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The Energy cost of females walking and jogging while pushing the Baby Jogger

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the Baby Jogger[®]**

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San Jose State University, 1993

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THE ENERGY COST OF FEMALES WALKING AND JOGGING
WHILE PUSHING THE BABY JOGGER®

A Thesis

Presented to

The Faculty of the Department of Human Performance
San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

By

Mindy Hansen

August, 1993

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ABSTRACT

THE ENERGY COST OF FEMALES WALKING AND JOGGING WHILE PUSHING THE BABY JOGGER®

by Mindy Hansen

The purpose of this study was to calculate the energy cost of females walking and jogging while pushing the Baby Jogger®. Thirteen active females were tested for maximum oxygen uptake rate and body composition, followed by three treadmill test conditions: a control test with no Baby Jogger®, pushing the Baby Jogger® with 15 pounds, and again with 30 pounds. For each condition, the following protocol was given: walking at 3.0 mph at 0% and 4% grade and jogging at 5.0 mph at 0% and 4% grade. Oxygen uptake rate (VO_2) (l/min and ml/kg/min), heart rate, and kilocalories per minute were measured at the end of each workload. For all variables, there were significant increases between conditions and across workloads. It was concluded that the greater metabolic and cardiovascular demands will result in greater overload and hence, optimize the development of fitness while pushing the Baby Jogger® at 5.0 mph.

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CHAPTER 1

Introduction

This chapter is divided into the following sections: background for the study, statement of the problem, statement of the purpose, approach to the problem, statement of the hypotheses, delimitations, limitations, assumptions, definitions, operational definitions, and summary.

Background for the Study

During the late 1960's and early 1970's the typical American family profile differed radically from today. Men were the main breadwinners of the family and women stayed home to keep house and look after the children. Simultaneously, aerobic exercise was becoming an integral part of many individual's lives, although exercise was popular primarily among men who ran (Cooper, 1988). With increasing living costs and the desire to "do better," many women began entering the work force in the late 1970's and early 1980's. At the same time, increasing numbers of women began exercising, mainly through aerobic dance (Cooper, 1988).

Though many families enjoyed more comfortable lives, scheduling time to exercise created a challenge for many parents as the commitment to exercise intruded on time otherwise spent with their children. One such couple was Phil and Mary Baechler who both worked as full-time professionals (Lloyd, 1988). As an avid runner, Phil Baechler was frustrated by his inability to find time to run without sacrificing time with his son. In 1983, Baechler took action and modified a baby stroller by welding three bicycle wheels to the frame of the stroller. Baechler tested the device by taking his son out for a "run" in the new stroller, and the Baby Jogger® was born ("Some Joggers," 1987).

From 1983 to 1985, nearly 200 Baby Joggers® were sold (Carter, 1985). Advertisements in running magazines and word-of-mouth provided the sole marketing efforts as Baechler maintained his job as a copy editor in Yakima, Washington ("If Phil

Baechler's," 1984). In 1988, Baechler quit his job to meet the rising demand for the Jogger (Lloyd, 1988). By 1989, with a staff of six to ten assemblers, 100 strollers were made each day, sales had increased 60% over the previous year, and gross revenue topped \$1 million ("Firm's Success," 1989). In 1990, strollers for physically handicapped children, twins, and the Walkabout®, a smaller version of the Baby Jogger®, were introduced ("Racing Strollers," 1990).

Statement of the Problem

While the popularity of the Baby Jogger® has steadily increased, no research had been conducted that quantifies the energy expenditure while pushing the Jogger.

Statement of the Purpose

The purpose of this study was to calculate the energy cost of females walking and jogging while pushing the Baby Jogger®.

Approach to the Problem

Thirteen females were measured for the following physiological variables: body mass (BM), relative fat (RF), lean body mass (LBM), anaerobic threshold (AnT VO_2), and maximal oxygen uptake rate (VO_2 max). In addition, oxygen uptake rate (VO_2) in l/min and ml/kg/min, heart rate (HR), and kilocalories per minute (kcal/min) were measured at each of the following workloads while pushing the Baby Jogger®: walking at 3.0 mph at 0% grade (Workload 1); walking at 3.0 mph at 4% grade (Workload 2); jogging at 5.0 mph at 0% grade (Workload 3); and jogging at 5.0 mph at 4% grade (Workload 4). VO_2 , HR and kcal/min values were obtained by averaging the fifth and sixth minutes of each of the workloads, which represented steady-state values.

Statement of the Hypotheses

1. There will be no significant increase in VO_2 (l/min and ml/kg/min) while pushing the Baby Jogger® when compared to walking and jogging with no Baby Jogger®.
2. There will be no significant increase in VO_2 (l/min and ml/kg/min) as speed of ambulation increases.
3. There will be no significant increase in VO_2 (l/min and ml/kg/min) as weight held

within the Baby Jogger® increases.

4. There will be no significant increase in VO_2 (l/min and ml/kg/min) as the grade is increased.
5. There will be no significant increase in heart rate while pushing the Baby Jogger® when compared to walking and jogging with no Baby Jogger®.
6. There will be no significant increase in heart rate as speed of ambulation increases.
7. There will be no significant increase in heart rate as weight held within the Baby Jogger® increases.
8. There will be no significant increase in heart rate as the grade is increased.
9. There will be no significant increase in kcal/min while pushing the Baby Jogger® when compared to walking and jogging with no Baby Jogger®.
10. There will be no significant increase in kcal/min as speed of ambulation increases.
11. There will be no significant increase in kcal/min as weight held within the Baby Jogger® increases.
12. There will be no significant increase in kcal/min as the grade is increased.

Delimitations

This study was delimited to the following:

1. Thirteen female subjects, aged 22-39 years, as these are considered prime child-bearing years.
2. Subjects were regular exercisers as defined by the American College of Sports Medicine (ACSM) guidelines (3-5 sessions per week; 60-90% HR max; 20-60 minutes per session) (1990).
3. Each subject was tested on the treadmill for oxygen uptake rate in l/min and ml/kg/min for a total of four tests. The first test was a maximal graded exercise test that served as a baseline for the remaining three tests. The second test consisted of a submaximal control test. The third and fourth tests served as test conditions. The control and two test conditions each consisted of the following: six minutes of walking at 3.0 mph and 0% grade (Workload 1); walking at 3.0 mph at 4% grade (Workload 2); jogging at 5.0

mph at 0% grade (Workload 3); and jogging at 5.0 mph at 4% grade (Workload 4). One test condition used a 15-pound weight in the Jogger and the other test condition utilized a 30-pound weight. The order of the 15- and 30-pound conditions was mixed.

4. The Baby Jogger®, manufactured by Racing Strollers, Inc., was used as the stroller apparatus.

Limitations

The following were the limitations to this study:

1. Testing was done on the treadmill, whereby running with the Baby Jogger® normally occurs on open terrain. Slight grades in the running surface may have had a small effect on the energy cost, as well as the type of surface. While the treadmill is a smooth, rubbery surface, the jogger will actually be jogging on gravel, grass, soil, pavement, or sand. This could also have had some effect on energy cost.
2. The modification of the Baby Jogger® itself may also have been a limitation. For the Jogger and the runner to both fit on the treadmill, the Jogger had to be welded down to fit the treadmill dimensions. The wheels from front to back were shortened and the width of the Jogger was reduced. Although the total mass was decreased from reducing the Jogger, that mass was weighed and added back to the Jogger, such that the net mass remained unchanged. While the mass remained constant, the modification may have had a small effect on the caloric expenditure due to the changed dimensions of the Jogger.
3. The lack of air resistance or wind that is found in the natural jogging setting as opposed to the laboratory may have had some effect on caloric expenditure.

Assumptions

The following were assumptions in this study:

1. The modified Baby Jogger® used was representative of the actual Baby Jogger®.
2. The subjects selected represented a normal distribution of the population.
3. Each subject understood the directions given to her.
4. Each subject put forth her best effort.

Definitions

The following are definitions of terms used throughout this paper.

Anaerobic Threshold (AnT): The exercise level or the level of oxygen uptake rate that blood lactate begins to show a systematic increase above a resting or some slightly higher than baseline level, or the onset of blood lactate accumulation. AnT is also evidenced when ventilation disproportionately increases with increases in oxygen uptake (McArdle, Katch, & Katch, 1991). Anaerobic threshold was determined as the last VO_2 value fitting the trend when expired ventilation (VE) was plotted against VO_2 during increasing workloads (Wasserman, Whipp, Koyal, & Beaver, 1973).

Body mass (BM): Body mass is the total weight of all body tissues expressed in kilograms (kg) and is calculated by adding fat mass plus lean body mass (McArdle et al., 1991).

Carbon dioxide production rate (VCO_2): The amount of carbon dioxide produced per minute and is calculated by the following equation: $\text{VCO}_2 = \text{VE}(\% \text{CO}_{2\text{E}} - \% \text{CO}_{2\text{I}})$, where $\% \text{CO}_{2\text{E}}$ is equal to the percent carbon dioxide in the expired air as determined by gas analysis, and the $\% \text{CO}_{2\text{I}}$ is equal to the percent carbon dioxide in inspired air, which is essentially constant at 0.03% (McArdle et al., 1991).

Energy cost/energy expenditure/caloric expenditure: The quantity of energy generated by the body during rest or muscular effort as determined by direct or indirect calorimetry. This energy metabolism ultimately depends on the utilization of oxygen (McArdle et al., 1991).

Kilocalories per minute (kcal/min): Kilocalorie is a measure used to express the heat or energy value of food and physical activity. It is the amount of heat necessary to raise the temperature of 1 kg of water 1 degree C, from 14.5 to 15.5 degrees C, expressed per minute in this study (McArdle et al., 1991).

Lean Body Mass (LBM): Body mass (BM) minus fat mass. Lean body mass includes a small percentage of essential fat stores, found within the central nervous system, marrow of the bones, and internal organs (McArdle et al., 1991).

Maximal Heart Rate (HR max): Heart rate maximum is the point at which heart rate plateaus and no further increases are evidenced with additional increases in workload. Heart rate max can also be estimated by the age-predicted maximum heart rate formula: $220 - \text{age}$ (McArdle et al., 1991). Maximal heart rate was determined as the highest heart rate reached during the maximal graded exercise test.

Maximal oxygen uptake rate (VO_2 max): Maximal oxygen uptake rate is the point at which oxygen uptake plateaus and no further increases are evidenced with additional increases in workload. VO_2 max was determined as the highest VO_2 value obtained when (1) heart rate was within 10 beats/min of age-predicted maximal heart rate, (2) respiratory quotient (RQ) was 1.0 or above, and/or (3) VO_2 plateaued (< 2.0 ml/kg/min) or decreased with increasing workloads (McArdle et al., 1991).

Oxygen uptake rate (VO_2): The rate at which the body's tissues extract oxygen to meet the muscle's energy demands. Oxygen uptake rate in liters per minute (l/min) represents the total capacity of the cardiorespiratory system. Since VO_2 l/min is related to body size, large people have larger scores. Oxygen uptake rate in milliliters per kilogram per minute (ml/kg/min) corrects for differences in body mass (McArdle et al., 1991).

Percentage of maximal oxygen uptake rate ($\% \text{VO}_2$ max): A given workload or oxygen uptake rate (VO_2) expressed as a percentage of the maximal oxygen uptake rate (VO_2 max) and is determined by dividing the submaximal oxygen uptake rate by the maximal oxygen uptake rate: $(\text{VO}_2 \text{ max} / \text{VO}_2 \times 100)$.

Relative Fat Mass (RF): Relative fat mass is the portion of the body weight composed of adipose tissue and is calculated by the following formula:

$$\text{RF} = [(4.57/D_B - 4.142) \times 100] \text{ (Brozek, Grande, Anderson \& Keys, 1963).}$$

Residual lung volume (RV): Residual volume is the air that remains in the lungs after a maximal expiration. Measuring body composition by hydrostatic weighing requires that correction be made in the equation for residual lung volume (Noble, 1986).

Respiratory Quotient (RQ): The quantity of carbon dioxide (CO_2) produced in relation to O_2 consumed. This ratio is based on the substrate metabolized. For example, RQ for

carbohydrate metabolism is 1.0 and RQ for fat metabolism is 0.70 (McArdle et al., 1991).

Submaximal oxygen uptake rate ($\dot{V}O_2$): That workload whereby an increase in workload is linearly paired with an increase in oxygen uptake rate (Noble, 1986).

Steady State: With an increase in exercise intensity, the subsequent transition for oxygen consumption to meet the exercise requirement, typically six minutes (Noble, 1986).

Operational Definitions

The following is an operational definition for purposes of this research:

Baby Jogger®: Three-wheeled stroller fitted with 20" steel rim bicycle wheels, aluminum frame, and Dupont Cordura fabric seat. Handle extends up for runner to grasp while walking or jogging.

Summary

The purpose of this research was to calculate the energy cost of females walking and jogging while pushing the Baby Jogger®. Female subjects were tested on the treadmill under four varying conditions to measure oxygen uptake rate and thus, energy expenditure while pushing the Baby Jogger®.

