasing or adding weight is but one aspect that will lower the economy of walking (Goodgold, Mohr, Samant, Parke, Burns, & Gardner, 2002).

Bloom and Woodhull-McNeal (1987) also investigated both internal and external backpack designs in men (n=9) and women (n=7) ages 19-26 years. Subjects were active college student with previous experience using backpacks for hiking. The backpacks were loaded with 19kg for males and 14kg for females. Bloom and Woodhull-Mcneal (1987) revealed that men prefer internal frame and women prefer the external framed backpacks. However, there were no significant differences in body posture between either backpack, despite significant postural changes seen in both designs. They theorized that the internal backpack would keep the load more central to the body, providing increased stabilization and less moment of inertia during walking. There were no significant differences in the variables measured. The internal frame backpacks were suggested to require more compensation because it rides lower on the hips. This lower position was said to be advantageous when transverse across rough terrain. The external frame backpack was suggested to be better suited for terrain that is more flat.

Despite individual backpack design preferences there was little or no differences found between an internal and external backpack designs in relation to energy consumption. Both designs have slight advantages (based mostly on preference) depending on the terrain encountered. However, this study will consist of a controlled environment (graded flat terrain) either backpack design would not have any effect upon the outcome of this research project.

Summary

As we know, the human gait and load carriage via backpack has many aspects that remain to be discovered. A search of the literature revealed that the area of load carriage has an obvious focus toward the male subjects leaving a paucity in research focusing on direct comparisons between males and females. When gender studies were conducted for the possibility of gender differences during load carriage, much of it was confounded. Research of past shows similarities, as well and differences, between males and females in; weight carried vs. bodyweight, body positioning, metabolic factors, perception of exercise intensities (RPE), fitness levels and many other factors. Load carriage is a limitless and vast frontier with endless implications and possibilities. Further research into the differences between males and females for a better insight during load carriage is warranted. Most of the research studies of the past were not sensitive to the differences between genders and did not address the differences listed above within their methodologies. This may be an explanation of why there are confounding results and somewhat confusing conclusions from earlier research.

CHAPTER III

METHODS

Subjects

The Institutional Review Boards (IRB) of both the University of Central Oklahoma and Oklahoma State University approved this study (Appendix A). A total of 24 subjects volunteered for this study (12 male and 12 female, 23.58 ± 2.31 years of age and 22.41 ± 2.19 years of age, respectively). Recruitment of subjects was conducted through a sample of convenience and through investigator solicitation. The subjects appeared to be healthy and moderately active individuals as indicated by the Godin Leisure Time Exercise Questionnaire (GLTAQ) (Appendix B) and the Physical Activity Readiness Questionnaire (PAR-Q) (Appendix C). A physically active sample was chosen for this study to ensure that the testing protocols could be completed with all subject groups and at minimal risk of injury. Subjects were asked to refrain from vigorous exercise, alcohol, drugs, and medications for at least 24 hours before testing; however, no direct controls were in place.

Table I
Testing Protocol

Preliminary Procedures	
Paper work	
Body Fat	
Height \ Weight	
Heart Rate\Blood Pressure	
Data Collection Procedures	
***Backpack Carrying Phase 1**	
Unloaded Standing Resting	Oxygen Consumption
Unloaded Walking Procedure	Oxygen Consumption \Forward Trunk Lean \RPE
Unloaded Self-select Procedure	Oxygen Consumption \ Forward Trunk Lean \RPE
Rest	
***Backpack Carrying Phase 2**	
15% Standing Resting	Oxygen Consumption
15% Walking Procedure	Oxygen Consumption \Forward Trunk Lean \RPE
15% Self-Select Procedure	Oxygen Consumption \Forward Trunk Lean \RPE
Rest	
***Backpack Carrying Phase 3**	
30% Standing Resting	Oxygen Consumption
30% Walking Procedure	Oxygen Consumption \Forward Trunk Lean \RPE
30% Self-Select Procedure	Oxygen Consumption \Forward Trunk Lean \RPE

*Phases were assigned in random and counter-balanced order.

Preliminary Procedures

After the solicitation of the subjects and on the first day of testing participants were asked to report to the human performance laboratory on the campus of the University of Central Oklahoma. All subjects read and signed the IRB approved informed consent, PAR-Q, and GLTEQ. The subject's body fat, height, weight, and body mass index (BMI) were measured by research assistants. Subjects' blood pressure and heart rate were checked to ensure they were in a "normal" range (<100 bpm and 140\90) before testing began (see instrumentation below). Subjects were excluded based on the following criteria: answering yes to any question indicated on the PAR-Q and earning a combined score greater than 56 or less than 30 as indicated on the GLTEQ.

Data Collection Procedures

Each subject received a random assignment for each of the three backpack carrying phases of 0%, 15% and 30% [BWT]. Subjects were properly fitted with an internal frame backpack (Gregory Petit Dru®, suggested retail price $425 dollars). The pack was equipped with features such as a padded hip belt, sternum strap, and shoulder lifters and was individually adjusted for each subject according to the manufacturer's suggestions. Appropriate fit parameters included torso length, hip belt positioning, and shoulder and sternum strap width and tightness. The capacity of the backpack was approximately 5,000 in^3, and the pack was loaded with plastic coated scuba diving weights. The subjects were properly fitted with a headpiece (Rudolph® two-way rebreathing valve and head support) for collection of respiratory gases, which was worn during all testing procedures. There was a 15-minute rest period between each of the three phases. All three backpack carrying phases included standing at rest on the treadmill, walking on the treadmill at 3 miles per hour and self-selecting a walking speed on the treadmill. Grade was held at a constant 3% across all phases (see sample protocol above). During the self-selection procedures the treadmill was completely stopped, and the subjects were asked to select a treadmill speed at which they felt most comfortable while walking. The subjects adjusted their speed with hand gestures until the proper speed was reached.

During the walking and self-selected procedures, a Parvomed TrueMax 2400® metabolic cart recorded oxygen consumption. In addition, a digital camera (Cannon ZR 90) captured images of subjects for the analysis of forward trunk lean during each of the walking phases. Digital pictures were analyzed by Peak Motus® software for the determination and measurement of forward trunk lean. Finally, RPE was recorded using a 6-20 scale (Borg, 1970) during each minute of testing. Each testing procedure lasted approximately five minutes or less to reach "steady state" and collect the metabolic data. The backpack carrying phases lasted approximately 30 minutes and included standing-resting, walking, and self-selecting. There were intermittent rest periods of 15 minutes between each phase. The testing of each subject was completed in approximately 1.5 hours. Data collection of all subjects lasted over four days.

Instrumentation

1. Blood Pressure- blood pressure was measured using a Baumanometer, sphygmomanometer and a stethoscope. Proper procedure was followed for each subject tested (ACSM, 2000).
2. Heart Rate- heart rate was determined by palpitation of the radial artery for 15 seconds and multiplying by four for estimation of pulse rate per minute (ACSM, 2000).
3. Informed Consent- is a document that educates the participants about risks and benefits and obtains their consent before involving them in research, while keeping them informed. The University of Central Oklahoma and Oklahoma State University approved the informed consent, however, this study is under the authority of Oklahoma State University (Appendix A).
4. Godin Leisure Time Exercise Questionnaire -this questionnaire was modified for use in this particular study. It was adapted for the determination of activity levels of the subjects' (Godin & Shepard, 1985). Subjects' were screened on the basis of meeting the minimal requirements of exercise (equaling a score greater than 30)

determined by the American College of Sports and Medicine (ACSM, 2000). ACSM states that a minimal of 30 minutes per day, most days of the week, is considered the classification of a non-sedentary individual. Composite scores greater than 56 were considered too active and not allowed to participate. Subjects' recorded how many times per week under one of three categories of intensity. The numbers of 15 minutes intervals of activity were multiplied by the following; 1) weekly leisure activities were multiplied by 9 for each 15 minutes block of strenuous of activity; 2) multiplied by 5 for each 15 minutes block of moderate activity; 3) multiplied by 3 for each 15 minutes block of mild activity (Appendix B).

