The Effect of Unloading Body Weight during Aerobic Exercise on Blood Pressure, Heart Rate, and Perceived Exertion

Bolander

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THE EFFECT OF UNLOADING BODY WEIGHT DURING AEROBIC EXERCISE ON BLOOD PRESSURE, HEART RATE, AND PERCEIVED EXERTION

by

Carolynn J. Bolander

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Health, Physical Education
and Recreation

Western Michigan University
Kalamazoo, Michigan
April 1998
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1998
ACKNOWLEDGMENTS

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And a special thanks to my future husband, TJ Derrick, for being so supportive during these last several months. Your patience was immeasurable.

Carolynn J. Bolander
THE EFFECT OF UNLOADING BODY WEIGHT DURING AEROBIC EXERCISE ON BLOOD PRESSURE, HEART RATE, AND PERCEIVED EXERTION

Carolynn J. Bolander, M.A.
Western Michigan University, 1998

The problem of the study was to examine the blood pressure, heart rate, and rating of perceived exertion of asymptomatic, active individuals during submaximal treadmill exercise while using an unloading system. Two levels of unloading, 20% unloaded body weight (UBW) and 40% UBW, were compared to 0% UBW. Treadmill speed was determined by the speed required to reach a steady state heart rate of 70% of maximum heart rate in an unloaded state. Twenty subjects, between the ages of 18 and 42 years, served as subjects. Subjects were grouped with respect to fitness level; walkers were those subjects who walked to achieve a steady state heart rate of 70% of maximum heart rate and runners ran to achieve the same state. No differences in preexercise measurements of heart rate or blood pressure were found across trial days. A difference was found between walkers’ and runners’ preexercise heart rate. Exercise heart rate, blood pressure, and RPE were not different across the trial days. Differences were found for heart rate, systolic blood pressure, and RPE among the UBW conditions. For heart rate, systolic blood pressure, and RPE, significant Group × UBW interaction effects were found. Larger differences between the UBW levels were found for runners than for walkers. These differences were thought to be due to the mechanical differences between running and walking and to the effect the harness has on the gait patterns.
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CHAPTER I

INTRODUCTION

High blood pressure affects approximately 40 million Americans in this country. According to many sources, this is a conservative estimate because many individuals with high blood pressure are never diagnosed due to lack of regular physical check-ups.

One of the most effective nondrug therapies used to control high blood pressure is exercise. However, in cases of blood pressure readings of 175/110 mmHg and over, strenuous aerobic exercise may not be an option due to the possibility of more serious health complications such as stroke. For these individuals, medication becomes the first call to action to control the situation, and then exercise becomes an option. Yet, even when on medications such as beta blockers, the body’s reaction to exercise may be affected, and any variations in heart rate may affect the aerobic benefits achievable in such persons.

A recent development in the area of physical therapy may provide an option for patients with high blood pressure who may or may not be on blood pressure medication. “Unweighting” or “unloading” devices, created by several manufacturers, allow physical therapy patients who have undergone surgery or who have problems with knees or hips to perform task-relevant exercise at varying proportions of their body weight during treadmill exercise. This hoist-like device consists of a body halter that lifts a percentage of a person’s body weight off the treadmill during the exercise. In the past, this machine was used to alleviate pain and pressure on the limbs and
body during exercise and allowed the patient to perform rehabilitative exercise that was task-specific in terms of regaining normal walking and running gaits. However, there may be a possible rehabilitation use for patients who either suffer from high blood pressure or are medically-evaluated obese.

Statement of the Problem

The problem of this study was to examine the blood pressure, heart rate, and rating of perceived exertion (American College of Sports Medicine [ACSM], 1995) of asymptomatic, active individuals during submaximal treadmill exercise while using an unloading system. Two levels of unloading, 20% unloaded body weight (UBW) and 40% UBW, were compared to 0% UBW.

Purpose of the Study

The major purpose of this study was to examine the effects on blood pressure of using an unloading machine during treadmill exercise. Additionally, the study may determine if, by using an unloading machine during cardiovascular exercise, the subject’s blood pressure would remain in a safe range and if heart rate could be maintained in an effective aerobic range throughout exercise.

Significance of the Study

The research may benefit persons diagnosed as hypertensive to severely hypertensive and obese individuals. By determining the effects of unweighting on a healthy individual’s blood pressure, possibilities for use with severe hypertensives may be researched in the future. The application for use with severely obese individuals as an exercise intervention prior to initial weight loss is also a possibility.
The research may also benefit individuals with gravitational stress limitations due to surgery, injury, etc., by allowing them a cardiovascular option to pool therapy or traditional nonforce rehabilitation exercise.

**Delimitations**

This study was delimited to the following:

1. Volunteers were males and females, ages 18 to 42 years.

2. All subjects resided in the Kalamazoo County area and reported they were free from any risk factors, such as high blood pressure, extreme obesity, smoking, asthma, diabetes, or musculoskeletal injuries.

3. Subjects were screened for potential health risks through use of a questionnaire.

4. The three dependent variables recorded during the exercise bouts were blood pressure, heart rate, and Borg’s rating of perceived exertion (ACSM, 1995).

5. Subjects were asymptomatic individuals who exercised occasionally or regularly; however, none would be termed an elite athlete. This delimitation was set due to possible differences of blood pressure and heart rate progression measurements in elite, endurance-type athletes.

6. Treadmill speed was determined by the speed required to reach a steady state heart rate of 70% of maximum heart rate for each individual in an unloaded state.