CHAPTER II

Review of Literature

Introduction

While the Baby Jogger's® popularity has steadily increased, as evidenced by increasing sales, no research has been conducted to quantify the energy cost of walking and jogging while pushing the Baby Jogger®. The purpose of this study was to quantify the energy expenditure of pushing the Baby Jogger® among women during walking and running.

To determine the effects of increased speeds and mass while pushing the Baby Jogger®, a review of literature was conducted. The studies examined involved subjects being tested on the treadmill, while manipulating speed, and mass added to various areas on the body. In addition, studies reviewing particular aspects of the caloric cost of running and walking were examined.

Caloric Costs of Walking and Running

Caloric Cost Differences Between Men and Women

One of the first studies to examine the differences in energy cost during walking between men and women was conducted by Booyens and Keatinge (1957). Ten males and ten females performed two trials on an outdoor level track over 300 yards: (1) a “leisurely” walking rate; and (2) “to catch a bus” walking rate. Expired gases were collected to determine energy expenditure. The authors found a significantly lower energy cost, stride frequency, and stride length among women when compared to men. Women proved to increase their walking speed by increasing the frequency of stride, which led to the original assumption that the lower energy cost was due to less vertical lift in the torso. A considerable variation between subjects was also evidenced. Though this study exhibited a lack of experimental control, it did establish differences in energy expenditure between men and women, which acted as the impetus for further research in this area.

The differences in the caloric cost of walking between men and women, believed to be caused from differences in the vertical lift of the body, was the focus of study for

Bhambhani and Singh (1985). This study sought to determine, by cinematography, whether the difference in stride length and running speed between men and women was due to vertical displacement. Twenty-four subjects, 12 females and 12 males, participated in each of the following sessions: (1) determination of the most comfortable gait speed; (2) calculation of energy cost during standing and walking and determination of vertical displacement, found by digitizing the center of gravity; and (3) same procedure as former, only with running. Results showed that stride frequency was 6% higher in females than males and that stride length was 7% shorter (both values were significant). In addition, females' natural gait speed was 9% slower than males'. No significant differences were found for vertical displacement or energy expenditure during standing. Males showed a 48% increase in energy cost of running over walking and females showed a 62% increase. When these values are corrected for stride frequency, running was 2.4 and 2.6 more costly than walking for males and females, respectively. When comparing the gross energy cost per km, net energy cost per km, and the net energy cost per stride for walking between males and females, no significant differences were found. The researchers concluded that the energy cost of running was significantly greater than walking and that females' energy cost was significantly greater than males during running, but not walking.

A study conducted by Bransford and Howley (1977) sought to compare the relationship between energy cost and the speed of running among four groups: trained males, trained females, untrained males, and untrained females. Each group consisted of ten subjects. Each subject ran at least four submaximal treadmill tests, at varying speeds (144 to 225 m/min for untrained subjects; and 144 to 307 m/min for trained subjects) for seven minutes. A gas sample was collected during the last two minutes of each run. Following the submaximal tests, a VO_2 max test was conducted for each subject. Regression equations were used to analyze the relationship between oxygen uptake rate and the running speed. For each group, the relationship could be plotted as a linear line and was deemed predictable. There were no significant differences between the slopes when compared to one another, which would indicate an increase in VO_2 for a given increase in speed to be

similar for all groups. While VO_2 increases linearly, regardless of sex or training, the actual cost of running at a given speed differed among the groups. Trained male runners ran most economically, while untrained females ran least economically. This is most likely attributed to the increase in lean body tissue among men and higher capacities for oxygen uptake. Caution should be used when reviewing the results of this study, however, as the maximal oxygen uptake test was conducted after the submaximal tests, a protocol which is not standard. In addition, speed was not held constant between subjects for the submaximal tests, and to estimate the percent of maximal oxygen uptake rate that each subject was working at during the submaximal tasks would be difficult since the maximal test was conducted last.

Prior to 1976, when Falls and Humphrey conducted their study, little research had been done on the energy cost of running and walking among females. As a result, the purpose of this study was to determine the caloric cost of walking and running among young, fit women, and to calculate if equations predicting energy expenditure for men were validly applicable to women as well. Seven females randomly walked or ran each of the following speeds on the treadmill: walking 4.0, 4.8, 5.6, 6.4, 7.2 and 8 km/hr, and running at 8.0, 8.9, 9.7, 10.5, 11.3, 12.1, 12.9, 13.7 and 14.5 km/hr at 0% grade. Heart rate and expired gas values were collected during the final 30 seconds of each third minute during a 6-minute test per speed. Respiratory exchange ratio was utilized to calculate energy cost. Correlation coefficients between actual and predicted values were 0.949 to 0.951 for walking (SEE of 0.79 to 0.80 kcal/kg•hr) and 0.856 to 0.975 for running (SEE of 0.40 to 0.60 kcal/kg•hr). The researchers found no significant differences for energy expenditure between gender when values were corrected for body mass. The authors concluded that the equations used for predicting energy cost of walking and running previously employed for males were also valid when applied to young, active females.

Effects of Testing

The purpose of this study was to compare the relationship between the total caloric cost of running (broken down by actual exercise plus recovery costs) and velocity over 1-mile

increments (Fellingham, Roundy, Fisher & Bryce, 1980). Twenty-four male athletes were tested for VO_2 max and divided into one of four blocks, as determined by aerobic fitness. Six treadmill tests were run with each subject: walking at 3, 4, and 5 mph, and running at 5, 7, and 9 mph. Caloric expenditure was determined from VO_2 measures taken every 20 seconds for a total running distance of 1 mile. Four prediction equations were formulated: dependent variable of total energy expenditure per mile and independent variable of body weight; dependent variable of total energy expenditure per mile and independent variable of speed; dependent variable of steady-state portion of exercise in l/min with independent variable of body weight; and dependent variable of steady-state portion of exercise in l/min with independent variable of speed. Results indicated that there were significant differences among subjects and among the various running velocities. The carry-over effects from treatment to treatment were also significant. As expected, walking costs were significantly less than running costs at all speeds. In addition, less fit subjects tended to run at a higher percentage of VO_2 max, burning more calories than more fit subjects, which suggested an “increased steady-state oxygen use with higher fitness levels.” The researchers found that a workout the day after an intense exercise bout had a higher energy cost than if that same workout followed a moderate exercise session. This effect was believed to last as long as 48 hours.

Effects of Body Mass

Differences in Body Mass Between Gender

A study was conducted by Hagan, Strathman, Strathman, and Gettman (1980) to compare linear and curvilinear regression equations relating energy cost and oxygen uptake rate to running speed. The researchers also sought to determine whether age, sex, and maximal aerobic power had any effect on the relations. A strong sample size of 67 males and 9 females, who regularly engaged in running, served as voluntary subjects. Each subject ran on the treadmill at 0% grade for four minutes at each of the following velocities: 147.8, 174.7, 201.6, 228.5, 255.4, and 282.2 m/min. Steady state was assumed to be achieved during the third minute of each velocity, and heart rate, oxygen uptake rate, and

ventilation rate were recorded. Using stepwise regression analysis, the coefficient of determination (r^2) for oxygen uptake rate and energy expenditure to running velocity values were as follows: (1) for the one-variable linear equation, r^2 was .86 and .897; (2) for the two-variable linear equation, the coefficient of determination was .895 and .901; and (3) for the two-variable curvilinear equations, values were .889 and .897. Age, gender, or VO_2 max had no influence on the relationship between oxygen uptake rate, energy expenditure and running velocity. The conclusion drawn was that when body mass was held constant, oxygen uptake rate and energy expenditure were dependent on running velocity.

A study conducted by Cureton and Sparling (1980) examined the effects of added weight to men to equate percent body fat between men and women on oxygen uptake rate. Two running conditions were employed for each of the trained 10 female and 10 male subjects: (1) a 12-minute field test; and (2) a treadmill test, whereby speed and grade were eventually increased until VO_2 max was reached. The male subjects were administered each running condition twice: (1) under normal-weight condition; and (2) with weight added to the waist and shoulders to equate percent body fat of a random female subject. During both treadmill and field conditions, VO_2 values and run times were greatest for men with no weight added, followed by males with added weight, and finally by the women. However, when corrected for fat-free weight, the values between equated percent body fat for males and females were similar. When weight was added to the males, treadmill time decreased by 1.3 minutes (32%) and 173 m (30%) for the field test. The difference between male and female runners' performance was reduced 30% when equating for body fat. The authors concluded that the greater biological fat among women was a significant determinant in the lower VO_2 values and running performance when compared with men.

Miller and Stamford (1987) examined the differences between gender in the energy cost of walking and running with hand weights, ankle weights, and both hand and ankle weights. Each subject was randomly assigned to each of the following testing conditions:

(1) walking at 2, 3 and 4 mph; (2) walking at 2,3,4 mph with ankle weights; (3) walking at 2,3, or 4 mph carrying handweights; (4) walking at 2,3,4 mph with both ankle and handweights; or (5) running at 5,6, or 7 mph. All tests were conducted on a treadmill at 0% grade and heart rate and oxygen uptake rate were measured. No significant differences were found between gender, so all data between the two sexes were combined. Caloric expenditure was greatest at all walking speeds for ankle and handweights, followed by handweights only, ankle weights only, and control. The ankle weight condition resulted in an average oxygen uptake rate increase of 0.8% per 100 g added (4500 g total). Handweights increased energy expenditure by 1.3%/100 g (4500 g) and both hand- and ankle weights resulted in an average increase of 0.9%/100 g increase (total of 9000 g). The conclusion drawn was that weighted walking may be an ideal form of exercise for diseased or poorly fit populations who need a higher intensity than normal walking but less demanding than jogging. The reader should note that with only four male and three female subjects, significant differences between gender may not have surfaced due to the small sample size.

Effects of Added Mass

In a classic study, Soule and Goldman (1969) compared weight added to the head, hands and feet to a control test with no weight. Ten males were maximally tested on the treadmill, after which each subject performed the following submaximal conditions at 4.0, 4.8, and 5.6 km/hr: (1) carrying no weight; (2) carrying 4 kg weights in each hand; (3) carrying 7-kg weights in each hand; (4) carrying a 14-kg load on the head; and (5) carrying a 6-kg load on each foot. Each test was 20 minutes, and three 2-minute gas samples were collected to determine energy cost. For each speed and over all conditions, there was an increase in energy expenditure with greater speeds and these increases were significant. Energy cost increases associated with weight for the hands were similar for weight on the head. In addition, energy expenditure increased significantly when weight was added to the feet ($p < .001$). Energy expenditure for weight added to the feet was 4.2 times greater than the no load condition at 4.0 km/hr, 5.8 times greater at 4.8 k/hr, and 6.35 times

greater at 5.6 km/hr. Weight added to the head was 1.2 times higher than the no-load condition. In addition, carriage load on the head proved to be 25% higher per kilogram than carrying the identical load on the torso. Carrying 7-kg weights with the hands resulted in a 1.9 greater cost than no load, independent of speed. The 4-kg weights resulted in a 1.4 increase in energy cost over no load.

While many studies have examined the relationship between energy cost and the weight of boots or footwear in general, this study sought to examine the difference between energy cost with and without weight carried in a backpack (Legg & Mahanty, 1986). In addition, how energy cost was affected when the backpack weight was shifted to the feet was also determined. Five male subjects were tested for VO_2 max, followed by a control condition of walking on the treadmill for one hour with no backpack at 4.5 km/hr with a 0% grade. The two experimental conditions utilized were: (1) carrying a backpack equal to 35% of their own body mass; and (2) subject carrying 30% of his body mass in the backpack, with the remaining 5% added to the boot. Oxygen uptake rate, ventilation rate and heart rate were measured for two minutes every ten minutes over one hour under each condition. While carrying 35% of the body mass in the backpack, significant increases in physiological and psychological cost were evident (mean increase in VO_2 of 0.41 l/min). This indicated a 0.15% increase per 100 g in weight carried in the backpack. When 5% of this body mass was at the feet, the physiological, but not subjective cost, increased significantly as well (mean increase in VO_2 of 0.321 l/min). This represented a 0.96% increase per 100 g increase in footwear. The authors concluded that the oxygen cost of carrying added mass on the boots was 6.4 times that of carrying weight in the backpack, and that the perceived exertion and discomfort associated with weighted feet is also greater than carrying the weight on the back or shoulders. Caution should be used when reviewing the results as only five subjects were employed.

The purpose of the final study was to determine the effects of experimentally-induced obesity on caloric expenditure (Hanson, 1973). Four male subjects were submaximally tested on the treadmill at varying grades (3 mph at 4-, 8- and 14-degree elevation) under

four conditions: (1) Basal or normal weight and controlled diet; (2) After 14-16% weight gain, achieved in 11 weeks; (3) After 18-20% weight gain, achieved in 16 weeks; and (4) basal weight plus weight added with a backpack (actual weight not specified) after experimental obesity had been lost. Oxygen uptake rate, heart rate, carbon dioxide (CO_2), and respiratory exchange ratio were measured, and paired t-tests were used for statistical analysis. Interestingly, while significant increases were not found in VE , VO_2 and VCO_2 with added weight, the percent increase in VO_2 similarly paired the increase in percent weight gain (15-19% with 14-16% weight gain). With a 19% weight gain, VE , VO_2 and VCO_2 were significantly higher than at basal weight. Again, the increase in VO_2 closely paralleled the increase in weight gain (19.2% vs. 19%, respectively). Perhaps the inability to find statistical significance between basal and 15% weight gain is from an insufficient sample size ($N = 4$). The data between weight gain values and backpack-weight added were similar. The author concluded that increases in body weight were associated with small, but insignificant increases in VO_2 .