5. PAR-Q -Physical Activity Readiness Questionnaire is a standardized method for classifying subjects as apparently healthy (Shephard, 1988). The PAR-Q addresses questions such as heart trouble, chest pain, dizziness, blood pressure, orthopedic problems, and general reasons why one should not exercise (Appendix C).

6. Parvomed TrueMax® 2400 Metabolic Cart - "a fundamental aspect of exercise testing and prescription is the ability to measure or estimate energy expenditure during exercise, like all metabolic events, produces heat, the rate of heat produced is directly proportional to the energy expended" (ACSM, 2000). Measuring heat production (direct calorimetry) is difficult, energy expenditure is often times measured indirectly, such as with oxygen consumption by a metabolic cart. This requires the subjects' to exercise while breathing into a tube that is measuring inspiratory (breath in) and expiratory (breath out) gases. Bassett, Howley,

Thompson, King, Strath, McLaughlin, and Parr (2001) found the Parvomedics TrueMax 2400 to have extreme precision when measuring oxygen consumption.

7. Peak Motus® v.7.0 - window based motion capture system that combines video with proprietary hardware to capture the coordinates of moving points. With these coordinates, accurate biomechanical data is produced, including velocities, accelerations, center of mass, distances and angles. Peak Motus® is robust in its ability to integrate numerous data acquisition methods and calculations so that kinematic and kinetic data can be synchronized and displayed or printed as stick figures, graphics, video images, and numerical data (Peak Performance technologies, Inc. Colorado).
8. Rate of Perceived Exertion (Borg) – "a scale from 6-20 that measured the perceived amount of exertion, or how hard you feel that your body is working during exercise. It is based on the physical sensations or experiences during physical activity, including increased heart rate, increased respiration or breathing rate, increased sweating, and muscle fatigue. Although this is a subjective measure, a person's exertion rating may provide a good estimate of the actual heart rate during physical activity" (Borg, 1970). "During the exercise test we want you to pay close attention to how hard you feel the exercise work rate is. The feeling should reflect your total amount of exertion and fatigue, combining all sensations and feelings of physical effort, and fatigue. Do not 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. Try not to underestimate or overestimate your feeling of exertion; be as accurate as you can" (Morgan &

Borg, 1976). Furthermore, the research of Borg, Hassmén, and Lagerström (1987) concluded, "exercise of a steady state type with increasing loads the incremental curve for perceived exertion can be predicted from a simple combination of heart rate and blood lactate." RPE appears to be an accurate and reflective measure of exercise intensity for both male and female subjects. The current research is in agreement with the Borg et al., (1987) showing that gender did not influence the validity of RPE. Chen Fan, and Moe (2002) meta-analysis found the Borg scale to be a reliable instrument (Appendix D).

9. Skin Fold Measurements- A Lange® skinfold caliper was used for the measurements of skinfolds and followed standard anthropometrical procedure (ACSM, 2000; Lohman, Roche, & Martorell, 1988). The Jackson-Pollock three-site equation was used and determined to be an accurate and reliable way to measure body composition (Jackson Pollock, 1978; Jackson, Pollock, & Graves, 1986; Jackson, Pollock, & Ward, 1980). The body density was converted into a percentage of body fat by the Siri equation (Siri, 1961).

Statistical Analysis

A 2 X 3 repeated measure of ANOVA design (Hyllegard, Mood & Marrow, 1996) was used to identify significant differences for each of the dependent variables (RPE, net metabolic rate and forward trunk lean). Statistical significance was set at an alpha level of $p < .05$ level. Data were analyzed with SPSS 11.5, between both groups on all dependant variables across all backpack loads (0%, 15% and 30% [BWT]).

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

This chapter reports the analysis for the dependent variables in college-aged males and females with subsequent discussion of the results that were significant to the stated hypothesis. The intended purpose of this study was to determine the effects of three backpack loads (0%, 15% and 30% [BWT]). The two groups were categorized by gender and tested across all three backpack loads for forward trunk lean, rate of perceived exertion (RPE), and the net metabolic cost of exercise.

Descriptive Data

Data were collected from both males and females during a period of approximately four days. Participants were administered questionnaires such as the physical activity readiness questionnaire (PAR-Q) and the Godin Leisure Time Activity Questionnaire (GLTAQ) to access the subjects' activity levels. The testing began with a total of 24 subjects (12 males and 12 females). The combined mean values for both males and females for age, BMI, weight, body fat, and height were 23 (±2.28) years, 23.11 (±4.90), 71.84 (±13.94) kg, 19.37(±6.77) percent and 175.18(±10.35) cm, respectively (Table II). The mean values and standard deviations for age, BMI, weight, body fat, and height of the male subjects were 23.58 (± 2.31) years, 23.29 (± 6.15), 81.99 (± 11.31) kg, and 15.80 (± 6.59) percent and 181.47 (± 8.13) cm, respectively (Table II). For the females, the means and standard deviations for these same variables were 22.41 (± 2.19) years, 22.93 (± 3.51), 61.69 (± 7.30) kg, and 22.95 ± 4.95 percent and 168.89 (± 8.47) cm, respectively (Table II).

Table II
Descriptive Statistics

	N	Age (y±SD)	BMI(m^3±SD)	Wt(kg±SD)	BF(pct±SD)	Ht(cm±SD)
Males	12	23.58 ±2.31	23.29 ±6.15	81.99 ±11.31	15.80 ±6.59	181.47 ±8.13
Females	12	22.41 ±2.19	22.93 ±3.51	61.69 ±7.30	22.95 ±4.95	168.89 ±8.47
Group	24	23 ±2.28	23.11 ±4.90	71.84 ±13.94	19.37 ±6.77	175.18 ±10.35

Hypotheses

Hypotheses were tested to determine if there were significant differences between and within the two groups. Repeated measures of analysis (ANOVA) were used to analyze the effects of gender and load. The 0.05 probability level was used for all tests as the criterion value to determine the presence or absence of significant differences.

Results of Hypothesis 1

HO_1= There will be no significant differences between college-aged males' and females' standing-resting metabolic rates among all backpack loads of 0%, 15%, and 30% [BWT].

The null hypothesis will be accepted based upon a 2 X 3 repeated measure of ANOVA that revealed no significant gender differences in net metabolic rates existed between college-aged males and females while standing at rest on a treadmill at a 3% grade across all backpack loads of 0, 15%, and 30% [BWT] (F = .413, df = 1, p =. 527). There were no significant within-subjects interactions across load x gender (F =2.96, df =

2, p =. 062). However, the main effects of load were found to be significant (F = 10.861, df = 2, p = .000) (Table III & Figure 1).

Table III
Standing-Resting Means

	GENDER	Mean	Std. Deviation	N
REST0	1.00	3.6742	.8262	12
	2.00	3.9967	.3417	12
	Total	3.8354	.6399	24
REST15	1.00	4.3183	.5068	12
	2.00	4.0533	.4584	12
	Total	4.1858	.4916	24
REST30	1.00	4.3217	.5276	12
	2.00	4.5608	.3535	12
	Total	4.4413	.4559	24

1=male, 2=female

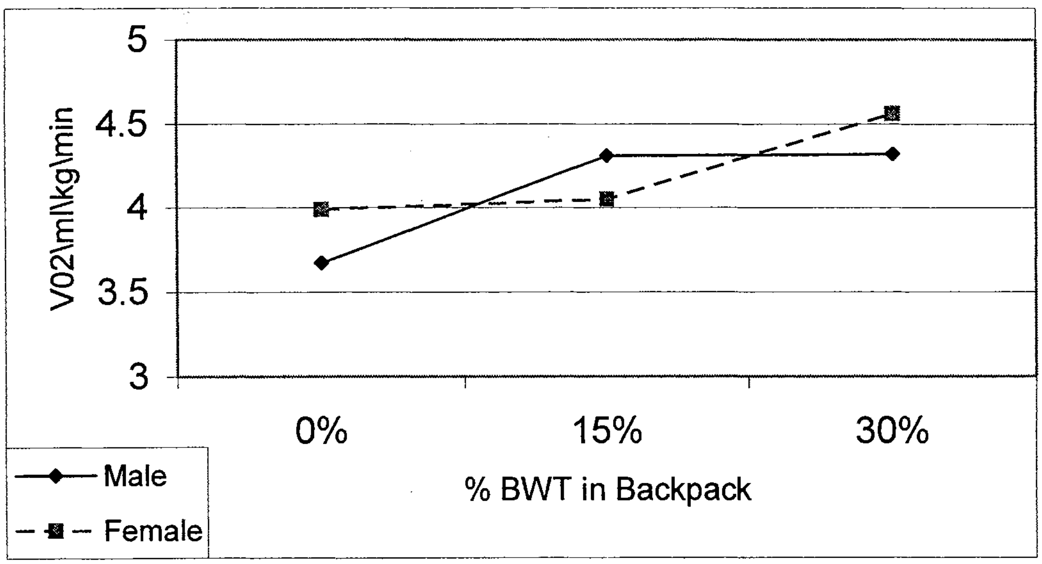

Figure 1. Standing-Resting Metabolic Rates

Results of Hypothesis 2

HO_2= There will be no significant differences in college-aged males' and females' net metabolic cost of walking at a 3% grade and 3 miles per hour among all backpack loads of 0%, 15%, and 30% [BWT].