7. The three different conditions of loading were measured ideally for 3 consecutive days at approximately the same time each day.

8. Pretesting was done the day prior to testing at the same time set for the actual test days.
Limitations

The limitation of this study was that the subjects were self-reportedly healthy individuals, not experiencing any of the conditions that may make this equipment a viable option for exercise for special populations. Therefore, heart rate and blood pressure results may be different than those of individuals with high blood pressure or extreme obesity conditions. Also, the subjects were volunteers and, therefore, may not represent the general population of subjects aged 18 to 42 years.

Assumptions

It was assumed that participants abstained from consuming alcohol during the testing days and did not exercise within the hour prior to participation, as they were requested to do.

Hypotheses of the Study

The experimental hypotheses of this study were as follows:

1. Individuals performing submaximal treadmill exercise were able to achieve between 40% to 70% of their maximum heart rate while maintaining blood pressures within a safe level.

2. Blood pressure at 0%, 20%, and 40% UBW would decrease with each increase in unloading.

3. Heart rate at 0%, 20%, and 40% UBW would decrease with each increase in unloading.

4. Rating of perceived exertion at 0%, 20%, and 40% UBW would decrease with each increase in unloading.
Definition of Terms

The terms that were specific to this study included:

1. \( VO_2 \) max—the maximum amount of oxygen consumed by the body in 1 min.

2. Maximal heart rate—the maximum number of beats per minute an individual’s heart can beat; obtained using the formula: 220 – age.

3. Rating of perceived exertion—based on Borg’s scale of perceived exertion, a subjective rating of effort on a scale of 1 to 20, from very, very light to very, very hard, respectively.

4. Unweighting/unloading—the removal of specific amounts of weight-bearing force by lifting the body in a vest-shaped harness system.
CHAPTER II

REVIEW OF LITERATURE

Similar Studies

Although there are now at least three companies offering unweighting devices for use in the physical therapy domain, there is not a lot of literature supporting the reported benefits of the equipment for patients.

In one study (Axen, Haas, & Mangione, 1996), researchers examined the effects of unweighting on exercise physiology and perceived pain. Trials were performed at 0%, 20%, and 40% of UBW using 4 men and 23 women with a mean age of 67.9 years. Oxygen consumption (VO₂), heart rate, and perceived pain were measured during the last minute of each exercise stage. The 0% condition was used as the first trial condition, and then the other two conditions were applied randomly. Treadmill tests were terminated when the subject met 65% to 75% of age-predicted maximal heart rate or experienced pain or electrocardiogram (EKG) abnormalities. Rest periods based on a return to resting levels were applied between the three conditions.

Results showed that at 0% of UBW, VO₂ increased with each increase in exercise stage. The magnitude of this increase decreased when exercising at the 20% UBW level and decreased even more at the 40% UBW. This linear relationship also held true for the heart rate data collected. In pain response measures, results varied significantly with the amount of time exercised resulting in increased perceived pain.
In another study (Hunter, Kelsey, Murray, & Paper, 1993), researchers examined subjects unweighted at 0%, 20%, and 40% walking at the speeds of 2 and 4 mph. During the last minute of each condition, measurements of heart rate and VO2 were collected. For the study, 21 subjects were used, with a mean age of 28.3 years. Results showed that at 2 mph, heart rate measurements were significantly lower at 0% and 20% UBW than at 40% UBW. However, VO2 and energy expenditure in kilocalories were not significantly different across the trials. At 4 mph, the heart rates were lower for the 40% UBW than for the 0% and 20% UBW measures, and 20% UBW also induced a lower heart rate value than the 0% UBW. In the case of the 4 mph trials, VO2 and energy expenditure in kilocalories were both significantly lower for the 20% and 40% UBW than for the 0% UBW values. No significant difference was found between the 20% and 40% UBW at 4 mph.

**Blood Pressure Studies**

One of the hypotheses of the present study was that heart rate levels can be maintained during the 0%, 20%, and 40% UBW within a range of 40% to 70% of maximal heart rate. Because heart rate expresses a linear relationship to VO2, this range was chosen from the number of studies (ACSM, 1995) claiming the effectiveness of its ability to produce the same, or greater, blood pressure-lowering effects as a higher intensity exercise bout. Therefore, it seems that moderate-intensity training may produce excellent effects on lowering blood pressure, perhaps better than more intense exercise.

As mentioned earlier, the normal response of blood pressure measurements to exercise is an almost linear increase in systolic pressure and a decline or slight rise in diastolic pressure. Peak blood pressure values at maximal heart rate levels are
estimated to range between 180 to 210 mmHg systolic and 60 to 80 mmHg diastolic. Factors affecting this range are age, weight, and gender (ACSM, 1995).

For individuals with hypertension, systolic and diastolic measures tend to increase proportionately from the resting levels during exercise. However, in the case of individuals with mild hypertension, exercise may induce a "normalization" of blood pressure through metabolic vasodilation, which lowers peripheral resistance.

Authorities suggested that exercise is the most effective nondrug therapy to combat high blood pressure (Cooper, 1990). A rise in systolic pressure and no decline or a slight decline in the diastolic pressure is typical for an average conditioned individual during exercise. An exception would be in the case of individuals classified as vascular reactors, subject to the "white coat syndrome." These individuals may be measured at a falsely high baseline blood pressure prior to exercise. Therefore, during exercise, the pressures may not seem to increase as expected due to the psychologically elevated starting blood pressure. However, during recovery from the exercise, systolic or diastolic blood pressure levels will usually drop to levels lower than the initial baseline measures. Another exception is the case of well-conditioned athletes. When these individuals exercise, diastolic blood pressure frequently drops significantly from baseline measures during exercise.