Effects of Handweights

Effects of Varying Handweights

Graves, Pollock, Montain, Jackson, and O'Keefe (1987) sought to observe the effect of handweights (HW) during submaximal and maximal exercise on heart rate, oxygen uptake rate, ventilation rate, blood pressure, and rating of perceived exertion. Subjects were twelve untrained males who were each given an initial diagnostic test to determine health and aerobic capacity. Subjects then underwent each of the following treadmill conditions: (1) 60% of VO_2 max, with three 8-minute trials each of no HW, 1-lb HW and 3-lb HW; (2) 75% of VO_2 max with the previous mentioned protocol; (3) constant 75% VO_2 max adjusted for grade with no HW and 3-lb HW (this was to determine whether blood pressure response was caused by the HWs, independent of workload); (4) VO_2 max with no HW; and (5) VO_2 max with 3-lb HW. Within each of the submaximal conditions, energy cost, heart rate, ventilation rate, and blood pressure increased significantly with the addition of HWs. When heart rate was held constant (test 3), systolic blood pressure

increased significantly. With maximal testing, values between weights and no weights were similar, although time to exhaustion was reduced with the addition of handweights. The authors concluded that using handweights significantly increased the energy cost of exercise, and that they may be useful for individuals who need to increase the intensity of their workouts.

A study designed to determine significant differences, if any, in oxygen uptake rate during walking and running with no weights and weights of two different masses was done by Francis and Hoobler (1986). While reviewing the results of this study, caution should be considered due to the low number of subjects per gender (N = 10, consisting of 5 males and 5 females). Each subject was measured for VO_2 max and then randomly assigned to each of the following test conditions: (1) walking and running at 4.8, 5.6 and 8.0 km/hour; (2) carrying no load, carrying 0.91 kg handweight in each hand, and carrying 1.81 kg handweight in each hand, at each speed. There was a significantly greater energy cost associated with increasing speeds (walking at 5.6 km/hr was 1.3 times more costly than walking at 4.8 km/hour, and running at 8 km/hr was twice as costly than walking at 5.6 km/hr, regardless of weight carried). Carrying the 0.91 kg handweight increased energy cost an average 1.8 ml/kg/min, and the 1.81 kg handweight increased energy expenditure by 2.7 ml/kg/min. The authors concluded that while the increase in energy cost was significant, its importance in practical terms was negligible when considering the additional stress placed on the extremities.

In 1988, a study conducted by Makalous, Araujo, and Thomas was unique in that it pursued two unexplored avenues: (1) the authors looked at the effects of hand-held weights on obese individuals; and (2) the authors studied exercise with handweights for 30 minutes. Eleven obese subjects, three males and eight females were measured for body composition and randomly assigned to each of three submaximal treadmill tests: (1) normal walking (UN); (2) normal walking with exaggerated arm exercise (AE); and (3) exaggerated arm exercise carrying 0.45 kg handweight in each hand (HW). Heart rate, oxygen uptake rate, respiratory exchange ratio, and substrate utilization were calculated

over five-minute periods. Mean handweight heart rate was 6% greater (127 beats/min) than normal walking and 3% greater than exaggerated-arm walking. VO_2 measures were significantly higher in the HW condition than normal walking; however, AE was not significantly different from either HW or UN. While respiratory exchange ratio (RER) measures increased significantly during the first ten minutes of each condition, there were no significant differences during exercise or recovery. The total energy expenditure was greater with HW than UN, but there were no significant differences for fat utilization using handweights (41.8% fat utilization with HW and 42.7% with UN). The conclusion drawn was that while handweights may increase energy expenditure for weight loss purposes, the effects are minimal. Thus, a one-pound handweight as utilized in this study, may not be enough weight to elicit higher energy costs.

While seeking to quantify significant increases in energy cost among active subjects, Zarandona, Nelson, Conlee, and Fisher (1986) sought to determine whether a pressor reflex, a disproportionate increase in blood pressure and heart rate, accompanied an increase in VO_2 when carrying handweights. Thirty active males were tested submaximally on the treadmill, walking at 3.5 mph or 7 mph. With each speed, the subjects randomly performed one of three treatments: (1) no weights; (2) carrying a 1-pound weight in each hand; and (3) carrying a 5-pound weight in each hand. Heart rate, VO_2 , and blood pressure were recorded during the final minute of each four-minute trial. For the walking condition, a significant increase in VO_2 and heart rate was evident while walking with the 5-lb weight, while no significant increases were found with no weight or 1-lb weights. A significant increase in blood pressure holding the 5-lb weight was also noted. During running, significant increases in VO_2 and heart rate were again evidenced with the 5-lb weights. No significant differences between weights and 1-lb weights were found for any of the physiological variables. The authors concluded that for significant increases in VO_2 , without risk of eliciting the pressor reflex, a 5-lb weight is superior to no weight or 1-lb weights.

The purpose of the study conducted by Claremont and Hall (1988) was to determine any

effects of extremity loading upon energy cost and biomechanical variables in the sagittal plane. Five male and three female physically active subjects were tested for maximal oxygen uptake rate. A unique variation in methodology with this study was the self-selected pace among subjects which ranged from 2.5 m/s to 3.8 m/s. Each subject ran a 30-minute test at their desired pace (mean was 78% VO_2 max) under four random conditions: (1) control run, no weight added; (2) carrying handweights (0.45 kg for women and 0.9 kg for the men); (3) carrying 0.45 kg weights on the ankles for both males and females, and; (4) carrying both ankle and handweights, equaling 0.98 kg for females and 2.7 kg for males. Gas analysis and heart rate were determined during the last two minutes of each five-minute interval during the 30-minute test. Although VO_2 and heart rate increased with additional loading, no significant differences between the four conditions were found. The increase in VO_2 represented a greater caloric expenditure of 3 to 10% for each kg of added mass. The authors estimated a 29 kcal increase in energy cost with the hand and ankle loading condition. While it was concluded that adding weight caused small increases in energy expenditure, the reader should note that with a small sample size, varying gender protocol, and light weights, significant results may not be feasible.

Effects of Varying Ranges of Motion With Handweights

Auble, Schwartz, and Robertson (1987) designed a study to compare the differences in energy cost between normal walking and with 1-, 2-, and 3-pound handweights through several ranges of motion. Nine male subjects, all physically active, were each given a VO_2 max test. The subjects were then randomly tested at four speeds (1.12, 1.34, 1.56, and 1.79 m/sec), for five minutes per speed with frequency held constant to correct for stride differences. During each speed, subjects used 1-, 2-, and 3-pound handweights and executed a “walk-and-pump” movement, whereby the “right arm flexes at the elbow and swings upward as the left leg strides forward. At the same time, the left arm fully extends at the side while the right leg extends behind the body.” Pumping was varied in 0.15-m increments and ranged from 0.61 to 1.07 m. Finally, VO_2 , carbon dioxide (CO_2),

ventilation rate, and respiratory quotient (RQ) were measured and calculated from the final 30 seconds of each treatment. Statistical analyses revealed that the energy cost of walking increased significantly as the speed increased. When increasing the pumping motion with handweights, regardless of walking speed, energy expenditure also increased by 2.1 to 25.5 ml/kg/min. The same was found with weight: the greater the mass of the handweight, the higher the energy cost. Finally, as speed increased while pumping the handweights, caloric cost also increased significantly. The authors concluded that in addition to increased handweight for greater energy expenditure, the range of arm movement is another factor that increases the caloric cost of walking.

Effects of Ankle Weights

Jones, Daniels, Knapik, and Toner (1986) sought to examine the effects of shoes and boots on energy cost during walking and running among women. Seven female subjects, four untrained and three trained, were tested to determine maximum oxygen uptake rate (VO_2 max). Two trials were conducted: (1) walking in shoes (mean weight = 514 g) and boots (mean weight = 1371 g) at speeds of 4.0, 5.6 and 7.2 km/hr; and (2) running in shoes and boots at 8.9 and 10.5 km/hr. The type of shoe worn first during testing was randomly ordered. Measures for VO_2 and heart rate were collected during the final two minutes of each six-minute walking interval and each four-minute running interval. For both trained and untrained subjects, energy expenditure was significantly greater when wearing boots as opposed to shoes at all speeds, except for walking at 4.0 km/hr. An average 1.0% increment increase in energy expenditure per 100-g increase in footwear, or 8.3% average increase in energy cost from shoes to boots was calculated. The conclusion drawn was that increased weight in footwear resulted in an increase in energy expenditure among women walking at speeds greater than 4.0 km/hr and running.

Jones, Toner, Daniels, and Knapik (1984) sought to find differences in energy cost and heart rate with different-weighted shoes and boots while walking and running on the treadmill. Fourteen males, both trained and untrained, were used as subjects. The following variables were evaluated: oxygen uptake rate at each level; energy cost

comparisons between walking and running in shoes and boots; and energy cost comparisons in walking and jogging in shoes and boots with weights. A baseline VO_2 max test was conducted with each subject. Three separate tests were taken: (1) walking at speeds of 4.0, 5.6 and 7.3 km/hr with regular jogging shoes (mean weight per pair = 616 g) and again with military boots (mean weight per pair = 1776 g); (2) running at speeds of 8.9, 10.5 and 12.1 km/hr with shoes and boots; and (3) running at speeds of 8.9, 10.5, and 12.1 km/hr with regular shoes and again at the three speeds with the regular shoes plus weights equal to the weight of the military boots. VO_2 and heart rate data were collected during the final two minutes of the six-minute walking interval or four-minute running interval. For both trained and untrained subjects, VO_2 measures were significantly higher for military boots over regular shoes (5.9-10.2% increase) at all speeds except the lowest walking speed (4.0 km/hr). VO_2 measures were also significantly higher for weighted shoes over regular shoes (5.0 - 6.3% increase) at all speeds except walking at 4.0 km/hr. No significant differences in energy cost were found between trained and untrained subjects when corrected for body mass, although heart rate was higher for untrained subjects indicating trained subjects were working at a lower percentage of VO_2 max than the untrained subjects. Forty-eight to 70% of the increase in energy cost was attributed to the addition of weight alone. The authors concluded that by increasing total weight with the addition of weighted shoes or boots, the energy cost of walking and running was increased significantly.

A study to determine the effects of weight loading on the lower extremities during treadmill running by measuring the running cycle (stride length, support time, swing time, and flight time), oxygen uptake rate (VO_2), and heart rate (HR) was conducted by Martin (1984). Fifteen men ran at 12 km/hr under a random order of the following treadmill tests: (1) one control condition with no weight added; (2) loads of 0.5 kg and 1.0 kg weight added to either the thighs or the feet with footwear remaining constant. The results showed a linear increase in VO_2 and HR with subsequent increases in weight, with foot loading nearly twice as great as thigh loading as evidenced by a 0.7% increase per 100 g of load for

the feet. VO_2 was shown to be more sensitive to weight increases than heart rate. Martin concluded that the increased oxygen uptake rate and heart rate with increased weight load was due to the increased demand for inertia caused by the added weight.

A final study was conducted with seven elite runners as subjects to determine the effects of shoe weight on the energy cost of running (Catlin & Dressendorfer, 1979). Runners were marathoners tested in running shoes weighing .87 kg and .52 kg. Each subject ran two km on the treadmill at an average of 73% of VO_2 max and again on a road surface at the same intensity. With the heavier shoes, mean energy expenditure was .51 kcal/min higher than the shoes weighing .52 kg ($p < .05$). Stride length was unaffected by shoe weight. While 94 kcal or a 3.3% greater expenditure was estimated for a 42.2 km distance, the authors concluded that the weight of the shoe had only a small effect on increasing the energy cost of running.

Summary

The review of literature has revealed several factors when considering energy expenditure during walking and jogging on the treadmill: (1) when compared with men, women have a lower VO_2 max, which is partially accounted for by females' higher essential body fat; (2) with an increased body mass and/or increased speed of ambulation, an increase in energy expenditure will result; (3) with handweights greater than 1 pound and speeds greater than 4.0 mph, an increase in energy cost will be evidenced when compared to no weight; (4) an increase in range of motion while carrying handweights will increase the energy cost of walking and jogging; and (5) the addition of ankle weights will increase energy cost, and those increases are greater at the distal extremities, with greater weights, and greater speeds.

Based on the review of literature, it would be expected that the increased weight associated with pushing the Baby Jogger® would indicate an increase in energy expenditure, and that as weight within the Jogger increases, energy cost would also increase. Based on the literature, it would also be expected that with greater speeds of ambulation and increased grades there would also be higher energy cost values. Since the

literature reveals differences in energy cost between males and females, only females were tested.