The null hypothesis will be accepted based upon a 2 X 3 repeated measure of ANOVA that revealed no significant differences exist between college-aged males and females in net metabolic rates of walking at a 3% grade and 3 mi·hr^{-1} across all backpack loads of 0%, 15%, and 30% [BWT] (F = .041, df = 1, p =. 841). There were no significant within-subjects interactions across load x gender (F =. 773, df = 2, p = .468). However, the main effects of load were found to be significant (F = 70.26, df = 2, p = .000) (Table IV & Figure 2).

Table IV
Walking Metabolic Rate Means

	GENDER	Mean	Std. Deviation	N
WALK0	1.00	9.9450	2.0109	12
	2.00	10.7833	1.4783	12
	Total	10.3642	1.7784	24
WALK15	1.00	13.6683	1.7429	12
	2.00	13.2008	2.3806	12
	Total	13.4346	2.0543	24
WALK30	1.00	16.6750	2.5238	12
	2.00	16.6717	2.3364	12
	Total	16.6733	2.3785	24

1=male, 2=female

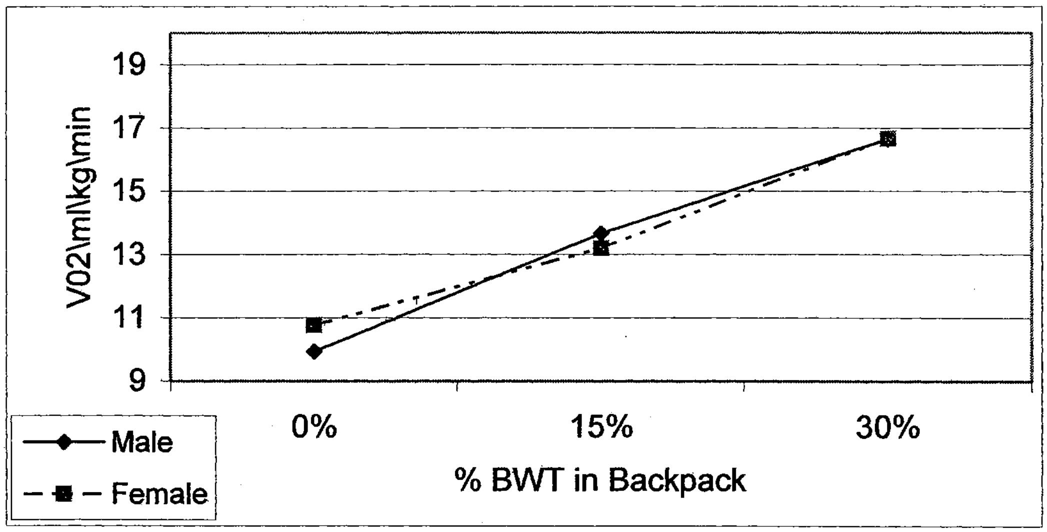

Figure 2. Metabolic Rates during Walking

Results of Hypothesis 3

HO_3= There will be no significant differences between college-aged males' and females' net metabolic cost of walking at a 3% grade at self-selected speed among all backpack loads of 0%, 15%, and 30% [BWT].

The null hypothesis will be accepted based upon a 2 X 3 repeated measure of ANOVA that revealed no significant differences exist between college-aged males and females in net metabolic rates of walking at a 3% grade and a self-selected speed across all backpack loads of 0%, 15%, and 30% [BWT] (F = .197, df = 1, p =. 662). There were no significant within-subjects interactions across load x gender (F =. 773, df = 2, p = .862). However, the main effects of load were found to be significant (F = 11.82, df = 2, p = .000) (Table V & Figure 3).

Table V
Self-Select Metabolic Rate Means

	GENDER	Mean	Std. Deviation	N
SELF0	1.00	10.7008	3.9573	12
	2.00	11.5558	3.0434	12
	Total	11.1283	3.4799	24
SELF15	1.00	12.2000	3.8469	12
	2.00	12.4617	3.2938	12
	Total	12.3308	3.5049	24
SELF30	1.00	13.5567	2.2133	12
	2.00	13.9883	2.8741	12
	Total	13.7725	2.5183	24

1=male, 2=female

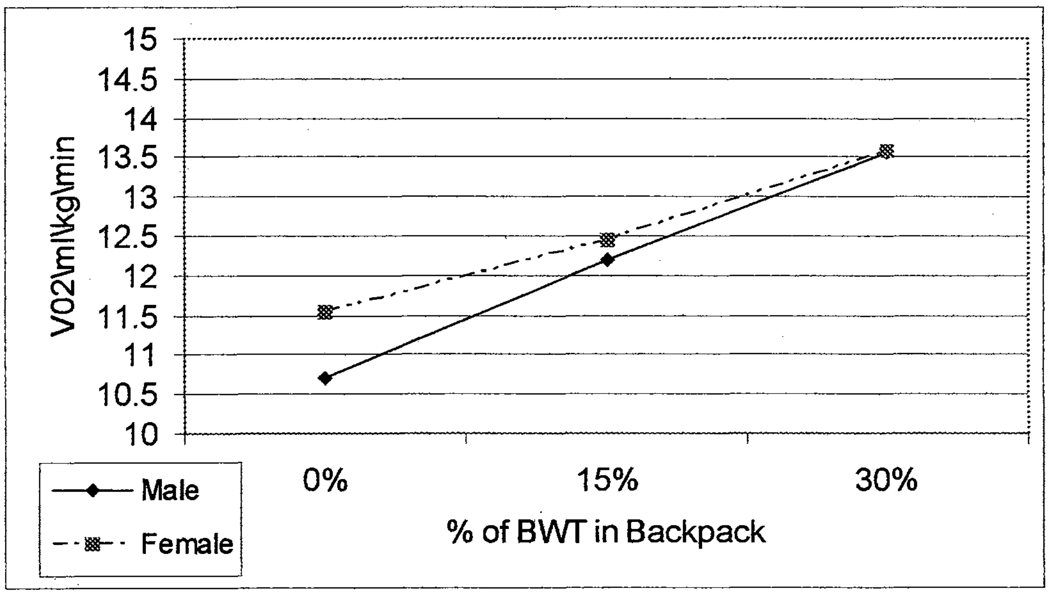

Figure 3. Self-Selection Metabolic Rates during Walking Speed

Results of Hypothesis 4

HO_4= There will be no significant differences between college-aged males' and females' RPE during walking at a 3% grade and 3 miles per hour among all backpack loads of 0%, 15%, and 30% [BWT].

The null hypothesis will be accepted based upon a 2 X 3 repeated measure of ANOVA that revealed no significant differences exist between college-aged males and females in RPE during walking at 3% grade and 3 miles per hour across all backpack loads of 0%, 15%, and 30% [BWT] (F = .012, df = 1, p =. 913). There were no significant within-subjects interactions across load x gender (F =. 073, df = 2, p = .929). However, the main effects of load were found to be significant (F = 58.05, df = 2, p = .000) (Table VI & Figure 4).