Studies have shown that consistent exercise can lower systolic blood pressure by 5 to 25 mmHg and diastolic pressure 3 to 15 mmHg for individuals with hypertension (White, 1993). The ACSM suggested possible reductions of 8 to 10 mmHg systolic and 5 to 8 mmHg diastolic pressures. Some of this reduction may be explained by weight loss resulting from consistent exercise. These decreases can be apparent within 4 to 5 weeks of the initiation of training and can be maintained with continuation of the exercise program. ACSM also reported that moderate intensity of
exercise seems to have a more favorable effect in lowering blood pressure than higher intensity or more frequently performed exercise.

Another study focused on the average resting and submaximal exercise systolic pressures of 7 middle-aged males. After 4 to 6 weeks of interval training, the resting rates dropped from 139 mmHg to 133 mmHg, and the exercise blood pressures lowered from 173 mmHg to 155 mmHg and diastolic from 92 mmHg to 79 mmHg (McArdle, Katch, & Katch, 1994).

Aqua Aerobic Studies

Studies have shown that even though many individuals experience lower heart rates while exercising in water than on land, the same aerobic benefits can be achieved at the lower heart rate level. Researchers at Adelphi University (Gaines, 1993) found that subjects experienced a heart rate 13% lower in water exercise than on land exercise, yet still received the same aerobic benefits. This is due to the fact that water dissipates the body's heat faster than air, so the body constricts the blood vessels leading to the limbs. Therefore, more blood is returned to the heart and heart rate lowers as blood output increases. Cardiac output per liter of O2 consumed, however, doesn't change in water versus land exercise. So, even though heart rate is lower, more oxygenated blood is being sent to the muscles, resulting in the same amount of oxygen being sent throughout the body.

Anderson and Eckerson (1992) examined heart rate and VO2 measured during water aerobics and a maximal treadmill test to examine the energy demands and training effects of water aerobics. Subjects consisted of 16 college-age females. Results indicated a mean heart rate of 162 bpm and a mean VO2 of 18.4 ml • kg • min⁻¹, representative of 74% of heart rate reserve, 82% of maximal heart rate, and
48% of VO₂ max. Although the heart rate values were within the ACSM recommended aerobic training range, the VO₂ fell just below the recommended minimum level. Therefore, researchers concluded that the metabolic intensity of water aerobics may be overstated.

Gaines (1993) estimated a 10 bpm lower target heart rate when performing vertical water exercise and 17 bpm lower target heart rate when executing horizontal water exercise. In general, it is recommended to subtract an average of 13 bpm from the result of Karvonen’s 220 – age formula to obtain a target range beneficial to aerobic benefits (White, 1993).

Microgravity Studies

Most studies performed to measure the physiological effects on subjects in a microgravity environment, such as spaceflight, have had to be simulated with ground-based environments. Studies are normally conducted using a 6° head down bed rest simulation. From 19 independent studies involving 214 men and women, the consensus was that VO₂ is reduced in a microgravity environment if no countermeasures are applied (Blatteis & Fregley, 1996).

Additionally, many ground-based studies involving bed rest reported a reduced exercise endurance based on the shorter time period necessary to reach volitional exhaustion when compared to pre-bed rest graded exercise sessions. Tests performed on 9 astronauts during 5 min of exercise during spaceflight show a slight, but consistent, drop in VO₂ when compared to exercise at the same workload at earth gravity conditions.

In another study, researchers examined the subjects’ level of aerobic fitness prior to space flight testing as a factor in determining the amount of VO₂ loss
experienced during exposure to microgravity. The researchers presented data showing that a 22% reduction in VO

2 reserve was experienced in an individual with an initial VO

2 of 4.1 L \cdot min^{-1}, but there was only a 13% reduction in a subject with an initial VO

2 of 3.5 L \cdot min^{-1} (Blatteis & Fregley, 1996).

Researchers examining spaceflight and ground-based studies found several significant physiological adaptations to microgravity (Hargens & Watenpaugh, 1996). Short-term responses included loss of gravitational pressures, low venous pressures, headward fluid shifts, plasma volume loss, and postflight orthostatic intolerance and reduced exercise capacity. These changes may be explained by altered blood and tissue pressures and fluid balance in cardiovascular system tissues. Due to the fact that tissues of the upper body, namely the head, may be compromised by increased blood pressures, there is probably a need for including countermeasures during long-duration spaceflight to simulate the higher blood pressures experienced in the lower body on earth.

Cardiovascular response to submaximal exercise in microgravity was the focus of another study measuring cardiac output, heart rate, blood pressure, and VO

2 at rest and at two levels of exercise (Eisenhardt et al., 1996). At rest, cardiac output in flight was 126% of cardiac output while standing erect but not significantly different than cardiac output while supine. Heart rate in flight was 81% of heart rate while standing and 91% of heart rate while supine. Therefore, stroke volume in flight was 155% of stroke volume while standing and 109% of stroke volume while supine. Also, in flight, mean arterial blood pressure and diastolic pressure were lower in flight than pressures while standing erect. During exercise, stroke volume in flight fell with increasing VO

2, but stroke volume while standing rose and stroke volume while
supine stayed constant. Blood pressure responses were not found to be different in flight from the standing erect or supine measures.