CHAPTER III

Methods

Introduction

This chapter details information on the subjects, instruments, testing methodology, statistical analysis, and a summary.

Subjects

The subjects were thirteen females aged 22-39 years. Subjects were physically active as defined by the American College of Sports Medicine (1990). This includes exercising 3-5 sessions per week at 60-90% HR max for 20-60 minutes per session. Experience pushing the Baby Jogger® was not required for participation in this study. All subjects completed and signed a consent form (Appendix A) and a health/medical history questionnaire (Appendix B) as approved by the Human Subjects Institutional Review Board of San Jose State University.

Instruments

The following instrument was utilized to determine the oxygen uptake rate while pushing the Baby Jogger®.

Baby Jogger®

The Baby Jogger® was donated by Racing Strollers, Inc. in Yakima, Washington. The Jogger contained three neumatic bicycle tires, equipped with 20" steel rims. The frame was made from anodized aluminum and the seat was made of Dupont Cordura fabric. To expedite testing on the treadmill, the Jogger's frame was welded down in length and width; the wheels and seat remained intact. The original dimensions were 54" long, 24" wide and 38" tall. After welding, the Jogger was 34" long, 14" wide and 38" tall. The mass of the stroller was 22 pounds. The weight that was removed from welding was weighed and added back to the Jogger to maintain validity.

Testing Methodology

The testing of the subjects was divided into measurement of body composition and

size, a maximal graded exercise test, one submaximal control test, and two test conditions. The control treadmill test was administered first, followed by a random order of the two test conditions.

Body Composition & Size

Anthropometric measures were determined by measuring height with a wall scale utilizing a Broca plane and body mass in kilograms (kg) on a platform scale.

Body composition was determined by underwater weighing corrected for residual lung volume via the oxygen dilution method (Wilmore, 1969). Residual volume was determined with a Med Science 505D Nitralyzer (Nitrogen Analyzer) and a Collins 8-Liter Spirometer. Prior to each test, the equipment was calibrated.

All subjects were measured for body mass in kilograms (kg) on a platform scale. Underwater weighing was performed in a metal tank with a webbed sling suspended from a Chatillon scale. Subjects performed six to ten trials of underwater weighing with the average of three scores (± 0.05 kg of each other) representing the underwater weight (Cisar, Johnson, Fry, Housh, Hughes, Ryan, & Thorland, 1987). Relative body composition was calculated from the formula of Brozek, Grande, Anderson, and Keys (1963) to determine percentage of body fat, relative fat mass (RF), and lean body mass (LBM).

Maximal Graded Exercise Test

Maximal graded exercise testing was conducted on each subject using the treadmill protocol described by Cisar, Thorland, Johnson, & Housh (1986) modified for females as follows: the test began at 3.0 mph with 1.0 mph workload increases every three minutes, to 8.0 mph, after which 2% grade increases were introduced every three minutes until voluntary exhaustion was achieved.

Each subject wore headgear containing a Hans-Rudolph respiratory valve and mouthpiece. Inhaled air then passed through a Parkinson-Cowan CD-4 Dry Test meter and into the respiratory valve. An Apple II+ computer, connected to a potentiometer, recorded the volume of inspired air (V_I). Expired air exiting the Hans-Rudolph valve

entered a mixing chamber where the air sample was analyzed.

The oxygen ($F_{E}O_2$) and carbon dioxide ($F_{E}CO_2$) content of the expired air was determined by a Wilmore-Costill Spinner Valve (WCSV) system. Each sample of expired air passed through the mixing chamber of the WCSV system prior to entering the gas analyzers. An Applied Electrochemical S-3A analyzer calculated the percent oxygen expired and a Beckman LB-2 Medical Gas Analyzer measured percent carbon dioxide expired. The analyzer was calibrated before each maximal test and every three minutes of the test with a standard gas sample. Inspired and expired air samples were collected each minute of the test.

The lead placement during the maximal test consisted of five surface electrodes which were placed at the subject's right and left arm, right and left leg, and V5. The leads monitored all cardiac electrical patterns and obtained heart rate during the last ten seconds of each minute of the test.

Expired ventilation rate (VE) was calculated from the inspired ventilation rate (V_I). Oxygen uptake rate (VO_2) and carbon dioxide production rate (VCO_2) rates were calculated from V_I , VE, $F_{E}O_2$, and $F_{E}CO_2$ values. The variables recorded for AnT were: AnT VO_2 in l/min and ml/kg/min and AnT HR. Anaerobic threshold oxygen uptake rate (AnT) was determined as the last VO_2 value fitting a linear trend when expired ventilation rate (VE) was plotted against VO_2 during increasing workloads (Wasserman et al., 1973). The last VO_2 value fitting the linear trend was determined visually by graphing VE against VO_2 and mathematically by calculating, each minute, the change in the standard error of estimate between VE and VO_2 . The last VO_2 fitting the linear trend when VE was plotted against VO_2 during increasing workloads also tended to be consistent with the point at which there was an increase in $F_{E}O_2$ without a corresponding decrease in $F_{E}CO_2$ (Wasserman et al., 1973). Anaerobic threshold heart rate (AnT HR) was the heart rate recorded during the minute in which AnT VO_2 occurred.

The test was terminated based on any of the following reasons: (1) the subject requested to terminate the test; (2) failure of the heart rate to increase with increasing

workloads; (3) pain or fatigue as indicated by decreased coordination or pallor; (4) abnormalities on the ECG reading; or (5) equipment failure (ACSM, 1986). For this study, each subject voluntarily terminated the test after giving a “last-minute” signal. Maximal oxygen uptake rate was determined as the highest VO_2 value obtained when (1) heart rate was within 10 b/min of age-predicted maximal heart rate, (2) respiratory quotient (RQ) was 1.0, and/or (3) VO_2 plateaued ($< 2.0 \text{ ml/kg/min}$) or decreased with increasing workloads (McArdle et al., 1991). Maximal heart rate (HR max) was determined as the highest heart rate reached during the maximal graded exercise test.

The control treadmill test was administered first, followed by a random order of the two test conditions.

Submaximal Control Test

The subject wore the headgear containing the respiratory valve and mouthpiece as described above. Lead placement, cardiac function, and heart rate were monitored using the same procedures as during the maximal graded exercise test.

Each subject was allowed a five-minute warm-up to become familiar with the treadmill. Each subject walked on the treadmill at 3.0 mph for six minutes (Workload 1). Expired ventilation rate (VE) was calculated from the inspired ventilation rate (V_I). Oxygen uptake rate (VO_2) and carbon dioxide production rate (VCO_2) rates were calculated from V_I , VE, $F_{E\text{O}_2}$, and $F_{E\text{CO}_2}$ values. These values were measured during each minute of the test. Heart rate was monitored the last 10 seconds of each minute and ECG monitoring was continuous. Kilocalories per liter of oxygen consumed were calculated from the nonprotein respiratory quotient (RQ) which was collected during the fifth and sixth minutes of each workload and then averaged. The RQ value was then multiplied by kcal per liter of oxygen consumed to obtain kcal/min (McArdle et al., 1991). VO_2 (determined from V_I , VE, $F_{E\text{O}_2}$, and $F_{E\text{CO}_2}$ values), HR, and kcal/min were determined by averaging the values collected during the fifth and sixth minutes, which represented steady-state values.

The grade of the treadmill was then increased by 4% (Workload 2), with each of the above physiological variables again being recorded and VO_2 (l/min and ml/kg/min), HR,

and kcal/min being calculated from the average of the values collected during the fifth and sixth minutes. The grade was then reduced to 0% and the speed was increased to a jogging speed of 5.0 mph, for six minutes (Workload 3), with the above protocol again being repeated, followed by another increase in grade by 4% for another six minutes (Workload 4).

Test Condition With 15 Pounds

The subject was given a five-minute warm-up period to become familiar with pushing the Baby Jogger® while on the treadmill. Following the warm-up, a fifteen-pound weight was added to the seat of the Baby Jogger®. The subject then walked at 3.0 mph for six minutes (Workload 1), with gas analysis data collected during each minute and heart rate data collected the final ten seconds of each minute. VO_2 (from V_I , VE , F_{EO_2} , and F_{ECO_2} values), HR, and kcal/min (from RQ and kcal per liter O_2 consumed) were determined by averaging the data from the fifth and sixth minutes. A 4% grade increase followed (Workload 2), with data being collected during each minute. Again, VO_2 (l/min and ml/kg/min), HR, and kcal/min were determined from the average of the fifth and sixth minutes. The grade was then lowered to 0%, while the speed was increased to 5.0 mph for six minutes (Workload 3), with physiological variables measured during each minute. Finally, another 4% grade increase was imposed at 5.0 mph for a final six minutes (Workload 4). Data was collected each minute, and VO_2 (l/min and ml/kg/min), HR, and kcal/min were calculated from the average of the fifth and sixth minutes. During the entire test, the subject was required to hold the Baby Jogger® with both hands.

Test Condition With 30 Pounds

Each subject executed the same procedure as the first test condition, only utilizing a thirty-pound weight in the seat of the Jogger instead of a fifteen-pound weight. Again, the subject was allowed a five-minute warm-up prior to adding 30 pounds to the Jogger. The subject was required to keep both hands on the Jogger during the test.

Statistical Analysis

Descriptive statistics, means and standard deviations, were used to describe the overall

characteristics of the subjects for height, body mass (BM), age, percent body fat, relative fat (RF), lean body mass (LBM), VO_2 and HR at anaerobic threshold, VO_2 max, and HR max. For each condition, the means and standard deviations for submaximal VO_2 , expressed in ml/kg/min, were calculated and expressed as a percentage of VO_2 max. In addition, means and standard deviations were given for VO_2 , HR, and kcal/min averaged from the data collected during the fifth and sixth minutes of each test condition. An overall repeated measures two-way analysis of variance (ANOVA) for VO_2 (l/min and ml/kg/min), HR, and kcal/min were performed. Follow-up repeated measures one-way ANOVAs with Tukey post hoc analyses were used to determine if significant differences existed between the means for oxygen uptake rate, heart rate, and kcal/min when working at different speeds, weights, and grades during the submaximal treadmill tests. The alpha level for statistical significance was $p \leq .05$.

CHAPTER IV

Analysis of Data

Introduction

The following sections will be presented in this chapter: level of significance, analysis of data, summary of findings, discussion of findings, conclusions, weaknesses, recommendations for future research, and summary.

Level of Significance

A probability level (p) of .05 or less was selected as the level of statistical significance for all the analysis of data.

Analysis of Data

Thirteen active, healthy females were tested for this study. Mean, standard deviation, standard error of the mean, variance, and range were calculated for each variable to examine the descriptive nature of the data. Table 1 summarizes the subjects' descriptive data. Variables reported include: age (27.1 ± 5.0 yr; mean $\pm$ SD); height (164.9 ± 6.1 cm); body mass (55.7 ± 6.6 kg); percent body fat ($22.2 \pm 4.9\%$); relative fat mass (12.7 ± 3.6 kg); and lean body mass (43.0 ± 4.0 kg).

Table 2 summarizes the subjects' physiological data. Data collected include: AnT VO_2 (2.07 ± 0.42 l/min); AnT VO_2 (37.33 ± 7.29 ml/kg/min); AnT HR (168.8 ± 16.1 b/min); VO_2 max (2.62 ± 0.45 l/min); VO_2 max (46.95 ± 7.00 ml/kg/min); and HR max (193.2 ± 7.8 b/min).

Table 3 summarizes the means and standard deviations each submaximal VO_2 condition, expressed in ml/kg/min and are expressed as a percentage of VO_2 max. For the control condition, mean values ranged from $27.7 \pm 3.3\%$ for Workload 1 to $81.3 \pm 12.7\%$ of VO_2 max for Workload 4. For the Baby Jogger® condition with 15 pounds, mean percentages ranged from $29.1 \pm 3.6\%$ for Workload 1 to $88.6 \pm 13.6\%$ for Workload 4 and for the 30-pound condition, mean percentages ranged from $31.1 \pm 4.1\%$ for Workload 1 to $94.9 \pm 11.5\%$ for Workload 4.