Table VI
Walking RPE Means

	GENDER	Mean	Std. Deviation	N
RPEW0	1.00	8.2917	1.6849	12
	2.00	8.2500	1.7645	12
	Total	8.2708	1.6874	24
RPEW15	1.00	10.4583	2.1686	12
	2.00	10.4583	1.3728	12
	Total	10.4583	1.7749	24
RPEW30	1.00	12.5833	2.3143	12
	2.00	12.8333	2.0926	12
	Total	12.7083	2.1615	24

1=male, 2=female

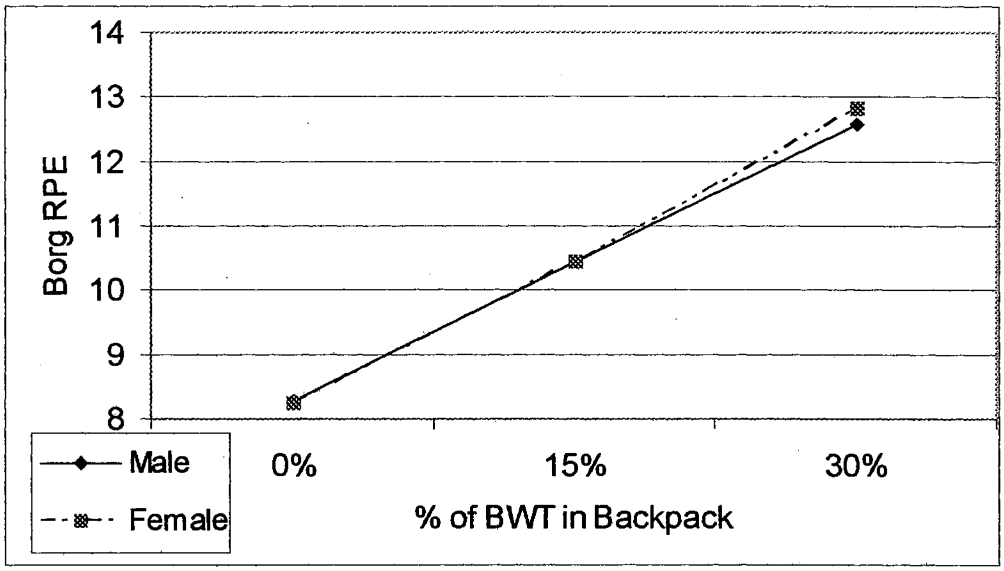

Figure 4. RPE during Walking

Results of Hypothesis 5

HO_5= There will be no significant differences between college-aged males' and females' RPE during walking at a 3% grade and self-selected speed among all backpack loads of 0%, 15%, and 30% [BWT].

The null hypothesis will be accepted based upon a 2 X 3 repeated measure of ANOVA that revealed no significant differences exist between college-aged males and females in RPE during walking at 3% grade and a self-selected speed across all backpack loads of 0%, 15%, and 30% [BWT] (F = .197, df = 1, p =. 662). There were no significant within-subjects interactions across load x gender (F =. 955, df = 2, p = .393). However, the main effects of load were found to be significant (F = 35.53, df = 2, p = .000) (Table VII & Figure 5).

Table VII
Self-Select RPE Means

	GENDER	Mean	Std. Deviation	N
RPES0	1.00	8.9583	1.7896	12
	2.00	8.7500	1.4848	12
	Total	8.8542	1.6116	24
RPES15	1.00	10.1250	2.3367	12
	2.00	11.2500	1.4222	12
	Total	10.6875	1.9771	24
RPES30	1.00	12.6667	2.6996	12
	2.00	13.1667	2.2088	12
	Total	12.9167	2.4257	24

1=male, 2=female

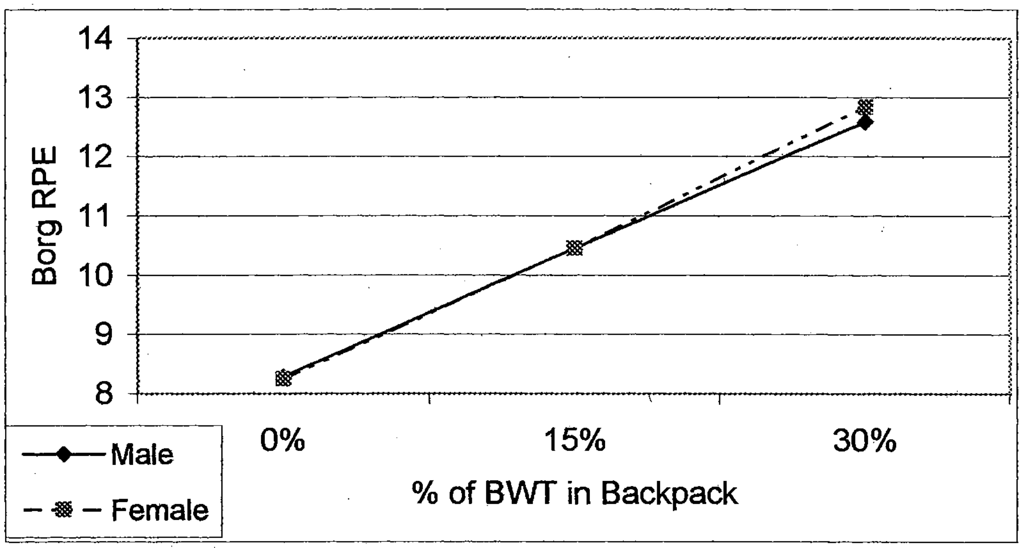

Figure 5. RPE during Self-Selection

Results of Hypothesis 6

HO_6= There will be no significant differences between college-aged males' and females' forward trunk lean during walking at a 3% grade and 3 miles per hour among all backpack loads of 0%, 15%, and 30% [BWT].

The null hypothesis will be accepted based upon a 2 X 3 repeated measures of ANOVA that revealed no significant differences exist between college-aged males and females in forward trunk lean during walking at 3% grade and 3 miles per hour across all backpack loads of 0%, 15%, and 30% [BWT] ($F = .012$, $df = 1$, $p = .912$). There were no significant within-subjects interactions across load x gender ($F = .025$, $df = 2$, $p = .976$). However, the main effects of load were found to be significant ($F = 123.33$, $df = 2$, $p = .000$) (Table VIII & Figure 6).

Table VIII
Walking Forward Trunk Lean Means

	GENDER	Mean	Std. Deviation	N
FTL0	1.00	3.5000	4.1010	12
	2.00	3.3333	2.2293	12
	Total	3.4167	3.2292	24
FTL15	1.00	10.5833	3.6045	12
	2.00	10.6667	2.9949	12
	Total	10.6250	3.2412	24
FTL30	1.00	18.4167	6.3024	12
	2.00	18.0833	3.8720	12
	Total	18.2500	5.1182	24

1=male, 2=female

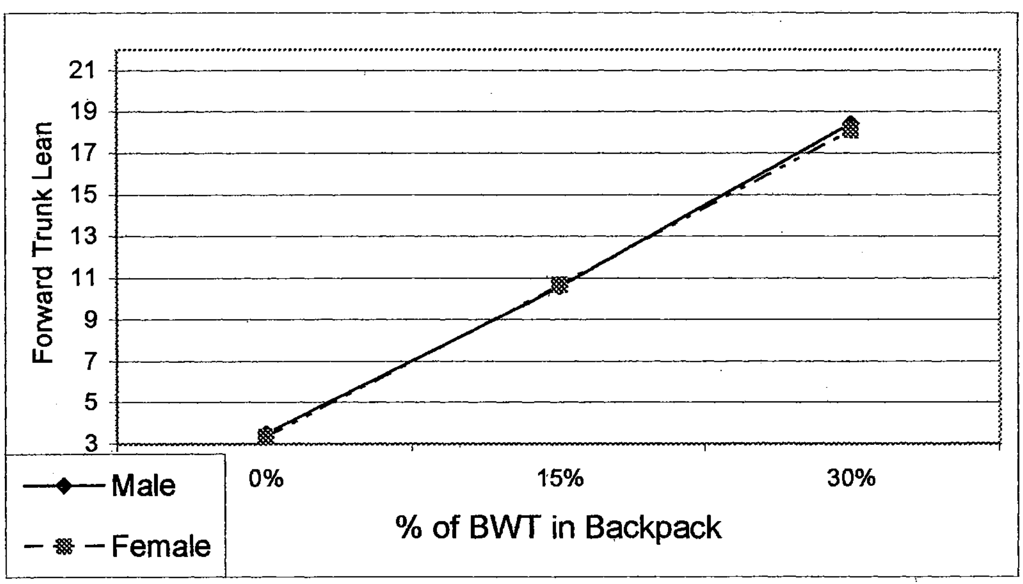

Figure 6. Forward Trunk Lean during Walking

Results of Hypothesis 7

HO_7= There will be no significant differences between college-aged males' and females' forward trunk lean during walking at a 3% grade and a self-selected speed among all backpack loads of 0%, 15%, and 30% [BWT].