Another study measured central venous pressure in 14 males during weightlessness achieved through a jet aircraft performing parabolic flight maneuvers and also at $+2 \text{ G}_z$ (headward acceleration with a head to foot direction of resultant inertial force from the gravitational field) (Bonde-Petersen, Elmann-Larsen, Foldager, Johansen, & Norsk, 1987). Central venous pressure was also measured in supine and upright-sitting positions during $+1 \text{ G}_z$. Data collected showed values of 2.6 mmHg pressure when sitting and 5.0 mmHg when supine. During weightlessness, central venous pressure increased to 6.8 mmHg. At $+2 \text{ G}_z$, central venous pressure was 2.8 mmHg. The researchers concluded that the introduction of weightlessness produced a significantly higher central venous pressure than the upright-sitting position and the supine position.
CHAPTER III

DESIGN AND METHODOLOGY

The purpose of this study was to determine the effects of using an unloading machine during treadmill exercise on subjects' blood pressure, heart rate, and RPE, and to determine if subjects' blood pressure would remain in a safe and aerobically effective range throughout exercise. The chapter is organized into five areas: (1) subject selection, (2) design, (3) measurements, (4) testing procedures, and (5) statistical analysis.

Subject Selection

Volunteer subjects (N = 20) were selected from respondents to announcements made at various physical fitness settings in Kalamazoo, Michigan (Appendix A). The subjects were both males and females, 18 to 42 years of age. Prior to acceptance into the study, all subjects were screened by way of ACSM's "Apparently Healthy" questionnaire to eliminate candidates with possible risk factors. According to self-reports, no health risks were found that would either skew the results of the study or put the individual at risk during the testing. The study was approved by the Human Subjects Institutional Review Board at Western Michigan University, Kalamazoo. Appendix B contains the approval letter. A consent form was signed by all volunteers before the screening (Appendix C).
Design

The design consisted of two research variables: (1) UBW, which had three levels, 0%, 20%, and 40% of total body weight; and (2) days, which numbered 3. The dependent variables included blood pressure, both systolic and diastolic, heart rate, and rating of perceived exertion. The design was repeated measures, in which subjects completed repeated trials (days) on all levels of UBW.

Measurements

Blood Pressure

Blood pressure was measured using a standard mercury sphygmomanometer and a stethoscope. To establish baseline measurements, blood pressures were recorded prior to exercise testing each trial day, including the day when the treadmill speed was determined. Both systolic and diastolic readings were measured and recorded prior to each test session.

Heart Rate

Heart rate was monitored and recorded using a Polar Heart Rate Monitor, model 61210. The sensor electrode strap was secured around the subject’s torso just under the chest, and the watch was worn on the subject’s right arm.

Rating of Perceived Exertion

The Borg Scale was used to measure perceived exertion. The original scale using the quantitative values ranging from 6 to 20 was selected (ACSM, 1995).
Establishment of Treadmill Speed

The treadmill used for the testing was a Quinton Model 643 from Quinton Instrument Company, Seattle, WA. For each individual, a treadmill speed that resulted in a steady state heart rate of 70% of the subject’s maximum heart rate \((220 - \text{age})\) at 0% UBW was used across all experimental conditions.

The protocol used for obtaining 70% of maximum heart rate included the following:

1. Subjects warmed up with a run/walk for 3 min at 4 mph.
2. Treadmill speed increased 1 mph every 3 min until the subject reached 70% of maximum heart rate.
3. Treadmill speed was adjusted until subjects were able to maintain a heart rate of 70% maximum for 3 min within ± 5 bpm.

Establishment of Baseline Measurements

Prior to any testing, baseline blood pressure and heart rate measurements were recorded. Upon the subject’s arrival at the laboratory, the Polar heart rate monitor was put on the subject, who was then asked to sit down for 5 min and relax. As the subject relaxed, the researcher asked him or her a few questions to determine if there were any prior conditions that may affect his or her heart rate or blood pressure, such as exercise or stress.

At the end of 5 min, the first of three heart rate readings was taken, followed by the first of three blood pressure readings. The other two readings for each variable were measured at the end of the next two 1-min time increments. These three
measures were then averaged and recorded as the baseline measurements for that testing day. This procedure was repeated each day (4) the subject participated in this study.

Data Collection

After establishing treadmill speed, the three unloading conditions were administered on each of 3 days at approximately the same time each day. On each day, the 0%, 20%, and 40% UBW conditions were applied using an unloading system manufactured by LiftAir, Kalamazoo, MI. To determine the appropriate unloading weights, the subject's body weight was measured using a physician's scale at the clinic. On each day, subjects experienced the three conditions, 0%, 20%, and 40% UBW in a random order. Subjects were not aware of the percentage of UBW used during each condition; therefore, even in the condition of 0% UBW, the subject wore the UBW system in an effort to maintain confidentiality of that information.

Steps in the data collection for each trial day were as follows:

1. Blood pressure and heart rate readings were recorded prior to exercise.
2. A warm-up was conducted at 4.0 mph for 3 min.
3. Within 1 min, the speed of the treadmill was increased to the established 70% maximal heart rate level.
4. The subject exercised for 5 min at the treadmill speed.
5. At the end of the 5th min, heart rate, blood pressure, and rating of perceived exertion (RPE) were recorded.
6. At the end of the 6th min, heart rate, blood pressure, and RPE were recorded.
7. At the end of the 7th min, heart rate, blood pressure, and RPE were recorded.