TABLE 1

Descriptive Data

	Age (yr)	Height (cm)	Body Mass (kg)	% Body Fat	Relative Fat Mass (kg)	Lean Body Mass (kg)
Mean	27.1	164.9	55.7	22.2	12.7	43.0
SD	5.0	6.1	6.6	4.9	3.6	4.0
Range	22.4-39.9	148.0-170.6	36.7-63.0	9.1-28.1	3.3-17.4	33.4-49.1

N = 13

TABLE 2

Physiological Data

	Ant VO ₂ (l/min)	Ant VO ₂ (ml/kg/min)	Ant HR b/min	VO ₂ Max (l/min)	VO ₂ Max (ml/kg/min)	HR Max b/min
Mean	2.07	37.33	168.8	2.62	46.95	193.2
SD	0.42	7.29	16.1	0.45	7.00	7.8
Range	1.52-2.92	28.41-53.85	131-191	1.70-3.34	35.67-61.71	175-205

N = 13

TABLE 3

Submaximal Test Conditions (VO_2 ml/kg/min) Expressed as a Percentage (%) of VO_2 Max

	W1	W2	W3	W4
Control				
Mean	27.7	37.1	66.5	81.3
SD	3.3	4.7	10.9	12.7
15 Pounds				
Mean	29.1	40.8	69.9	88.6
SD	3.6	5.0	11.9	13.6
30 Pounds				
Mean	31.1	45.4	73.5	94.9
SD	4.1	7.1	11.0	11.5

N = 13

Table 4 summarizes the means and standard error of the means for oxygen uptake rate (VO_2) expressed in liters per minute (l/min) during the three submaximal trials. Repeated measures two-way analysis of variance revealed significant differences between trials, $F(2, 24) = 8.92$ $p < .001$, across workloads, $F(3, 36) = 944.85$ $p < .001$, as well as the interaction between trials and workloads, $F(6, 72) = 9.94$ $p < .001$. Repeated measures one-way analyses of variance determined significant differences between all of the trials and Tukey post-hoc analyses detected significant differences between all of the workloads. Repeated measures one-way analyses of variance revealed significant differences between the four workloads. Follow-up Tukey post-hoc analyses detected significant differences between the control and 30-pound conditions at Workloads 1, 2 and 3. For Workload 4, Tukey post-hoc analyses detected significant differences between all of the trials.

Interaction between trials and workloads for VO_2 (l/min) can be observed in Figure 1. Between all the test conditions, the greatest increases in oxygen uptake rate are seen from Workload 2 to 3, or walking to jogging (control: 0.96 ± 0.04 to 1.71 ± 0.05 [mean $\pm$ SEM]); 15-pound condition: 1.06 ± 0.04 to 1.79 ± 0.06 ; 30-pound condition: 1.19 ± 0.08 to 1.90 ± 0.10). The increases in grade both at walking and jogging were greater with each increasing work condition (control: W1 to W2, 0.72 ± 0.03 to 0.96 ± 0.04 ; W3 to W4, 1.71 ± 0.05 to 2.09 ± 0.06 . 15-pounds: W1 to W2, 0.75 ± 0.03 to 1.06 ± 0.04 ; W3 to W4, 1.79 ± 0.06 to 2.28 ± 0.07 . 30-pounds: W1 to W2, 0.81 ± 0.05 to 1.19 ± 0.08 ; W3 to W4, 1.90 ± 0.10 to 2.46 ± 0.09). In addition, the increase in grade with jogging was greater than the increase in grade with walking. The mean increase in oxygen uptake rate from the control to the 15-pound condition was less than the mean increase from the 15-pound to 30-pound condition (W 1: 0.72, 0.75, 0.81 [control, 15 pounds, and 30 pounds]; W2: 0.96, 1.06, 1.19; W3: 1.71, 1.79, 1.90; and W4: 2.09, 2.28 to 2.46).

Table 5 summarizes the means and standard error of the means for oxygen uptake rate (VO_2) expressed in milliliters per kilogram per minute (ml/kg/min) during the three trials. Repeated measures two-way analysis of variance revealed significant differences between

TABLE 4

Oxygen Uptake Rate (l/min) Responses During The Three Trials

	W1	W2	W3	W4
Control				
Mean	0.72	0.96	1.71	2.09
SEM	0.03	0.04	0.05	0.06
15 Pounds				
Mean	0.75	1.06	1.79	2.28
SEM	0.03	0.04	0.06	0.07
30 Pounds				
Mean	0.81	1.19	1.90	2.46
SEM	0.05	0.08	0.10	0.09

Note: Repeated measures two-way analysis of variance revealed significant differences between trials, $F(2, 24) = 8.92$ $p < .001$, across workloads, $F(3, 36) = 944.85$ $p < .001$, as well as the interaction between trials and workloads, $F(6, 72) = 9.94$ $p < .001$.

Repeated measures one-way analyses of variance determined significant differences between all of the trials and Tukey post-hoc analyses detected significant differences between all of the workloads. Repeated measures one-way analyses of variance revealed significant differences between the four workloads. Follow-up Tukey post-hoc analyses detected significant differences between the control and 30-pound conditions at Workloads 1, 2 and 3. For Workload 4, Tukey post-hoc analyses detected significant differences between all of the trials.

Figure 1. Interaction Between Trials and Workloads for VO_2 in Liters/Minute

TABLE 5

Oxygen Uptake Rate (ml/kg/min) Responses During The Three Trials

	W1	W2	W3	W4
Control				
Mean	12.83	17.15	30.59	37.43
SEM	0.35	0.32	0.53	0.65
15 Pounds				
Mean	13.45	18.88	32.06	40.81
SEM	0.27	0.35	0.47	0.76
30 Pounds				
Mean	14.48	21.21	34.07	43.99
SEM	0.68	1.21	1.35	1.24

Note: Repeated measures two-way analysis of variance revealed significant differences between trials, $F(2, 24) = 9.64$ $p < .001$, across workloads, $F(3, 36) = 1267.29$ $p < .001$, as well as the interaction between trials and workloads, $F(6, 72) = 9.98$ $p < .001$. Repeated measures one-way analyses of variance revealed significant differences between the three trials and Tukey post-hoc analyses detected significant differences between all of the workloads. Repeated measures one-way analyses of variance also revealed significant differences between workloads. Tukey post-hoc analyses detected significant differences between the control and 30-pound trial at Workload 1; between the control and 30-pound trials, and 15- and 30-pound trials at Workload 2; between control and 30-pounds for Workload 3; and between all of the trials at Workload 4.

trials, $F(2, 24) = 9.64$ $p < .001$, across workloads, $F(3, 36) = 1267.29$ $p < .001$, as well as the interaction between trials and workloads, $F(6, 72) = 9.98$ $p < .001$. Repeated measures one-way analyses of variance revealed significant differences between the three trials and Tukey post-hoc analyses detected significant differences between all of the workloads. Repeated measures one-way analyses of variance also revealed significant differences between workloads. Tukey post-hoc analyses detected significant differences between the control and 30-pound trial at Workload 1; between the control and 30-pound trials, and 15- and 30-pound trials at Workload 2; between control and 30-pound trials for Workload 3; and between all of the trials at Workload 4.

Interaction between trials and workloads for VO_2 (ml/kg/min) can be observed in Figure 2. As with oxygen uptake rate expressed in l/min, VO_2 expressed in ml/kg/min showed a similar interaction. For example, the most significant increase in VO_2 was between Workloads 2 and 3, or walking to jogging (control: 17.15 ± 0.32 to 30.59 ± 0.53 [mean $\pm$ SEM]; 15-pound condition: 18.88 ± 0.35 to 32.06 ± 0.47 ; 30-pound condition: 21.21 ± 1.21 to 34.07 ± 1.35). The mean increase in VO_2 at both speeds for the increased grade were greater with increased workloads (control: W1 to W2, 12.83 ± 0.35 to 17.15 ± 0.32 ; W3 to W4, 30.59 ± 0.53 to 37.43 ± 0.65 . 15-pounds: W1 to W2, 13.45 ± 0.27 to 18.88 ± 0.35 ; W3 to W4, 32.06 ± 0.47 to 40.81 ± 0.76 . 30-pounds: W1 to W2, 14.48 ± 0.68 to 21.21 ± 1.21 ; W3 to W4, 34.07 ± 1.35 to 43.99 ± 1.24). In addition, the increase in grade with jogging was greater than the increase in grade with walking. Finally, mean increases in oxygen uptake rate were lower between the control and 15-pound condition than between the 15-pound and 30-pound trials (W1: 12.83, 13.45, 14.48 [control, 15 pounds, and 30 pounds]; W2: M = 17.15, 18.88, 21.21; W3: 30.59, 32.06, 34.07; and W4: 37.43, 40.81, 43.99).

Table 6 summarizes the means and standard error of the means for heart rate during the three trials. Repeated measures two-analysis of variance revealed significant differences between trials, $F(2, 24) = 3.57$ $p < .044$ and across workloads, $F(3, 36) = 448.72$ $p < .001$. There was no significant interactions between trials and workloads, $F(6, 72) = 2.15$

Figure 2. Interaction Between Trials and Workloads for VO_2 in Milliliters/Kilogram/Minute

TABLE 6

Heart Rate (b/min) Responses During the Three Trials

	W1	W2	W3	W4
Control				
Mean	93.8	107.9	148.5	167.9
SEM	3.1	2.9	4.3	4.9
15 Pounds				
Mean	90.3	107.8	149.0	170.7
SEM	2.8	3.4	4.1	4.4
30 Pounds				
Mean	95.3	113.0	151.2	173.8
SEM	3.4	3.7	4.4	4.3

Note: Repeated measures two-analysis of variance revealed significant differences between trials, $F(2, 24) = 3.57$ $p < .044$ and across workloads, $F(3, 36) = 448.72$ $p < .001$. There was no significant interaction between trials and workloads, $F(6, 72) = 2.15$ $p < .058$. Repeated measures one-way analyses of variance revealed significant differences between the three trials and Tukey post-hoc analyses detected significant differences between all of the workloads. Repeated measures one-way analyses of variance revealed significant differences between Workloads 2 (3.0 mph, 4% grade) and 4 (5.0 mph, 4% grade), and Tukey post-hoc analyses detected a significant difference between the control and 30-pound trials during Workload 4.

$p < .058$. Repeated measures one-way analyses of variance revealed significant differences between the three trials and Tukey post-hoc analyses detected significant differences between all of the workloads. Repeated measures one-way analyses of variance revealed significant differences between Workloads 2 (3.0 mph, 4% grade) and 4 (5.0 mph, 4% grade), and Tukey post-hoc analyses detected a significant difference between the control and 30-pound trials during Workload 4.

Table 7 summarizes the means and standard error of the means for kilocalories expended per minute (kcal/min) during the three trials. Repeated measures two-way analysis of variance revealed significant differences between trials, $F(2, 24) = 7.46$ $p < .003$, across workloads, $F(3, 36) = 614.76$ $p < .001$, as well as the interaction between trials and workloads, $F(6, 72) = 10.40$ $p < .001$. Repeated measures one-way analyses of variance revealed significant differences between the control, 15-pound, and 30-pound trials and Tukey post-hoc analyses detected significant differences between all of the workloads at each of the trials. Repeated measures one-way analyses of variance revealed significant differences between Workloads 2 (3.0 mph, 4% grade) and 4 (5.0 mph, 4% grade). Follow-up Tukey post-hoc analyses detected significant differences between the control and 30-pound trials and between the 15- and 30-pound trials during Workload 2. Tukey post-hoc analyses found significant differences between all trials for Workload 4.

Interaction between trials and workloads for kilocalories can be observed in Figure 3. As with oxygen uptake rate, for both l/min and ml/kg/min, we find that the most significant increases in kcal/min are from Workloads 2 to 3, or walking to jogging (control: 4.51 ± 0.17 to 8.19 ± 0.25 [mean $\pm$ SEM]; 15-pound condition: 4.84 ± 0.20 to 8.66 ± 0.29 ; 30-pound condition: 5.44 ± 0.37 to 9.14 ± 0.53) With an increase in grade, there were greater increases in kcal/min with each increasing condition (control: W1 to W2, 3.32 ± 0.14 to 4.51 ± 0.17 ; W3 to W4, 8.19 ± 0.25 to 10.21 ± 0.29 . 15-pounds: W1 to W2, 3.40 ± 0.15 to 4.84 ± 0.20 ; W3 to W4, 8.66 ± 0.29 to 11.21 ± 0.39 . 30-pounds: W1 to W2, 3.54 ± 0.28 to 5.44 ± 0.37 ; W3 to W4 9.14 ± 0.53 to 12.14 ± 0.51 .). In addition, the

TABLE 7

Kilocalorie (kcal/min) Responses During The Three Trials

	W1	W2	W3	W4
Control				
Mean	3.32	4.51	8.19	10.21
SEM	0.14	0.17	0.25	0.29
15 Pounds				
Mean	3.40	4.84	8.66	11.21
SEM	0.15	0.20	0.29	0.39
30 Pounds				
Mean	3.54	5.44	9.14	12.14
SEM	0.20	0.37	0.53	0.51

Note: Repeated measures two-analysis of variance revealed significant differences between trials, $F(2, 24) = 7.46$ $p < .003$, across workloads, $F(3, 36) = 614.76$ $p < .001$, as well as the interaction between trials and workloads, $F(6, 72) = 10.40$ $p < .001$. Repeated measures one-way analyses of variance revealed significant differences between the control, 15-pound, and 30-pound trials and Tukey post-hoc analyses detected significant differences between all of the workloads at each of the trials. Repeated measures one-way analyses of variance revealed significant differences between Workloads 2 (3.0 mph, 4% grade) and 4 (5.0 mph, 4% grade). Follow-up Tukey post-hoc analyses detected significant differences between the control and 30-pound trials and between the 15- and 30-pound trials during Workload 2. Tukey post-hoc analyses found significant differences between all trials for Workload 4.