The null hypothesis will be accepted based upon a 2 X 3 repeated measure of ANOVA that revealed no significant differences exist between college-aged males and females in forward trunk lean during walking at 3% grade at a self-selected speed across all backpack loads of 0%, 15%, and 30% [BWT] (F =. 001, df = 1, p =. 981). There were no significant within-subjects interactions across load x gender (F =. 068, df = 2, p = .934). However, the main effects of load were found to be significant (F = 140, df = 2, p = .000) (Table IX & Figure 7).

Table IX
Self-Select Forward Trunk Lean Means

	GENDER	Mean	Std. Deviation	N
FTLSELF0	1.00	2.8333	2.4802	12
	2.00	3.1667	2.4058	12
	Total	3.0000	2.3956	24
FTLSF15	1.00	10.5833	3.6045	12
	2.00	10.6667	2.9949	12
	Total	10.6250	3.2412	24
FTLSF30	1.00	18.4167	6.3024	12
	2.00	18.0833	3.8720	12
	Total	18.2500	5.1182	24

1=male, 2=female

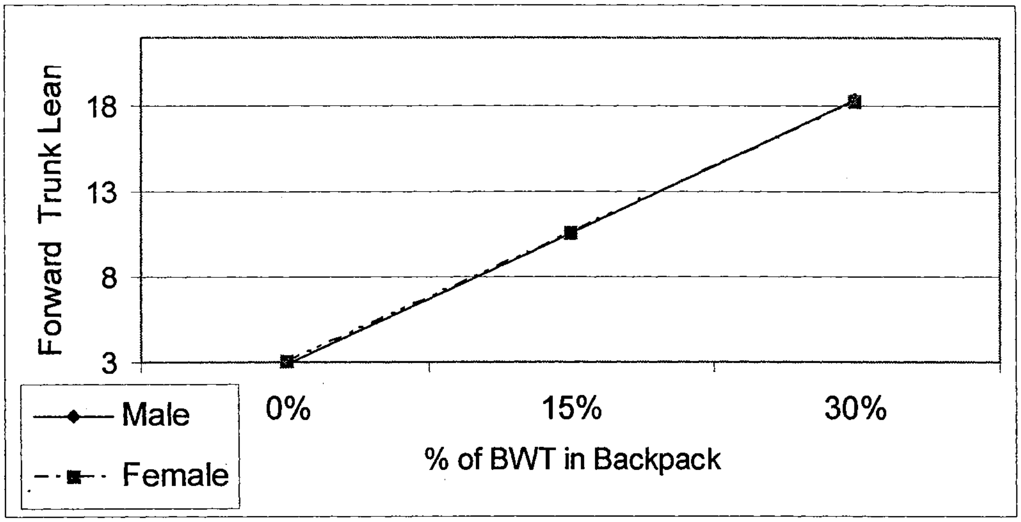

Figure 7. Forward Trunk Lean during Self-Selection

Discussion of Results

The purpose was to determine if gender differences exist between males and females while carrying weight via backpack by comparing the effects of three different backpack loads during walking. The responses to the increases in backpack weight during the three conditions were large enough to be significantly different for all variables (RPE, metabolism, forward trunk lean) for the total group. These sections expound on the findings and compare them to prior research conducted on healthy and active college males and females.

Standing resting metabolic rates

The results of this study indicated there are no significant differences during standing-resting metabolic rates between college-aged males and females across all backpack loads of 0%, 15%, and 30% [BWT]. The standing-resting metabolic rates were used to obtain a net metabolic cost of exercise between two groups by subtracting standing-rest oxygen consumption measures from the walking and self-selected metabolic measures. Obtaining a "true" net value ensured that the increases in metabolism were the result of exercise only. The standing metabolic rates between the two groups did not reveal any gender specific significant differences at rest with each backpack load ($p = .527$). Both groups revealed no significant interactions of load across gender. Increasing the backpack weight by 15% [BWT] during standing-rest significantly increased the metabolic cost for both males and females. However, men and women responded metabolically similarly during standing rest across all backpack loads.

Greater upper body strength and a greater capacity for exercise would appear to give males a distinct performance advantage over females. In regard to body size, men are physically larger giving them some anatomical advantages during aspects of weight carriage. Despite these apparent advantages, the current research revealed no metabolic differences existed between men and women during standing-resting and wearing a weighted or non-weighted backpack. It is well known that males and females share the same relative metabolic rate during rest (1 MET). However, comparisons between males and females closest to a resting level (such as standing with or without a weighted backpack) should result in no observable metabolic difference.

The results of this study were in agreement with previous studies by Quesada, Mengelkoch, Hale and Simon (2000) and Pandoff, Givoni, and Goldman (1977) who studied standing metabolic rates of both men and women during load carriage. The results from their study revealed that energy expenditure while carrying a backpack load of 15% bodyweight was relatively low in comparison to the standing resting values. Small increases in backpack weight resulted in significant increases in metabolism during standing-resting in both genders. In this study the heaviest standing condition (30% body weight) invoked the greatest metabolic response for all standing conditions. Apparently this was not intense enough to reveal any metabolic differences.

Walking Metabolic Rates

The walking condition resulted in an increase of approximately one-and-a-half times resting metabolic rate above that of the standing-resting condition. This metabolic increase was shown to be slightly higher than during a resting condition. During a treadmill walk and while carrying a weighted backpack, there may not have been a high enough amount of metabolic stress. Most of the backpack weight is loaded onto the hips in order to comfortably support the increased weight added to the body by the backpack. This is an important aspect to consider when any situation requires an absolute amount of weight to be carried. Any study comparing males and females while using absolute backpack loads may give the male subjects some slight advantage due to the larger body size.

The results of this study are in contrast to studies by Martin and Nelson (1986) and Bhambhani and Maikala, (2000) who found significant biomechanical and physiological gender differences during weighted backpack walking between men and women. Martin & Nelson (1986) and Bhambhani and Maikala (2000) required the subjects to carry absolute loads without consideration of body weight. It is well known that females, when compared to males, have less upper body musculature and consequently less strength (McCardle, Katch, & Katch, 2003). This would appear to be a distinct disadvantage to women based solely on their smaller body size and not from any gender limitation regarding oxygen consumption. However, when females carry weighted backpacks relative to their bodyweight during walking, as indicated by this research, it appears they are as metabolically efficient as their male counterpart. When a backpack is properly fitted and the weight loaded into the backpack is in relation to the females' overall bodyweight, it appears females are at no distinct disadvantage during walking at 3 miles per hour or a self-selected pace. However, some consideration must be given to the overall amount of weight loaded into the backpack. This weight should be in relation to body size, regardless of gender.

Rate of Perceived Exertion

This study is in contrast to research by Glass, Whaley, and Wegner (1991), who suggested gender differences in ratings of perceived exertion (RPE) between men and women at predetermined relative heart rate between two treadmill protocols and steady state exercise in a field setting. Also, O'Connor, Raglin, and Morgan (1996) found the perceived exertion scale (RPE) and perceived dyspnea scale (RPD) during progressive arm ergometry were significantly different between 60 male and female subjects. They found the RPE of women slightly higher than the RPE of men, but did not give explanation for these differences. The above studies used slightly different methodologies. For example, the studies did not include backpack carriage during walking, only using arm exercise protocols (arm ergometry). Other factors may have resulted in such physiological differences. These differences include higher heart rates of women who are given the same workloads. This is because the legs and arms of females are smaller and contain less muscle mass. Also, most females have smaller hearts and lower cardiac output; this causes the female heart to work harder during the same submaximal workload (McCardle, Katch, & Katch, 2003). In addition, gender differences in their study of RPE during arm and leg exercises may have caused the discrepancy between groups. It is well known that most females are smaller and generate less arm and leg power when in comparison to men. This would require females to work harder in order to maintain the same workload as a larger and more powerful male.