8. After all measures were taken, the subject rested until his or her heart rate dropped below 100 beats per min (bpm).

9. Steps 3 through 8 were then repeated for the remaining two conditions.

10. After all three conditions were completed, subjects were taken through a series of stretches to minimize the risk of any injuries and reduce the chance of soreness.

Throughout the trials, any indication that the subject’s health was being compromised resulted in stopping the test. ACSM’s “General Indications for Stopping an Exercise Test in Apparently Healthy Adults” (ACSM, 1995) was used as a guideline.

Statistical Analysis

The research variables consisted of three levels of UBW, 0%, 20%, and 40% UBW, and 3 days (trials). The dependent variables consisted of recorded measurements of 0%, 20%, and 40% UBW blood pressure, both systolic and diastolic, and heart rate and RPE. A randomized block factorial ANOVA was used to compare differences among UBW levels and differences among days for each of the dependent variables. In case a post hoc test was required to analyze the data, a Tukey HSD Multiple Comparison test was used.

To determine if heart rate was maintained within an effective aerobic range, previously stated as 40% to 70% of maximum heart rate, a chi-square goodness of fit test was calculated. If the ANOVA found no significant difference between trials
(p > .05), then a one-way chi-square was calculated. If the ANOVA found a significant difference between trials (p < .05), a two-way chi-square was calculated.
CHAPTER IV

RESULTS AND DISCUSSION

Introduction

This chapter contains the results obtained in the aforementioned study and possible factors affecting physiological measures during unloaded submaximal exercise. The purpose of this study was to determine if differences in blood pressure, heart rate, or RPE occurred as a result of exercising at either 20% or 40% UBW in comparison with 0% UBW. Additionally, the study was used to determine if heart rates obtained during UBW exercise were within 40% to 70% of maximum heart rate, thereby providing adequate aerobic benefits to the participant. It was the intention to confirm or reject, with this research, the hypotheses that systolic blood pressure, heart rate, and RPE would decrease as UBW increased. Additionally, the research would confirm or reject the hypothesis that heart rate could be maintained at 40% to 70% of the subjects' maximal heart rate levels during 20% and 40% UBW.

Initially the researcher assumed that most, if not all, participants would be either running or jogging to reach 70% of their maximum heart rate. However, as the study progressed, it was apparent that many subjects were able to attain 70% of maximum heart rate while walking on the treadmill. It was evident that the physiological measures varied depending on whether the subject was walking or running. Therefore, subjects were placed in groups, walkers or runners. All ANOVAs calculated used this grouping variable.
The data were analyzed at Western Michigan University, Kalamazoo, using the BMDP program. An ANOVA, split-plot factorial statistical design with fixed effects, was calculated for each of the dependent variables. Tukey HSD or a simple main effects test was used for multiple comparisons when a main effect or a first-order interaction effect were significant. The research variables for the first set of ANOVAs for baseline data were (a) days with 4 levels, Days 1, 2, 3, and 4; and (b) group with two levels, walkers and runners. The baseline dependent variables were resting heart rate, systolic blood pressure, and diastolic blood pressure. The research variables for the second set of ANOVAs for the exercise data were (a) UBW % with three levels, 0%, 20% and 40%; (b) mode of exercise with two levels, walkers and runners; and (c) days, 3. The dependent variables for this design were heart rate, systolic blood pressure, diastolic blood pressure, and RPE.

Results

Demographics

Subjects consisted of 9 men and 11 women, ranging in age from 18 to 42 years. Table 1 contains descriptive data for all 20 subjects and is subdivided to include statistical data on each of the two groups, walkers and runners. Notable differences between the groups, walkers and runners, included (a) average age of walkers was 25.67 years, and average age of runners was 29.64 years; (b) average treadmill speed for walkers was 4.01 mph, and average speed for runners was 5.18 mph; (c) average resting heart rate for walkers and runners was 79.74 bpm and 66.46 bpm, respectively; and (d) average blood pressure readings were 113.44 systolic and
69.69 mmHg diastolic for walkers and 117.77 systolic and 73.59 mmHg diastolic for runners.

Table 1
Demographic Description of Subjects

<table>
<thead>
<tr>
<th>Variable</th>
<th>All</th>
<th>Walkers</th>
<th>Runners</th>
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<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Age</td>
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<td>25.7 5.57</td>
<td>29.6 6.86</td>
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<td>194.33 5.57</td>
<td>190.36 6.86</td>
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<tr>
<td>THR</td>
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<td>136.11 4.04</td>
<td>133.27 4.82</td>
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<td>147.78 36.03</td>
<td>160.09 41.65</td>
</tr>
<tr>
<td>Speed</td>
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<td>4.01 0.68</td>
<td>5.18 0.89</td>
</tr>
<tr>
<td>HR</td>
<td>72.44 12.41</td>
<td>79.74 12.77</td>
<td>66.46 8.32</td>
</tr>
<tr>
<td>BP-Sys.</td>
<td>115.83 11.74</td>
<td>113.44 9.72</td>
<td>117.77 12.95</td>
</tr>
<tr>
<td>BP-Dia.</td>
<td>71.84 8.57</td>
<td>69.69 7.96</td>
<td>73.59 8.74</td>
</tr>
</tbody>
</table>

Note. BP-Sys. and BP-Dia. are abbreviations for systolic blood pressure and diastolic blood pressure, respectively.