Figure 3. Interaction Between Trials and Workloads for Kilocalories per Minute

increase in grade with jogging was greater than the increase in grade with walking. The mean differences between the 30-pound and 15-pound condition were greater than when comparing the 15-pound condition to the control condition (W1: 3.32, 3.40, 3.54 [control, 15 pounds, and 30 pounds]; W2: 4.51, 4.84, 5.44; W3: 8.19, 8.66, 9.14; and W4: 10.21, 11.21, 12.14).

Summary of Findings

Summary tables for repeated measures two-way analyses of variance which were used to analyze VO_2 , expressed in l/min and ml/kg/min, heart rate (b/min), and kilocalories (kcal/min) are summarized in Appendix H. Two-way analysis of variance for oxygen uptake rate, expressed in l/min, resulted in significant differences between trials, across workloads, as well as a significant interaction between trials and workloads. One-way analyses of variance revealed significant differences between the control, 15-pound, and 30-pound trials and Tukey post-hoc analyses detected significant differences between all workloads within each trial. One-way analyses of variance revealed significant differences across workloads, and Tukey post-hoc analyses detected significant differences between the control and 30-pound trials at Workloads 1, 2, and 3. For Workload 4, Tukey post-hoc analyses found significant differences between all of the trials.

When examining the interaction for VO_2 (l/min), it was found that between all the test conditions, the greatest increases in oxygen uptake rate are seen from Workload 2 to 3, or walking to jogging, while increasing the grade resulted in greater increases with jogging than with walking. These increases were greater with each working condition. The increase in oxygen uptake rate was greater when comparing the 15-pound to the 30-pound condition than when comparing the control condition to the 15-pound condition.

Two-way analysis of variance for oxygen uptake rate expressed in ml/kg/min revealed significant differences between trials, across workloads, as well as a significant interaction between trials and workloads. One-way analyses of variance and Tukey post-hoc analyses revealed significant differences between the three trials, and between all of the workloads for each of those trials. One-way analyses of variance detected significant differences

between workloads. Tukey post-hoc analyses revealed significant differences between the control and 30-pound trials for Workload 1; significant differences between both the control and 30-pound trials and 15- and 30-pound trials at Workload 2; between the control and 30-pound trials for Workload 3; and finally, between all of the trials for Workload 4.

As with oxygen uptake rate expressed in l/min, the interaction between trials and workloads for VO_2 expressed in ml/kg/min showed a similar trend. For example, the most significant increase in VO_2 was between Workloads 2 and 3, or walking to jogging. Increasing the grade resulted in a greater increase with jogging than with walking and the increases were greater with each working condition. The increase in oxygen uptake rate was greater when comparing the 15-pound to the 30-pound condition than when comparing the control condition to the 15-pound condition.

Two-way analysis of variance for heart rate revealed significant differences between the three trials and across the workloads; however, there was no significant interaction between trials and workloads. One-way analyses of variance resulted in significant differences across the three trials and Tukey post-hoc analyses detected differences between each of the workloads during the three trials. One-way analyses of variance revealed significant differences between Workloads 2 (3.0 mph, 4% grade) and 4 (5.0 mph, 4% grade). Tukey post-hoc analyses detected significant differences between the control and 30-pound trials at Workload 4.

Two-way analysis of variance for kilocalories expended per minute revealed significant differences between the three trials and across the four workloads, as well as a significant interaction between trials and workloads. One-way analyses of variance revealed significant differences between the control, 15-pound and 30-pound trials and Tukey post-hoc analyses found significant differences between all the workloads with each of the trials. One-way analyses of variance showed a statistically significant difference between Workloads 2 and 4. Tukey post-hoc analyses showed significant differences between the control and 30-pound trials, as well as between the 15- and 30-pound trials during Workload 2. Tukey post-hoc analyses also detected significant differences between all the

trials during Workload 4.

For the interaction between trials and workloads for kcal/min we find that the most significant increases are from Workloads 2 to 3, or walking to jogging. Increasing the grade resulted in a greater increase in kcal/min with jogging than with walking and the increases were greater with each working condition. The increase in kcal/min was greater when comparing the 15-pound to the 30-pound condition than when comparing the control condition to the 15-pound condition.

Discussion of Findings

The purpose of this study was to determine the energy cost of walking and jogging while pushing the Baby Jogger®. After the data was gathered and analyzed for the 13 female subjects, all of the variables analyzed were significantly different among the three trials. Between the four workloads, all variables analyzed were significantly different between most of the trials.

The subjects in this study had increases in VO_2 values as weight within the Jogger increased, speed increased, and grade increased, as other researchers investigating energy cost have also reported (Miller et al., 1987; Soule et Goldman, 1969; Legg et al, 1986; Graves et al, 1987; Makalous et al, 1988; Auble et al, 1987; Jones et al, 1986; Jones et al., 1987; and Martin, 1984). For example, the mean VO_2 (ml/kg/min) for the 15-pound condition was 4.6%, 9.2%, 4.6% and 8.3% greater for the four workloads over the control condition. With the 30-pound condition, VO_2 (ml/kg/min) was 11.4%, 19.1%, 10.2%, and 14.9% greater than without the Jogger. When comparing the 15-pound condition with the 30-pound condition, VO_2 increased 7.1%, 11.0%, 5.9%, and 7.2% from 15 to 30 pounds. Obviously, the greater differences in VO_2 between trials were evidenced with the increased grades. For the control condition, VO_2 (ml/kg/min) increased 25.2% from Workload 1 to Workload 2; 43.9% from Workload 2 to 3; and 18.3% from Workload 3 to 4. This represents an overall increase in VO_2 of 65.7% (from 12.83 ml/kg/min in Workload 1 to 37.431 ml/kg/min in Workload 4). For the 15-pound condition, Workload 2 was 28.8% more demanding than Workload 1. There was an increased demand for VO_2

of 41.1% and 21.4% between Workloads 2 and 3, and Workloads 3 and 4, respectively. This represents an overall increase in VO_2 of 67% (from 13.45 to 40.81 ml/kg/min). Finally, there were similar increases between workloads for the 30-pound condition: 31.7% increase of Workload 2 over Workload 1, 37.7% between Workloads 2 and 3, and a 22.6% increase between Workloads 3 and 4, with an overall increase in VO_2 of 67.1% (14.48 ml/kg/min in Workload 1 and 43.99 ml/kg/min in Workload 4). Again, the greatest increases in VO_2 across workloads was evidenced in the increase in speed from 3.0 mph to 5.0 mph.

This study is unique in that weight was added with the trials, although not directly to the body, thus making direct comparisons with the reviewed studies difficult. In addition, past research has employed vastly different testing protocols. However, the current findings are consistent with past research in that significant increases occurred in VO_2 with increased weights, increased speeds, and increased grades. For example, Legg et al. (1986) found that VO_2 increased 0.41 l/min when 35% of the subject's weight was added into a backpack. When 5% of this added weight was shifted to the feet, VO_2 increased an average of 0.321 l/min. Hanson (1973) reported significantly higher VO_2 values when experimental obesity was added, and those increases were similar to actual percent weight gained.

With respect to handweights, Makalous et al. (1988), Zarandona et al. (1986), and Claremont et al. (1988) all measured the effects of increased speed and weight on VO_2 . In each of these studies where weights greater than one pound were employed, significant increases in VO_2 were found. Auble et al. (1987) found similar results with handweights in that increased speeds and weight increased VO_2 . However, the studies also employed an increased range of motion with the handweights. Jones et al. (1984; 1987) and Martin (1984) examined the effects of varying ankle weights on VO_2 . In both studies conducted by Jones et al. (1984; 1987), significant increases in VO_2 were evidenced with weighted shoes. Martin (1984) also found significantly higher VO_2 values with greater weight at the feet, a 0.7% increase per 100 g of load for the feet.

Heart rate values increased with additional weight, greater speeds, and high grades, with most of the increases being statistically significant. While direct comparisons cannot be made among studies, a similarity exists whereby some studies have also found significant increases in heart rate, while others did not (Legg et al., 1986; Graves et al., 1987; Makalous et al., 1988; Zarandona et al., 1986; Claremont et al., 1988; Jones et al., 1984; and Martin, 1984). For example, the mean heart rate for the 15-pound condition was -3.7%, 0.09%, 0.3%, and 1.2% over the control condition. The 30-pound trial was 1.6%, 4.5%, 1.8%, and 3.4% higher than the control condition. The 30-pound heart rate values were higher than the 15-pound values by 5.2%, 4.6%, 1.5%, and 1.8% across the four workloads. For the control condition heart rates increased 13.1% from Workload 1 to Workload 2; 27.3% from Workloads 2 to 3; and 11.6% from Workloads 3 to 4 representing an overall increase in heart rate of 74.1 beats per minute or 44.1%. For the 15-pound trial, heart rate increased 16.2% from Workloads 1 to 2; 27.7% from Workloads 2 to 3; and 12.7% from Workloads 3 to 4 representing an overall increase of 80.4 beats per minute or 47.1% across workloads. Finally, for the 30-pound trial, heart rate increased 15.7% from Workloads 1 to 2; 25.3% from Workloads 2 to 3; and 22.6% increase from Workloads 3 to 4. An overall increase of 78.5 b/min or 45.2% was evidenced in this trial. As with VO_2 , and as would be expected, greater increases were found with an increase in speed by 2.0 mph than with the increase in grade at a given speed.

Past research studying the effects of adding weight to the shoes found similar increases in heart rate. Legg et al. (1986) found significant increases in heart rate when a load equal to 35% of the subject's weight was added in a backpack as well as when 5% of that weight was redistributed to the feet. Jones et al. (1984) and Martin (1984) also found significant heart rate increases with weighted feet when compared to control trials.

Graves et al. (1987) found significant increases in heart rate with the addition of 1-lb and 3-lb handweights at 60% and 75% of VO_2 max. Makalous et al. (1988) detected a mean heart rate increase of 6% or 127 beats per minute with the addition of 0.45 kg handweights for obese subjects. This increase was only 3% when arm movements were

exaggerated. Zarandona et al. (1986) found significant increases in heart rate with 5-lb, but not 1-lb handweights among males walking and running on the treadmill. Claremont et al. (1988) found an increase in heart rate values with walking and jogging, though not statistically significant, with the addition of weight to males' and females' hands, ankles, or a combination thereof.

Higher energy cost was also associated with greater weight in the Baby Jogger®, increased speeds and higher grades. Based on past research, the trend was anticipated (Miller et al., 1987; Soule et al., 1969; Legg et al., 1986; Graves et al., 1987; Francis et al., 1986; Makalous et al., 1988; Zarandona et al., 1986; Claremont et al., 1988; Auble et al., 1987; Jones et al., 1986; Jones et al., 1984; Martin et al., 1984; and Catlin et al., 1979). When comparing energy cost of the 15-pound trial in relation to the control trial, values were 2.4%, 6.8%, 5.4%, and 8.9% greater across workloads with the 15-pound trial. The 30-pound trial showed increases of 4.0%, 11.0%, 5.2%, and 7.7% over the 15-pound trial and the 30-pound trial had overall increases of 6.2%, 17.1%, 10.4%, and 15.90% when compared to the control trial. Between all trials the greater increases in energy cost came when the grade was increased at a given speed. When comparing energy cost across workloads, there were increases of 26.4% from Workload 1 to Workload 2; 44.9% from Workloads 2 to 3; and 19.8% from Workloads 3 to 4. This is an overall increase of 67.5% (3.32 kcal/min in Workload 1 to 10.21 kcal/min in Workload 4). For the 15-pound condition, there was a 29.8% increase from Workload 1 to Workload 2; a 44.1% increase from Workloads 2 to 3; and a 22.7% increase from Workloads 3 to 4. This is equivalent to a 70% increase in energy cost, or 3.40 kcal/min (Workload 1) to 11.21 kcal/min (Workload 4). Similar increases in energy cost with the 30-pound trial were found. There was a 34.9% increase from Workload 1 to Workload 2; a 40.5% increase from Workloads 2 to 3; and a 24.7% increase from Workloads 3 to 4. An overall increase from 3.54 kcal/min to 12.14 kcal/min is equal to an overall increase of 70.8%. As with VO_2 and heart rate, the greater increases across workloads were evidenced with the increase in speed, rather than the increase in grade.

While direct comparisons between this study and past research are difficult due to the use of different methods, this study found that energy cost does increase with increased loads, speeds, and grades. For example, Miller et al. (1987) found a 1.3%/100 g of added weight increase in energy expenditure with the addition of handweights and a combination of both handweights and ankle weights results in an average increase of 0.9%/100 g of added weight. Soule et al. (1969) found a 1.4 times increase in energy cost with 4-kg weights held in the hands over no weight and a 1.9 times increase with 7-kg weights over no weight. Legg et al. (1986) noted a 0.15% increase per 100 g increase in energy expenditure when 35% of each subject's weight was added to the body in the form of a backpack. When 5% of this increase was redistributed to the feet a 0.96% increase per 100 g of added weight was detected.