The study of Robertson, et al., (2000) shared similar methodologies as this study. The RPE for the overall body, chest, legs, and arms in 9 male and 10 female subjects were compared regarding absolute and relative oxygen uptake and heart rate. Subjects were compared during several different exercise modes including treadmill walking (weight bearing), simulated skiing (partial weight bearing), and cycling (non-weight bearing) exercise. RPE did not differ between genders when relative comparisons were made for oxygen consumption (metabolism) during higher exercise intensity. This supports the finding of this study during RPE and walking while carrying weight.

Forward Trunk Lean

No significant gender difference were noted in forward trunk lean during walking at 3% grade and 3 miles per hour across all backpack loads of 0%, 15%, and 30% [BWT]. When adding weight to a backpack, it is natural for forward trunk lean to begin to increase. As weight increases, there is a shift of the body's center of gravity, requiring the subject to compensate by leaning forward. In the attempt to maintain balance, the biomechanics of walking must also change to counteract the extra backpack weight. Without forward trunk lean, it would be impossible to maintain balance and, therefore, walking would be impossible. Gimmer, Williams, and Gill (1999) investigated the craniovertebral angle of 985 students (ages 12-18) with and without backpack loads. The results indicated a significant change in craniovertebral angle across all ages when comparing loaded and unloaded backpacks. The change was greater in younger, smaller students suggesting that the craniovertebral angle (forward trunk lean) may be size and not gender specific. With increasing age comes an increase in bodyweight. This increased bodyweight will naturally help to decrease the amount of forward trunk lean when carrying the same amount of backpack weight. Bloom and Woodhull-McNeal (1987) investigated both internal and external frame backpacks in men (n=9) and women (n=7) ages 19-26. However, there were no significant differences in body posture between either backpack designs, despite a shift in body positioning using both designs. The above studies are in agreement with the results of the current study and allude to the fact that increasing the amount of weight via backpack simultaneously increases forward trunk lean. Forward trunk lean seems independent of gender because increases in backpack weight had similar effects to trunk posture in both males and females. The smaller the individual, the more one must lean forward to offset the increased load to the back. However, the current study revealed that if the backpack weight is relative to the bodyweight, all subjects exhibit the same amount of postural adjustment as indicated by the amount of forward trunk lean. When either sex carries weight by backpack, it should be proportional to body size. When bodyweight is considered, females seem to have the same postural adjustments (forward trunk lean) as do males. This research recommends a limit for backpack loading should be based upon bodyweight, regardless of gender.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

There were no significant differences between males and females for the dependent variables of this study, except for the expected increases in metabolism when greater loads were added to the backpacks. The null hypothesis was retained for the variables of RPE, forward trunk lean, and the net metabolic cost of walking at a self-selected speed and 3 $mi \cdot hr^{-1}$ at a 3% grade across all backpack loads of 0%, 15%, and 30% [BWT] in college-aged males and females. However, if a female is to carry an absolute weight by backpack, 90 pounds for example, this weight will represent a greater percentage of her carrying capacity, in comparison to her heavier male counterparts. This absolute load could result in increased fatigue and metabolic and or anatomical stress to the female when there is no regard to the weight carried and the females' total bodyweight.

The methodology incorporated in this study ensured that the differences between males and females, ignored by research of the past, were properly addressed for a more appropriate comparison. The current research revealed that when comparisons of gender are on an equal basis, such as the amount of weight carried relative to bodyweight, net metabolic rates (increases in metabolism accounted for by exercise only) and activity levels (for males and females of similar fitness levels), differences between men and women become far less apparent. Males and females were not significantly different during backpack walking while carrying various loads when in relation to their body weight or, more importantly, their lean body mass (amount of muscle). The current research did not find that females were exposed to increased fatigue, metabolic stress, or anatomical stress, perceived or otherwise, when carrying weighted backpacks while walking or standing. However, it is interesting that females seem to have anatomical disadvantages (smaller structures and less muscularity), decreased mechanical efficiency during walking (due to greater hip width and increased Q angle), and smaller capacity for maximal exercise (smaller heart, lungs and lower blood volumes).

This study examined the effects of carrying backpack loads on varying magnitudes of metabolism and posture as indicated by forward trunk lean. Males and females displayed similar responses in metabolism during graded treadmill walking. However, through observation alone, it appeared that the females seemed to experience more difficulty during the 30% BWT condition than did the males. One explanation may be that men may exhibit a greater exposure to "weighted walking" (through work or play) than do females. Subjects most tolerant of the heaviest backpack loads seemed to have in common a shorter torso and an increased amount of bodyweight. The shorter torso may have allowed the backpack to remain positioned higher upon the upper back while the subject used the hips as a shelf for the backpack to rest. A consensus among the subjects was that the weight was easier to transport if the backpack waist belt was slightly overtightened and the backpack rested higher upon the back with the straps tightly fitted around the torso and shoulders. Both groups voiced equal concern during the heaviest backpack loads, explaining that the shoulder straps were the most significant cause of discomfort. The backpack was outfitted with a hip belt that when tightened relieved most of the acute shoulder discomfort. Careful consideration was used when fitting all subjects; however, having only one size of backpack meant not all subjects were an identical fit.

Conclusions

The increasing popularity of the backpack ensures certainty for this means of transportation of items during walking. However, the future of backpack designs should focus on a more customized overall fit. Backpacks of the future could be fitted with loading or posture sensors that detect the amount of forward trunk lean, alerting the wearer of an overloaded backpack. Air chambers could be designed throughout the backpack, sensing an increased amount of weight and filling these air chambers for a more comfortable fit. The backpack of the future should be designed with consideration to the length of the torso. Future designs may consider forward trunk lean as an indicator of an overloading situation. This may be corrected by offsetting the weight on the back by loading additional compartments onto the chest. Many of these future design characteristics will only help the rising popularity of backpacking to become safer and more comfortable.

Recommendations

1. A larger, more random sample of the population of both men and women should be used.
2. Males and females with varying ages need future investigation.
3. Dietary controls would improve the validity of the study and may need to be addressed for future research.

4. Temperature and climate variations may reveal distinct individual differences between males and females.
5. Walking on only a treadmill gives a limited perspective during load carriage. Walking on more natural surfaces, as those encountered during hiking, may need more investigation.
6. Walking protocols during this study were less than five minutes. Increasing the walking time may reveal distinct gender differences.
7. Forward trunk lean may be an important indicator for how much weight is loaded into a backpack. Future research may be used to reveal more appropriate weight recommendations.
8. Testing subjects of different heights may reveal differences in load carriage by backpacks.
9. There are many different backpack designs and fitting characteristics. Investigations using several different types may reveal safer and more efficient way to carry loads with a backpack.
10. Investigations using external framed backpacks may reveal gender differences during backpacking.
11. Different sizes of backpacks could be used to ensure an exact fit for all subjects.
12. Extended periods of hiking may reveal gender differences not shown during laboratory settings.

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APPENDICES

APPENDEX A

CONSENT TO VOLUNTARY PARTICIPATION IN A RESEARCH PROJECT

This is to certify that I, ____________________ agree to participate as a volunteer in a study titled "The Gender Responses Of Load And The Dynamics Of Oxygen Consumption And Body Posture During Graded Walking In College Aged Males And Females". All testing will be completed in the Human Performance Laboratory at UCO in Edmond Oklahoma. The subjects and data will be completed at UCO, however, this study is under the authority of both the University of Central Oklahoma and Oklahoma State University. Supervision of testing will be under the direction of Mr. Brady Redus and representative research assistants.

Purpose:

The purpose of this investigation is to compare metabolic work, perceived exertion (RPE) and forward trunk lean during self selected and set treadmill speed (3% grade, 3.0 mph) using three different backpack-loads (0, 15% and 30% body weight [BWT]).

Procedure:

The subject will complete a standard Physical Activities Readiness Questionnaire and the Godin Leisure Time Activity Questionnaire to ensure they have no disqualifying conditions and that they are moderately active.