Baseline ANOVAs

Heart Rate

The pre-exercise heart rate values obtained prior to establishment of treadmill speed and on each of the 3 trial days served as the dependent variable. An ANOVA summary is presented in Table 2. The following results were found:
1. A significant difference in mean heart rate values was found between the runners and walkers, $F(1, 18) = 8.95$, $p = .01$. The mean heart rates for the walkers and runners were 79.74 bpm and 66.46 bpm, respectively.

2. No significant difference in the mean heart rate values was found among the days, $F(3, 54) = 2.50$, $p = .07$. The means for the 4 days were 71.87 bpm, 74.34 bpm, 73.28 bpm, and 70.28 bpm, respectively.

3. No significant first-order interaction effect, of Days $\times$ Group, was found, $F(3, 54) = 0.43$, $p = .73$.

Table 2
ANOVA Summary Table for Baseline Heart Rate

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walkers/Runners (W)</td>
<td>3492.32</td>
<td>1</td>
<td>3492.32</td>
<td>8.95*</td>
<td>.01</td>
</tr>
<tr>
<td>Subj. w/in groups</td>
<td>7022.95</td>
<td>18</td>
<td>390.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days (D)</td>
<td>199.64</td>
<td>3</td>
<td>66.55</td>
<td>2.50</td>
<td>.07</td>
</tr>
<tr>
<td>W $\times$ D</td>
<td>34.67</td>
<td>3</td>
<td>11.56</td>
<td>0.43</td>
<td>.73</td>
</tr>
<tr>
<td>D $\times$ Subj. w/in groups</td>
<td>1438.40</td>
<td>54</td>
<td>26.64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Systolic Blood Pressure

The pre-exercise systolic blood pressure values obtained prior to establishment of treadmill speed and on trial days served as the dependent variable.
An ANOVA summary table is presented in Table 3. The following results were found:

1. No significant difference in mean systolic blood pressure values was found between walkers and runners, $F(1, 18) = 0.72, p = .41$. The means for walkers and runners were 113.44 and 117.77 mmHg, respectively.

2. No significant difference in the mean systolic blood pressure values was found among the 4 trial days, $F(3, 54) = 2.40, p = .08$. The means for the 4 days were 118.05, 115.70, 114.85, and 114.70 mmHg, respectively.

3. No significant first order interaction effect, Days $\times$ Group, was found for systolic blood pressure, $F(3, 54) = 0.19, p = .90$.

Table 3
ANOVA Summary Table for Baseline Systolic Blood Pressure Across Groups

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walkers/Runners (W)</td>
<td>370.93</td>
<td>1</td>
<td>370.93</td>
<td>0.72</td>
<td>.41</td>
</tr>
<tr>
<td>Subj. w/in groups</td>
<td>9252.62</td>
<td>18</td>
<td>514.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days (D)</td>
<td>148.84</td>
<td>3</td>
<td>49.61</td>
<td>2.40</td>
<td>.08</td>
</tr>
<tr>
<td>W $\times$ D</td>
<td>12.04</td>
<td>3</td>
<td>4.01</td>
<td>0.19</td>
<td>.90</td>
</tr>
<tr>
<td>D $\times$ Subj. w/in groups</td>
<td>1114.31</td>
<td>54</td>
<td>20.64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Diastolic Blood Pressure

The pre-exercise diastolic blood pressure values obtained prior to establishment of treadmill speed and on each of the trial days served as the dependent variable. An ANOVA summary table for diastolic blood pressure is presented in Table 4. The following results were found:

1. No significant difference in mean diastolic blood pressure values was found between walkers and runners, $F(1, 18) = 1.22$, $p = .28$. The means for walkers and runners were 69.69 and 73.59 mmHg, respectively.

2. No significant difference in the mean diastolic blood pressure was found among days, $F(3, 54) = 0.90$, $p = .45$. The means for the 4 days were 72.40, 72.65, 71.25, and 71.05 mmHg, respectively.

3. No significant first order interaction effect, Days $\times$ Group, for diastolic blood pressure was found, $F(3, 54) = 1.13$, $p = .35$.

Table 4

ANOVA Summary Table for Diastolic Blood Pressure Across Groups

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walkers/Runners (W)</td>
<td>300.61</td>
<td>1</td>
<td>300.61</td>
<td>1.22</td>
<td>.28</td>
</tr>
<tr>
<td>Subj. w/in groups</td>
<td>4439.03</td>
<td>18</td>
<td>246.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days (D)</td>
<td>48.09</td>
<td>3</td>
<td>16.03</td>
<td>0.90</td>
<td>.45</td>
</tr>
<tr>
<td>W $\times$ D</td>
<td>60.39</td>
<td>3</td>
<td>20.13</td>
<td>1.13</td>
<td>.35</td>
</tr>
<tr>
<td>D $\times$ Subj. w/in groups</td>
<td>962.03</td>
<td>54</td>
<td>17.82</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Exercise ANOVAs

Consistency of Data Across Days

ANOVAs were calculated to determine the consistency of RPE, heart rate, and blood pressure across the 3 days. Table 5 presents the F ratios for days for each dependent variable at each level of UBW. F ratios for all levels of UBW and for all dependent variables were not significant.