With handweights greater than one pound and at speeds greater than 4.0 mph, significant increases in energy cost when compared to no handweights were found. Graves et al. (1987) found significant increases in caloric cost while carrying 3-lb handweights during submaximal testing (60% and 75% VO_2 max). Francis et al. (1986) found significant increases with the use of handweights at three different speeds with 0.91 kg handweights. Makalous et al. (1988) found greater energy expenditure values with 0.45 kg handweights when compared to no handweights among obese subjects during walking for 30 minutes. While Zarandona et al. (1986) found no significant differences between no handweights and 1-lb handweights, significant differences were detected in energy cost with the use of 5-lb handweights during a walking and running protocol. Claremont et al. (1988) calculated a 3 to 10% increase in caloric expenditure for each kg of added handweight and ankle weight mass among subjects during walking and jogging. Finally, Auble et al. (1987) found significant increases in energy cost as speed, handweight mass (1-, 2-, and 3-lb handweights), and range of motion with the arms was increased.

When reviewing the literature for ankle weight energy cost similar results were noted. Jones et al. (1986) found an average increase of 1.0% per 100 g increase in footwear and an 8.3% increase in energy expenditure when footwear changed from shoes to boots.

Jones et al. (1984) found significant increases with the addition of military boots at 5.6 and 7.3 km/hr, but not at 4.0 km/hr. A 5.9-10.2% increase in energy cost was noted when comparing military boots to regular shoes and a 5.0-6.3% increase when comparing weighted over regular shoes. Martin (1984) calculated a 0.7% increase per 100 g load on the feet which represented twice the energy cost of carrying the same weight at the thigh. Finally, Catlin et al. (1979) noted a significantly higher mean energy expenditure between shoes weighing 0.87 kg and 0.52 kg, representing a difference of 3.3%.

Figure 4 depicts the nearly linear relationship between heart rate and oxygen uptake rate during treadmill walking (Stone, 1987). Juxtaposed with this data are the heart rate and oxygen uptake rate data for the three trials in this study. For all three test conditions, walking at both 0% and 4% grades does not elicit the appropriate heart rate response to meet ACSM guidelines for fitness (60-90% of HR max). For those exercisers using the Baby Jogger® as part of their fitness regimen, the exerciser must jog at approximately 5.0 mph, regardless of weight held within the Baby Jogger®. Jogging at 5.0 mph with no Baby Jogger®, with 15 pounds added, and 30 pounds added to the Baby Jogger® elicited training heart rate percentages between 77-90%. Jogging at 5.0 mph at a 4% grade with 30 pounds elicited a mean 90% max heart rate value with an oxygen uptake rate mean of 94.9% of HR max. In order to comply with ACSM training guidelines a jogger would not want to exceed 90% HR max. Although it is difficult to monitor or maintain an exact speed and/or grade, it is important that females exercising with the Baby Jogger® regularly check their heart rate to ensure they do not exceed the recommended guidelines, particularly because the weight of a child will gradually increase over time. Since the collected percentage of HR max and VO_2 max data from this study fall along a similar linear relationship between percentage of HR max and VO_2 max values collected by Stone on the treadmill (1987), female joggers using the Baby Jogger® can use their heart rate as an accurate measure of their exercise intensity.

Figure 4. Relationship Between HR and VO₂ Max

Conclusions

Within the limits of this study, the following conclusions were made:

1. There was a significant increase in VO_2 (l/min and ml/kg/min) while pushing the Baby Jogger® when compared to walking and jogging with no Baby Jogger®.
2. There was a significant increase in VO_2 (l/min and ml/kg/min) as speed of ambulation increased.
3. There was a significant increase in VO_2 (l/min and ml/kg/min) as weight held within the Baby Jogger® increased.
4. There was a significant increase in VO_2 (l/min and ml/kg/min) as the grade increased.
5. There was not a significant increase in heart rate while pushing the Baby Jogger® when compared to walking and jogging with no Baby Jogger®.
6. There was a significant increase in heart rate as speed of ambulation increased.
7. There was not a significant increase in heart rate as weight held within the Baby Jogger® increased.
8. There was a significant increase in heart rate as the grade increased.
9. There was a significant increase in kcal/min while pushing the Baby Jogger® when compared to walking and jogging with no Baby Jogger®.
10. There was a significant increase in kcal/min as speed of ambulation increased.
11. There was a significant increase in kcal/min as weight held within the Baby Jogger® increased.
12. There was a significant increase in kcal/min as the grade increased.

Weaknesses

Simulation of walking and jogging with the Baby Jogger® on the treadmill cannot account for an actual walk or run on real terrain. During testing on the treadmill the Baby Jogger®'s wheels remained parallel to the treadmill belt. While on an outside surface a jogger would make small corrections and turns, even if remaining in a straight-ahead direction. During testing, as mentioned in the limitations, rolling resistance and thus

energy expenditure could have been affected by the smooth, rubbery surface of the treadmill as opposed to land which has small bumps and grooves inherent in its surface. In addition, wind resistance was absent in the lab which would be present with actual use of the Baby Jogger®.

As mentioned in the limitations, the modification of the Baby Jogger® may have had some effect on energy cost. Although the weight was added back to the Baby Jogger® after welding, the Baby Jogger® had a slight tendency to tip backwards due to its change in weight distribution. The subject's force to push the Jogger may have been altered thus affecting energy cost.

Recommendations for Future Research

Within the limits of this study, the following recommendations were made:

1. Future research should calculate the energy cost (VO_2 and kcal/min) of walking and jogging with the Baby Jogger® on open terrain and determine if there are significant differences between lab and field results.
2. Research should calculate the energy cost (VO_2 and kcal/min) of males walking and jogging while pushing the Baby Jogger®.
3. Future research should examine additional speeds of ambulation.
4. Future research should examine additional variations in weight held within the Baby Jogger®.
5. Research should determine the energy cost of pushing the Baby Jogger® at grades other than those presently studied.
6. Future research should collect blood lactate during testing in order to estimate the actual contributions of aerobic and anaerobic metabolism while exercising with the Baby Jogger®.

References

- American College of Sports Medicine (1990). The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adults. Medicine and Science in Sports and Exercise, 22(2), 265-274.
- Auble, T.E., Schwartz, L., & Robertson, R.J. (1987). Aerobic requirements for moving handweights through various ranges of motion while walking. The Physician and Sportsmedicine, 15(6), 133-141.
- Bhambhani, Y., & Singh, M. (1985). Metabolic and cinematographic analysis of walking and running in men and women. Medicine and Science in Sports and Exercise, 17(1), 131-137.
- Booyens, J., & Keatinge, W.R. (1957). The expenditure of energy by men and women walking. Journal of Physiology, 138, 165-171.
- Bransford, D.R., & Howley, E.T. (1977). Oxygen cost of running in trained and untrained men and women. Medicine and Science in Sports, 9(1), 41-44.
- Brozek, J.F., Grande, J.T., Anderson, J., & Keys, A. (1963). Densiometric analysis of body composition: Revision of some quantitative assumptions. Annals of the New York Academy of Science, 110, 113-140.
- Carter, T. (1985, March 21). Now baby can train for Boston, too. The Washington Times, p. 2B.
- Catlin, M.J., & Dressendorfer, R.H. (1979). Effect of shoe weight on the energy cost of running. Medicine and Science in Sports, 9, 80.
- Cisar, C.J., Johnson, G.O., Fry, A.C., Housh, T.J., Hughes, R.A., Ryan, A.J., & Thorland, W.G. (1987). Preseason body composition, build, and strength as predictors of high school wrestling success. Journal of Applied Sports Science Research, 4, 166-170.
- Cisar, C.J., Thorland, W.G., Johnson, G.O., & Housh, T.J. (1986). The effect of endurance training on metabolic responses and the prediction of distance running performance. Journal of Sports Medicine, 26, 234-240.

- Claremont, A.D., & Hall, S.J. (1988). Effects of extremity loading upon energy expenditure and running mechanics. Medicine and Science in Sports and Exercise, 20(2), 167-171.
- Cooper, K.H. (1988). The New Aerobics For Women. New York: Bantam Books.
- Cureton, K.J., & Sparling, P.B. (1980). Distance running performance and metabolic responses to running in men and women with excess weight experimentally equated. Medicine and Science in Sports and Exercise, 12(4), 288-294.
- Falls, H.B., & Humprey, L.D. (1976). Energy cost of running and walking in young women. Medicine and Science in Sports, 8(1), 9-13.
- Fellingham, G.W., Roundy, E.S., Fisher, A.G., & Bryce, G.R. (1978). Caloric cost of walking and running. Medicine and Science in Sports, 10(2), 132-136.
- Firm's success rolls on three wheels. (1989, January 9). USA Today, p. 6B.
- Fox, E.L., Bowers, R.W., & Foss, M.L. (1988). The physiological basis of physical education and athletics (4th ed.). Dubuque, IA: Wm. C. Brown Company Publishers.
- Francis, K., & Hoobler, T. (1986). Changes in oxygen consumption associated with treadmill walking and running with light hand-carried weights. Ergonomics, 29(8), 999-1004.
- Graves, J.E., Pollock, M.L., Montain, S.J., Jackson, A.S., & O'Keefe, J.M. (1987). The effect of hand-held weights on the physiological responses to walking exercise. Medicine and Science in Sports and Exercise, 19(3), 260-265.
- Hagan, R.G., Strathman, T., Strathman, L., & Gettman, L.R. (1980). Oxygen uptake and energy expenditure during horizontal treadmill running. Journal of Applied Physiology, 49(4), 571-575.
- Hanson, J.S. (1973). Exercise responses following production of experimental obesity. Journal of Applied Physiology, 35(5), 587-591.
- If Phil Baechler's Baby Jogger ever appears in a movie, just call it *Chariots of Sire*. (1984, June 11). People, p. 24.

- Joggers' Kids Can Roll Along. (1988, January 25). The New York Times, p. B4.
- Jones, B.H., Knapik, J.J., Daniels, W.L., & Toner, M.M. (1986). The energy cost of women walking and running in shoes and boots. Ergonomics, 29(3), 439-443.
- Jones, B.H., Toner, M.M., Daniels, W.L., & Knapik, J.J. (1984). The energy cost and heart-rate response of trained and untrained subjects walking and running in shoes and boots. Ergonomics, 27(8), 895-902.
- Legg, S.J., & Mahanty, A. (1986). Energy cost of backpacking in heavy boots. Ergonomics, 29(3), 433-438.
- Lloyd, B. (1988, January 25). Joggers' kids can roll along. The New York Times, p. 12A.
- Makalous, S.L., Araujo, J., & Thomas, T.R. (1988). Energy expenditure during walking with handweights. The Physician and Sportsmedicine, 16(4), 139-148.
- Martin, P.E. (1984). The effect of lower extremity loading on mechanical and physiological measures of running performance. Medicine and Science in Sports and Exercise, 16, 185.
- McArdle, W.D., Katch, F.I., & Katch, V.L. (1991). Exercise Physiology: Energy, Nutrition, and Human Performance (3rd ed.). Malvern, PA: Lea & Febiger.
- Miller, J.F., & Stamford, B.A. (1987). Intensity and energy cost of weighted walking vs. running for men and women. Journal of Applied Physiology, 62(4), 1497-1501.
- Noble, B.J. (1986). Physiology of Exercise and Sport. St. Louis: Times Mirror/Mosby College Publishing.
- Racing strollers. (1990, July). CEO, p. 10.
- Ralston, H.J. (1960). Comparison of energy expenditure during treadmill walking and floor walking. Journal of Applied Physiology, 15, 1156.
- expenditure in marching on snow-covered ground. Journal of Applied Physiology, 21, 1747-1749.
- Some joggers take the baby along. (1987, November 5). Los Angeles Times, p. A6.

- Soule, R.G., & Goldman, R.F. (1969). Energy cost of loads carried on the head, hands, or feet. Journal of Applied Physiology, 27(5), 687-690.
- Stone, W.J. (1987). Adult Fitness Programs: Planning, Designing, Managing, and Improving Fitness Programs. Glenview, IL: Scott, Foresman and Company.
- Wasserman, K.B., Whipp, B., Koyal, S., & Beaver, W.L. (1973). Anaerobic threshold and respiratory gas exchange during exercise. Journal of Applied Physiology, 35, 236-243.
- Wilmore, J.H. (1969). Special communications: a simplified method for determination of residual lung volumes. Journal of Applied Physiology, 27(1), 96-100.
- Zarandona, J.E., Nelson, A.G., Conlee, R.K., & Fisher, A.G. (1986). Physiological responses to hand-carried weights. The Physician and Sportsmedicine, 14(10), 113-120.

APPENDIX A

STATEMENT OF INFORMED CONSENT -- FOR BODY COMPOSITION AND
SIZE AND CARDIORESPIRATORY ENDURANCE

College of Applied Sciences and Arts • Department of Human Performance

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STUDY TO DETERMINE THE CALORIC EXPENDITURE OF WALKING AND
JOGGING WHILE PUSHING THE BABY JOGGER®

STATEMENT OF INFORMED CONSENT -- FOR BODY COMPOSITION AND
SIZE AND CARDIORESPIRATORY ENDURANCE

Invitation to Participate

You are invited to participate in a study quantifying the caloric expenditure of walking and jogging while pushing the Baby Jogger®. This study will be conducted at the San Jose State University campus.