Testing Procedures

Height, weight, blood pressure, body fat, and heart rate will be recorded. Subjects will be fitted with a headpiece for collection of expiratory air. A Parvomed TrueMax 2400 metabolic cart will measure O2 consumption at standing rest, walking and self select procedures. A Peak Performance video camera will record and analyze trunk forward lean during each load. RPE will be recorded during each minute during walking. Subjects will walk on a treadmill (3% grade, 3.0 mph) three separate times with one of three randomly assigned loads (0, 15%, 30% BWT). Approximately 5 min or less of walking/load will be required to collect metabolic data. After each backpack carrying phase, the subjects will rest 15 min. Testing will take approximately 1.5 hrs.

Participation is voluntary and subjects may withdraw at any time without penalty. All collected day be confidential and will not be released in a format that will allow subject identification.

For questions concerning this research project contact Dr. Bert Jacobson and or Mr. Brady Redus at (405) 627-0114. Any questions concerning subject's rights as a research participant can contact Sharon Bacher with the IRB office located at 415-whitehurst on the campus of Oklahoma State University in Stillwater Oklahoma (405) 744-5700.

I hereby agree to participate in the above-described research. I understand my participation is voluntary and that I may withdrawal at any time. I am at least 18 years of age or older. I understand that the research investigators named above will answer any of my questions about research procedures, my rights as a subject, and research-related material and that I will receive a copy of this form.

____

Date Signature (Participant)

____

Date Brady S. Redus

APPENDEX B

GODIN LEISURE TIME EXERCISE QUESTIONNAIRE

Considering a **7-day period** (a week), how many times on the average do you do the following kinds of exercise for **more than 15 minutes** during your free time (write on each line the appropriate number)?

Times Per Week

a) **STRENUOUS EXERCISE**
(HEART BEATS RAPIDLY)
(i.e. running, jogging, football, soccer, squash, basketball, judo, roller skating, vigorous swimming, vigorous long distance bicycling) ____________

b) **MODERATE EXERCISE**
(NOT EXHAUSTING)
(i.e. fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, popular and folk dancing) ____________

c) **MILD EXERCISE**
(MINIMAL EFFORT)
(i.e. yoga, archery, fishing from river band bowling, horseshoes, golf, easy walking) ____________

2. Within the last 1 year have you participated in any activity that requires the use of a backpack (such as hiking or climbing)?

↳YES NO

If yes, then how many times per week and for how long? ____________

Describe the activity. ____

____

Adapted for GODIN and R.J. SHEPARD. A simple method to assess exercise behavior in the community. Can. J. Appl. Sport Sci 10:141-146, 1985.

APPENDEX C

PAR-Q & YOU

Has your doctor ever said you have heart trouble?

↳YES NO

Do you frequently have pains in your heart or chest?

↳YES NO

Do you often feel faint or have spells of severe dizziness?

↳YES NO

Has a doctor ever said your blood pressure was too high?

↳YES NO

Has a doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worst with exercise?

↳YES NO

Is there a good reason not mentioned here why you should not follow an activity program even if you wanted to?

↳YES NO

Are you over the age 65 and not accustomed to vigorous exercise?

↳YES NO

APPENDEX D

Instructions for Borg Rating of Perceived Exertion (RPE) Scale

While doing physical activity, we want you to rate your perception of exertion. This feeling should reflect how heavy and strenuous the exercise feels to you, combining all sensations and feelings of physical stress, effort, and fatigue. Do not concern yourself with any one factor such as leg pain or shortness of breath, but try to focus on your total feeling of exertion.

Look at the rating scale below while you are engaging in an activity; it ranges from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion." Choose the number from below that best describes your level of exertion. This will give you a good idea of the intensity level of your activity, and you can use this information to speed up or slow down your movements to reach your desired range.

Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Your own feeling of effort and exertion is important, not how it compares to other people's. Look at the scales and the expressions and then give a number.

6 No exertion at all
7
Extremely light (7.5)
8
9 Very light
10
11 Light
12
13 Somewhat hard
14
15 Hard (heavy)
16
17 Very hard
18
19 Extremely hard
20 Maximal exertion

9 corresponds to "very light" exercise. For a healthy person, it is like walking slowly at his or her own pace for some minutes

13 on the scale is "somewhat hard" exercise, but it still feels OK to continue.

17 "very hard" is very strenuous. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired.

19 on the scale is an extremely strenuous exercise level. For most people this is the most strenuous exercise they have ever experienced.

Borg RPE scale

APPENDEX E

SUBJECTS PLEASE DO NOT WRITE ON THIS SHEET

Name______________________________ **Date**_______

Informed Consent □ YES □ NO **PAR-Q** □ YES □ NO

Godin Activity Score ______

Sex M \ F **Height**_______in. **BMI**________

Weight______ Kg 15%______ 30%_______

Female Skinfolds Triceps_____ Suprailliac _____Abdominal ______ Sum______

Male Skinfolds Triceps _____ Chest_____ Subscap ______ Sum_____

BD_______________ Percent BF_________

HR_______________ BP_____________

UNLOADED

Standing Resting _________ VO2 ml\O2\kg

Walking _________ Net VO2 _____RPE

Self-Select _________ Net VO2 _____RPE

15% PROTOCOL

Standing Resting _________ VO2 ml\O2\kg

Walking _________ Net VO2 _____RPE

Self-Select _________ Net VO2 _____RPE

30% PROTOCOL

Standing Resting _________ VO2 ml\O2\kg

Walking _________ Net VO2 _____RPE

Self-Select _________ Net VO2 _____RPE

APPENDEX F

SUBJECT	AGE	GENDER	HT	WT	BF	BMI	RESTO
1.00	20.00	2.00	184.00	74.77	31.00	22.20	3.64
2.00	26.00	1.00	191.77	81.81	12.60	22.50	4.40
3.00	25.00	1.00	179.07	86.81	9.20	27.40	3.64
4.00	22.00	1.00	179.00	91.36	25.00	28.80	2.94
5.00	21.00	2.00	162.50	64.50	20.00	24.40	3.86
6.00	22.00	1.00	182.88	100.50	12.70	30.00	3.97
7.00	21.00	2.00	177.80	61.80	18.70	19.50	3.86
8.00	26.00	2.00	170.00	50.50	14.30	18.50	4.22
9.00	21.00	1.00	184.00	75.00	13.10	22.40	4.60
10.00	21.00	2.00	170.00	55.00	22.50	18.90	4.40
11.00	26.00	2.00	170.00	65.90	22.70	27.00	3.50
12.00	25.00	1.00	169.00	71.30	26.10	13.40	2.94
13.00	22.00	1.00	178.00	79.70	26.60	10.50	4.05
14.00	23.00	2.00	152.40	56.80	24.48	29.20	3.72
15.00	21.00	2.00	160.00	58.00	23.40	24.30	3.78
16.00	21.00	1.00	193.00	76.30	9.20	21.00	2.48
17.00	26.00	1.00	174.00	70.00	10.60	25.00	5.18
18.00	22.00	1.00	175.00	83.90	16.00	29.70	3.38
19.00	23.00	1.00	177.00	66.30	10.70	22.20	3.84
20.00	28.00	1.00	195.00	101.00	17.80	26.60	2.67
21.00	25.00	2.00	166.00	71.82	30.40	27.10	4.62
22.00	20.00	2.00	174.00	62.20	18.30	21.50	3.96
23.00	22.00	2.00	175.00	65.40	27.70	22.60	4.38
24.00	23.00	2.00	165.00	53.60	22.00	20.00	4.02