Table 5

F Ratios for Days for All Dependent Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>UBW</th>
<th>F</th>
<th>p</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR</td>
<td>0%</td>
<td>1.44</td>
<td>.24</td>
<td>132.95</td>
<td>14.59</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>0.75</td>
<td>.48</td>
<td>127.81</td>
<td>12.51</td>
</tr>
<tr>
<td></td>
<td>40%</td>
<td>0.87</td>
<td>.42</td>
<td>122.51</td>
<td>13.09</td>
</tr>
<tr>
<td>Sys.</td>
<td>0%</td>
<td>0.16</td>
<td>.86</td>
<td>142.85</td>
<td>13.57</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>0.16</td>
<td>.85</td>
<td>138.23</td>
<td>12.62</td>
</tr>
<tr>
<td></td>
<td>40%</td>
<td>0.25</td>
<td>.78</td>
<td>134.22</td>
<td>11.69</td>
</tr>
<tr>
<td>Dias.</td>
<td>0%</td>
<td>0.63</td>
<td>.54</td>
<td>67.65</td>
<td>6.75</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>0.25</td>
<td>.78</td>
<td>67.47</td>
<td>6.81</td>
</tr>
<tr>
<td></td>
<td>40%</td>
<td>0.39</td>
<td>.68</td>
<td>67.70</td>
<td>6.76</td>
</tr>
<tr>
<td>RPE</td>
<td>0%</td>
<td>0.92</td>
<td>.41</td>
<td>12.59</td>
<td>2.06</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>0.19</td>
<td>.82</td>
<td>11.87</td>
<td>1.97</td>
</tr>
<tr>
<td></td>
<td>40%</td>
<td>0.18</td>
<td>.83</td>
<td>11.01</td>
<td>2.35</td>
</tr>
</tbody>
</table>
Because no significant differences were found, the dependent variables used in the exercise data ANOVAs are the mean RPE, heart rate, and blood pressure for the 3 days.

**Heart Rate**

Mean heart rate values for the 3 exercise days measured at 0%, 20%, and 40% UBW served as the dependent variable. An ANOVA summary table is presented in Table 6. The following results were found:

1. No significant difference in mean heart rate values was found between walkers and runners, $F(1, 18) = 0.64$, $p = .53$. The means for walkers and runners were 125.40 and 129.67 bpm, respectively.

Table 6

ANOVA Summary Table for Heart Rate Across Groups and Within Subjects

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walkers/Runners (W)</td>
<td>271.69</td>
<td>1</td>
<td>271.69</td>
<td>0.64</td>
<td>.53</td>
</tr>
<tr>
<td>Subj. w/in groups</td>
<td>7620.12</td>
<td>18</td>
<td>423.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UBW (U)</td>
<td>968.47</td>
<td>2</td>
<td>484.24</td>
<td>37.79*</td>
<td>.00</td>
</tr>
<tr>
<td>W × U</td>
<td>386.36</td>
<td>2</td>
<td>193.18</td>
<td>15.08*</td>
<td>.00</td>
</tr>
<tr>
<td>U × Subj. w/in groups</td>
<td>461.32</td>
<td>36</td>
<td>12.81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*$F(2, 36) = 3.23$, $p < .05$. 


2. A significant difference in mean heart rate values was found among the UBW conditions, \( F(2, 36) = 37.79, p = .00 \). The means for 0%, 20%, and 40% UBW were 132.95, 127.81, and 122.51 bpm, respectively.

3. A significant difference in mean heart rate was found for the first-order interaction effect, Groups \( \times \) UBW, \( F(2, 36) = 15.08, p = .00 \).

A simple main effects test to determine where differences occurred among the UBW conditions for each group was calculated. The simple main effects summary table is presented in Table 7. The following results were identified from the simple main effects test:

Table 7
Simple Main Effects Summary Table for UBW Heart Rate Values Between Groups

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W at 0%</td>
<td>316.8</td>
<td>1</td>
<td>316.80</td>
<td>2.12</td>
</tr>
<tr>
<td>W at 20%</td>
<td>298.85</td>
<td>1</td>
<td>298.84</td>
<td>2.00</td>
</tr>
<tr>
<td>W at 40%</td>
<td>42.50</td>
<td>1</td>
<td>42.50</td>
<td>0.28</td>
</tr>
<tr>
<td>Within cell</td>
<td>8081.44</td>
<td>54</td>
<td>149.66</td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UBW (U) at walkers</td>
<td>135.52</td>
<td>2</td>
<td>67.76</td>
<td>5.29*</td>
</tr>
<tr>
<td>U at runners</td>
<td>1340.92</td>
<td>2</td>
<td>670.46</td>
<td>52.34*</td>
</tr>
<tr>
<td>U ( \times ) Subj. w/in groups</td>
<td>461.32</td>
<td>36</td>
<td>12.81</td>
<td></td>
</tr>
</tbody>
</table>

\( *F(2, 36) = 3.23, p < .05 \).
1. No significant difference in mean heart rate values was found between walkers and runners at the 0%, 20%, or 40% UBW conditions.

2. A significant difference in mean heart rate values was found for UBW conditions for walkers, $F(2, 36) = 5.29, p < .05$. The means for walkers at 0%, 20%, and 40% UBW were 128.55, 123.53, and 124.13 bpm, respectively.

3. A significant difference in mean heart rate values was found for UBW conditions for runners, $F(2, 36) = 52.34, p < .05$. The means for runners at 0%, 20%, and 40% UBW were 136.55, 131.30, and 121.19 bpm, respectively.