Basis for Selection

You have been selected as a participant because you are a healthy female aged 20 to 40 who regularly engages in aerobic exercise. Should you decide to participate, your response to a health history questionnaire will be reviewed by an exercise physiologist and if satisfactory, you will be asked to participate in the tests described below.

Purpose of the Study

The purpose of this study is to quantify the caloric expenditure of walking and jogging while pushing the Baby Jogger®.

Explanation of Procedures

Body Composition and Size Test

Your body weight will be assessed on a balance-type scale and your height will be measured on a stadiometer. Your body composition will be determined via underwater weighing. Underwater weighing involves three measures: body weight, body weight while under water, and residual lung volume (the amount of air left in your lungs after you have fully exhaled). For this test, you will be seated in a chair, breathing room air through a mouthpiece. At the end of 3-4 normal

breaths, you will be asked to take a maximal inspiration and maximal expiration.

To obtain body weight while under water, you will be sitting in a 4-inch wide canvas sling which will be suspended from a scale so that you are about neck deep in water. You will then tuck your knees up and bend your head forward so that you are completely submerged while blowing out as much air from your lungs as possible. You must try to remain motionless for 5 to 10 seconds before raising your head, to allow a scale reading. These procedures will be repeated 6 to 10 times with rest intervals between each procedure.

Maximal Aerobic Capacity

Your maximal aerobic capacity will be determined from a test which involves running on a treadmill at progressively increasing workloads. Your expired air will be collected through a mouthpiece connected to rubber tubing. Your heart rate will be monitored by six electrodes attached to your chest wall. You will begin by walking on the treadmill at 3.0 mph. Every three minutes, the speed will be increased by 1.0 mph to 8.0 mph, after which a 2% grade increase will occur until voluntary exhaustion is achieved. Following completion of the test, the resistance will be reduced so that you can recover comfortably. Dr. Craig Cisar, head of this research committee, and an exercise physiology professor at San Jose State University, will be present during the administration of the maximal uptake test. Certified CPR personnel will also be present during testing.

Submaximal Tests

Three subsequent submaximal treadmill tests will follow: one submaximal trial with no Baby Jogger®, one trial with the Baby Jogger® containing a 15-pound weight, and a trial with the Baby Jogger® containing a 30-pound weight. The first trial will involve warming up by walking on the treadmill for five minutes. The test will then begin by walking on the treadmill at a speed of 3.0 mph for six minutes, after which a 4% grade increase will be introduced for another six minutes. The treadmill will then return to a 0% grade, followed by an increase in speed to 5.0

mph. This speed will be maintained for six minutes, after which the grade will again be increased by 4% for another six minutes. During the entire test, your heart rate will be monitored on an electrocardiograph by placing six electrodes on your chest and your expired air will be collected through a mouthpiece connected to rubber tubing.

The second trial will repeat the above-described protocol. You will be given a five-minute warm-up while pushing the Baby Jogger® to allow you to become familiar with the Jogger. Then the above protocol will be repeated with the addition of a 15-pound weight.

The third trial will repeat the protocol, using a 30-pound weight rather than a 15-pound weight. Certified CPR personnel will be present during testing.

Discomfort and Risks

Underwater Weighing

As with any pool situation, chlorine irritation, swallowing of water, and choking are possible. There may be some discomfort associated with submersion under water.

Residual Lung Volume

Some persons experience faintness and/or dizziness when performing the breathing procedures. Discomfort associated with this test may come from breathing through a mouthpiece with a noseclip in place.

Cardiorespiratory Endurance

You may experience some discomfort and dryness in the mouth, throat, and chest during the exercise test. You may also experience discomforts commonly associated with exercise: sweating; increased heart rate, breathing rate, and body temperature; and fatigue. Changes that may be anticipated at or near the end of the exercise test include abnormal blood pressure, fainting, dizziness, muscle fatigue or cramps, nausea, and abnormalities in heartbeat (some of these could result in death). Individuals will be excluded from participation in this investigation when

abnormalities are detected in electrocardiographic recordings or medical history indicates that testing is contraindicated. During exercise you may experience heartbeat abnormalities. If these are detected, the test will be stopped immediately. You may be fatigued, lightheaded, and slightly nauseous for a short time following the exercise test.

Benefits from Participation in the Study

You will benefit from this testing by receiving an accurate assessment of your body composition and cardiorespiratory fitness. This information may be used as the basis of an aerobic training program.

Compensation for Participation in the Study

There will be no compensation for participation in this study.

Assurance of Confidentiality

Each subject's test data will be coded by number, not by subject name, to ensure maximum confidentiality. These results will be kept in a locked file cabinet. The results of this investigation may be used for research publication and presentation. Your right to confidentiality will be protected unless your express consent is granted prior to the publication or presentation of the data.

Withdrawal from the Study

Your participation in this study is completely voluntary. You may withdraw your consent and discontinue participation at any time (including during the testing) without prejudice. You are free to decline to answer any specific item or question on the medical history questionnaire.

If you have questions about the investigation now or during the testing, please feel free to ask. If additional questions come up later, or in case of an emergency, Mindy Hansen 408-736-2812, Dr. Craig J. Cisar 408-924-3018, or Dr. James Bryant 408-924-3010 will be happy to answer them. In the case of any complaints during or after the testing, you may contact Dr. Serena Stanford, Associate Academic Vice President of Graduate Studies and Research, at 408-924-2480.

Consent

By signing this form, you are agreeing that:

- (a) you have decided to participate in this study having read the information provided above;
- (b) you understand the discomforts and risks involved;
- (c) you understand that you can withdraw at any time; and
- (d) you understand that your name will be kept confidential except with your express consent.

You will be given a copy of this consent form for your personal records.

Signature of Test Subject _____ Date _____

Print Name _____

Signature of Test Director _____ Date _____

APPENDIX B

PRE-EXERCISE TESTING HEALTH STATUS QUESTIONNAIRE

APPENDIX B

PRE-EXERCISE TESTING
HEALTH STATUS QUESTIONNAIRE

Name _____ Number _____ Date _____

A. Health Status Check areas you previously or currently have problems:

☐ High Blood Pressure	☐ Acute Infection
☐ Heart Disease or Dysfunction	☐ Diabetes or Blood Sugar
☐ Peripheral Circulatory Disorder	☐ Anemia
☐ Lung Disease or Dysfunction	☐ Hernias
☐ Arthritis or Gout	☐ Thyroid Dysfunction
☐ Edema	☐ Pancreas Dysfunction
☐ Epilepsy	☐ Liver Dysfunction
☐ Multiple Sclerosis	☐ Kidney Dysfunction
☐ High Blood Cholesterol or
triglyceride levels	☐ Neural Dysfunction
	☐ Others you feel we should know
about _____

B. Family History: Check if any of your blood relatives have or have had any of the following:

☐ Heart attacks or strokes prior to age 50	☐ Heart Disease
☐ Elevated blood cholesterol or triglycerides	☐ High Blood Pressure
☐ Diabetes	☐ Others you feel we should know
about _____

C. Physical Perceptions: Indicate any unusual sensations or perceptions you have had during or shortly after physical activity (PA); or during sedentary periods (SED).

PA	SED		PA	SED	
☐	☐	Chest Pain	☐	☐	Nausea
☐	☐	Heart Palpitations	☐	☐	Light Headedness
☐	☐	Unusually rapid breathing	☐	☐	Loss of Balance
☐	☐	Overheating	☐	☐	Loss of Coordination
☐	☐	Muscle Cramping	☐	☐	Extreme Weakness
☐	☐	Muscle Pain	☐	☐	Numbness
☐	☐	Joint Pain	☐	☐	Mental Confusion
☐	☐	Other _____			

D. Current Habits: Check any of the following that apply:

Smoking

Do you smoke? Yes () No ()

If yes, how many per day? _____ How many years? _____

In case you stopped, when did you smoke? _____ How many years? _____

Diet

What is your weight now? _____ One year ago? _____ At age 21? _____

Are you dieting? _____ Why? _____

Exercise

() Regularly do manual garden or yard work

() Regularly go for long walks: How far? _____ Frequency per week _____

() Frequently rides a bicycle: How far? _____ Frequency per week _____

() Participates in aerobic dance program: Frequency per week _____

() Uses the Stairmaster: How long? _____ Frequency per week _____

() Running: How far? _____ Frequency per week _____

() Weight Conditioning Program: Frequency per week _____

() Engage in a sports program more than once per week. If so, what does this consist of? _____

() Other exercise you participate in: _____

How long or far? _____ Frequency per week _____

Current Medication Usage (List the drug name and the condition being managed)

Medication

Condition

_____	_____
_____	_____
_____	_____

APPENDIX C

PERCENT OF VO_2 MAXIMUM ACROSS WORKLOADS

Appendix C

Fig 1: Comparison of percentage of VO₂ max for Workload 1 (3.0 mph, 0% grade), Workload 2 (3.0 mph, 4% grade), Workload 3 (5.0 mph, 0% grade), and Workload 4 (5.0 mph, 4% grade).

APPENDIX D

VO₂ IN LITERS PER MINUTE ACROSS WORKLOADS

Appendix D

Fig 2: Comparison of VO₂ in l/min for Workload 1 (3.0 mph, 0% grade), Workload 2 (3.0 mph, 4% grade), Workload 3 (5.0 mph, 0% grade), and Workload 4 (5.0 mph, 4% grade).

APPENDIX E

VO₂ IN MILLILITERS PER KILOGRAM PER MINUTE ACROSS WORKLOADS

Appendix E

Fig 3: Comparison of VO₂ in ml/kg/min for Workload 1 (3.0 mph, 0% grade), Workload 2 (3.0 mph, 4% grade), Workload 3 (5.0 mph, 0% grade), and Workload 4 (5.0 mph, 4% grade).

APPENDIX F

HEART RATE IN BEATS PER MINUTE ACROSS WORKLOADS

Appendix F

Fig 4: Comparison of heart rate for Workload 1 (3.0 mph, 0% grade), Workload 2 (3.0 mph, 4% grade), Workload 3 (5.0 mph, 0% grade), and Workload 4 (5.0 mph, 4% grade).

APPENDIX G

KILOCALORIES PER MINUTE ACROSS WORKLOADS

Appendix G

Fig 5: Comparison of kilocalories per minute (kcal/min) for Workload 1 (3.0 mph, 0% grade), Workload 2 (3.0 mph, 4% grade), Workload 3 (5.0 mph, 0% grade), and Workload 4 (5.0 mph, 4% grade).

APPENDIX H

REPEATED MEASURES TWO-WAY ANALYSIS OF VARIANCE SUMMARY TABLES

APPENDIX H-1. Repeated Measures Two-Way Analysis of Variance

Summary Table for VO₂ in Liters Per Minute During Trials

SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	1.75	24	0.07		
Trials	1.30	2	0.65	8.92	.001
.....					
TOTAL	3.05	26			

SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	.70	36	0.02		
Trials	55.33	3	18.44	944.85	.001
.....					
TOTAL	56.03	39			

SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	.33	72	0.00		
Trials	.27	6	0.05	9.94	.001
.....					
TOTAL	.60	78			

APPENDIX H-1. Repeated Measures Two-Way Analysis of Variance
 Summary Table for VO₂ in Milliliters Per Kilogram Per Minute During Trials

SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	502.37	24	20.93		
Trials	403.56	2	201.78	9.64	.001
.....					
TOTAL	905.93	26			
SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	168.99	36	4.69		
Trials	17846.32	3	5948.77	1267.29	.001
.....					
TOTAL	18015.31	39			
SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	97.52	72	1.35		
Trials	81.13	6	13.52	9.98	.001
.....					
TOTAL	178.65	78			

APPENDIX H-1. Repeated Measures Two-Way Analysis of Variance

Summary Table for Heart Rate During Trials

SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	1715.33	24	71.47		
Trials	510.50	2	255.25	3.57	.044
.....					
TOTAL	2225.83	26			
SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	3987.05	36	110.75		
Trials	149087.95	3	49695.98	448.72	.001
.....					
TOTAL	153075.00	39			
SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	928.87	72	12.90		
Trials	166.63	6	27.77	2.15	.058
.....					
TOTAL	1095.50	78			

APPENDIX H-1. Repeated Measures Two-Way Analysis of Variance

Summary Table for Kilocalories per Minute Rate During Trials

SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	42.75	24	1.78		
Trials	26.56	2	13.28	7.46	.003
.....					
TOTAL	69.31	26			

SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	28.47	36	0.79		
Trials	1458.45	3	18.44	944.85	.001
.....					
TOTAL	1486.92	39			

SOURCE	SS	DF	MS	F	SIGNIFICANCE
Within Cells	11.36	72	0.16		
Trials	9.85	6	1.64	10.40	.001
.....					
TOTAL	21.21	78			