WALK0	SPEED0	SELF0	RPEW0	RPES0	REST15	WALK15	SPEED15
10.60	3.40	11.80	7.00	10.00	4.06	12.94	3.20
7.47	4.30	19.40	6.00	10.00	4.42	13.48	4.20
11.26	3.40	13.16	11.00	12.00	4.10	12.88	3.00
9.58	2.80	7.88	9.00	11.00	4.08	12.00	2.60
11.54	2.60	11.64	9.00	9.00	4.00	13.50	2.60
10.09	3.60	13.51	7.00	7.00	4.12	14.62	2.80
11.04	2.20	8.36	10.00	9.00	4.30	13.54	2.20
6.56	3.00	8.66	7.00	10.00	4.24	12.64	3.00
11.42	2.90	9.38	7.00	7.50	5.16	11.56	2.40
11.30	2.60	8.78	8.00	9.00	4.64	12.34	2.60
10.38	2.60	8.76	11.00	9.00	3.96	7.26	2.20
12.20	2.80	11.60	9.00	9.00	3.64	13.80	2.60
10.63	2.80	10.09	8.00	8.00	5.08	12.82	2.50
11.34	3.60	15.88	7.00	10.00	4.44	14.12	3.20
12.50	3.20	13.86	11.00	11.00	3.68	17.00	3.00
5.02	2.40	2.54	6.00	6.00	4.98	18.16	2.40
9.20	2.80	9.02	8.00	9.00	4.14	12.80	2.80
10.50	3.20	11.74	11.00	11.00	4.22	13.98	2.40
11.84	2.60	9.60	8.00	8.00	4.22	15.12	2.60
10.13	3.00	10.49	9.50	9.00	3.66	12.80	2.80
10.70	3.40	12.70	8.00	7.00	4.32	12.60	3.30
10.20	4.20	17.64	6.00	7.00	3.32	12.22	3.80
11.40	2.80	11.34	6.00	6.00	3.18	16.05	2.20
11.84	2.60	9.25	9.00	8.00	4.50	14.20	2.40

SELF15	RPEW15	RPES15	REST30	WALK30	SPEED30	SELF30	RPEW30
12.82	11.00	11.00	4.25	15.43	3.00	16.93	13.00
23.78	7.00	12.00	4.98	18.58	3.00	17.24	10.00
12.40	11.00	10.00	4.26	17.64	2.40	14.24	15.00
10.44	11.00	11.00	4.10	13.06	2.40	10.94	15.00
11.50	11.00	12.00	4.90	17.56	2.10	11.58	13.00
12.44	14.00	11.50	3.90	18.42	3.10	14.62	15.00
9.40	11.00	12.00	4.74	15.90	2.00	9.42	16.00
12.70	11.00	11.00	5.12	13.66	2.80	13.50	13.00
10.30	10.00	8.00	5.00	18.68	2.00	12.40	12.00
9.82	12.50	13.00	4.54	16.16	2.60	14.04	16.00
7.26	11.00	10.00	4.38	14.74	2.20	9.74	13.50
11.36	7.50	7.00	4.76	14.52	2.00	9.18	10.00
9.86	11.00	10.00	4.94	12.48	2.60	13.52	13.00
14.84	9.00	10.00	4.78	18.99	3.00	17.00	13.00
18.08	10.00	13.00	4.22	22.36	2.40	14.76	14.00
9.70	9.00	8.00	3.92	18.24	2.00	13.00	12.00
13.36	11.00	11.00	3.44	17.40	2.60	14.36	9.00
9.82	11.00	11.00	4.18	14.60	2.60	12.34	11.00
12.30	9.00	7.00	4.62	20.58	2.40	16.42	13.00
10.64	14.00	15.00	3.76	15.90	2.80	14.42	16.00
14.58	10.00	11.00	4.62	16.48	3.00	15.92	10.00
17.38	7.00	8.00	3.80	15.18	3.40	17.75	9.00
11.54	11.00	12.00	4.64	18.22	2.00	11.44	12.50
9.62	11.00	12.00	4.74	15.38	2.20	15.78	11.00

RPES30	FTL0	FTL15	FTL30	FTLSELF0	FTLSF15	FTLSF30
13.00	5.00	10.00	17.00	5.00	10.00	17.00
10.00	.00	5.00	10.00	.00	5.00	10.00
13.00	.00	5.00	10.00	.00	5.00	10.00
17.00	3.00	10.00	20.00	2.00	10.00	20.00
14.00	5.00	8.00	10.00	5.00	8.00	10.00
13.00	5.00	10.00	33.00	5.00	10.00	33.00
17.00	5.00	10.00	20.00	5.00	10.00	20.00
13.00	5.00	10.00	15.00	5.00	10.00	15.00
11.00	8.00	15.00	18.00	5.00	15.00	18.00
17.00	5.00	10.00	15.00	5.00	10.00	15.00
13.00	5.00	15.00	25.00	5.00	15.00	25.00
7.50	11.00	13.00	25.00	8.00	13.00	25.00
14.00	10.00	15.00	17.00	5.00	15.00	17.00
14.00	.00	5.00	20.00	.00	5.00	20.00
12.00	5.00	15.00	20.00	5.00	15.00	20.00
13.50	3.00	7.00	15.00	3.00	7.00	15.00
11.00	.00	15.00	17.00	.00	15.00	17.00
12.00	2.00	10.00	15.00	2.00	10.00	15.00
13.00	.00	12.00	20.00	2.00	12.00	20.00
17.00	.00	10.00	21.00	2.00	10.00	21.00
10.00	2.00	15.00	20.00	.00	15.00	20.00
10.00	.00	10.00	20.00	.00	10.00	20.00
12.00	.00	10.00	15.00	.00	10.00	15.00
13.00	3.00	10.00	20.00	3.00	10.00	20.00

APPENDEX G

Oklahoma State University
Institutional Review Board

Protocol Expires: 7/22/2004

Date : Wednesday, March 24, 2004 IRB Application No ED042

Proposal Title: THE GENDER RESPONSES OF LOAD AND THE DYNAMICS OF OXYGEN CONSUMPTION AND BODY POSTURE DURING GRADED WALKING IN COLLEGE AGED MALES AND FEMALES

Principal
Investigator(s) :

Brady Steven Redus	Bert Jacobson
1229 W. Britton Rd	204 Willard
Oklahoma City, OK 73114	Stillwater, OK 74078

Reviewed and
Processed as: Expedited

Approval Status Recommended by Reviewer(s) : Approved **Modification**

Please note that the protocol expires on the following date which is one year from the date of the approval of the original protocol:

Protocol Expires: 7/22/2004

Signature

Carol Olson, Director of University Research Compliance

Wednesday, March 24, 2004
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modifications to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

UNIVERSITY OF
CENTRAL
OKLAHOMA

Dr. Joe C. Jackson College
of Graduate Studies & Research
Office of the Dean

July 22, 2003

Brady Steven Redus
Box 189
University of Central Oklahoma
Edmond, OK 73034

Re: Application for Review of Human Subjects Research

Dear Mr. Redus:

The Jackson College of Graduate Studies and Research is pleased to inform you of the approval of your application for review of human subjects (IRB) on the research proposal "The Gender Responses of Load and the Dynamics of Oxygen Consumption and Body Posture During Graded Walking in College Aged Males and Females".

If the JCGS&R can be of any further assistance in your pursuit of research, please do not hesitate to contact us.

With kind regards, I am

Sincerely,

Dr. John M. Garic
Associate Dean
Jackson College of Graduate Studies and Research

JMG/

cc: S. N. Rao, Dean

VITA

BRADY STEVEN REDUS

Dissertation: GENDER DIFFERENCES IN OXYGEN CONSUMPTION, FORWARD TRUNK LEAN AND RATING OF PERCIEVED EXERTION DURING LOAD CARRIAGE

Major Field: Ph.D. in Health, Leisure and Human Performance

Personal Data: Born in Oklahoma City, Oklahoma, On May 1, 1970, the son of Tom Steven Redus and Marie Luise Hooper. Grandson, Brother and Uncle of Leamon and Elvira Redus; Leanna Mendoza; Lenna and Elyissa Mendoza.

Education: Graduated from Britton Christian Academy, Oklahoma City, Oklahoma in May 1988; received a Bachelor of Science degree in Community Health from University of Central Oklahoma, Edmond, Oklahoma in December 1998. Completed the requirements for the Master of Science degree with a major in Exercise Sciences at the University of Oklahoma in May 2001). Completed the Requirements for the Doctorate of Philosophy degree at Oklahoma State University in May, 2004.

Experience: University of Central Oklahoma, Edmond, OK. 73120: Department of Kinesiology and Health Studies. Wantland Hall 101A (405) 974-5232 bredus@ucok.edu.