**Systolic Blood Pressure**

Mean systolic blood pressure values for the 3 exercise days measured at 0%, 20%, and 40% UBW served as the dependent variable. The ANOVA summary table for systolic blood pressure is presented in Table 8. The following results were found:

1. No significant difference in mean systolic blood pressure values was found between walkers and runners, $F(1, 18) = 1.88, p = 0.19$. The means for walkers and runners were 134.73 and 141.46 mmHg, respectively.

2. A significant difference in mean systolic blood pressure values was found among the UBW conditions, $F(2, 36) = 32.76, p = .00$. The means for 0%, 20%, and 40% UBW were 142.85, 138.23, and 134.22 bpm, respectively.

3. A significant difference in mean systolic blood pressure values was found for the first-order interaction effect, Groups $\times$ UBW, $F(2, 36) = 4.05, p = .03$.

A simple main effects test to determine where differences occurred among the UBW conditions for each group was calculated. The simple main effects summary table is presented in Table 9. The following results were identified from the simple main effects test:
Table 8
ANOVA Summary Table for Systolic Blood Pressure
Across Groups and Within Subjects

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walkers/Runners (W)</td>
<td>673.85</td>
<td>1</td>
<td>673.85</td>
<td>1.88</td>
<td>.19</td>
</tr>
<tr>
<td>Subj. w/in groups</td>
<td>6464.00</td>
<td>18</td>
<td>359.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UBW (U)</td>
<td>694.65</td>
<td>2</td>
<td>347.32</td>
<td>32.76*</td>
<td>.00</td>
</tr>
<tr>
<td>W × U</td>
<td>85.84</td>
<td>2</td>
<td>42.92</td>
<td>4.05*</td>
<td>.03</td>
</tr>
<tr>
<td>U × Subj. w/in groups</td>
<td>381.62</td>
<td>36</td>
<td>10.60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*F(2, 36) = 3.23, p < .05.

1. No significant difference in mean systolic blood pressure values was found between walkers and runners at the 0%, 20%, or 40% UBW conditions.

2. A significant difference in mean systolic blood pressure values was found among UBW conditions for walkers, F(2, 36) = 7.40, p < .05. The means for walkers at 0%, 20%, and 40% UBW were 138.04, 133.78, and 132.37 mmHg, respectively.

3. A significant difference in mean systolic blood pressure values was found among UBW conditions for runners, F(2, 36) = 31.87, p < .05. The means for runners at 0%, 20%, and 40% UBW were 146.79, 141.88, and 135.73 mmHg, respectively.
Table 9
Simple Main Effects Summary Table for UBW Systolic Blood Pressure Values Between Groups

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W at 0%</td>
<td>378.98</td>
<td>1</td>
<td>378.98</td>
<td>2.99</td>
</tr>
<tr>
<td>W at 20%</td>
<td>324.77</td>
<td>1</td>
<td>324.77</td>
<td>2.56</td>
</tr>
<tr>
<td>W at 40%</td>
<td>55.88</td>
<td>1</td>
<td>55.88</td>
<td>0.44</td>
</tr>
<tr>
<td>Within cell</td>
<td>6845.62</td>
<td>54</td>
<td>126.77</td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UBW (U) at walkers</td>
<td>156.85</td>
<td>2</td>
<td>78.43</td>
<td>7.40*</td>
</tr>
<tr>
<td>U at runners</td>
<td>675.60</td>
<td>2</td>
<td>337.80</td>
<td>31.87*</td>
</tr>
<tr>
<td>U x Subj. w/in groups</td>
<td>381.62</td>
<td>36</td>
<td>10.60</td>
<td></td>
</tr>
</tbody>
</table>

*F(2, 36) = 3.23, p < .05.

Diastolic Blood Pressure

Mean diastolic blood pressure values for the 3 exercise days measured at 0%, 20% and 40% UBW served as the dependent variable. An ANOVA summary table is presented in Table 10. The following results were found:

1. No significant difference in mean diastolic blood pressure values was found between walkers and runners, F(1, 18) = 0.23, p = .64. The means for walkers and runners were 66.85 and 68.22 mmHg, respectively.
2. No significant difference in mean diastolic blood pressure values was found among the UBW conditions, \( F(2, 36) = 0.45, p = .64 \). The means for 0%, 20%, and 40% UBW were 67.65, 67.47, and 67.70 mmHg, respectively.

3. No significant difference in mean diastolic blood pressure values was found for the first-order interaction effect, Groups \( \times \) UBW, \( F(2, 36) = 1.37, p = .27 \).

Table 10

ANOVA Summary Table for Diastolic Blood Pressure Across Groups and Within Subjects

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walkers/Runners (W)</td>
<td>27.89</td>
<td>1</td>
<td>27.89</td>
<td>0.23</td>
<td>.64</td>
</tr>
<tr>
<td>Subj. w. groups</td>
<td>2191.70</td>
<td>18</td>
<td>121.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UBW (U)</td>
<td>0.78</td>
<td>2</td>
<td>0.39</td>
<td>0.45</td>
<td>.64</td>
</tr>
<tr>
<td>W ( \times ) U</td>
<td>2.40</td>
<td>2</td>
<td>1.20</td>
<td>1.37</td>
<td>.27</td>
</tr>
<tr>
<td>U ( \times ) Subj. w/in groups</td>
<td>31.51</td>
<td>36</td>
<td>0.88</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(*F(2, 36) = 3.23, p < .05.*

**RPE**

Mean RPE values for the 3 exercise days measured at 0%, 20%, and 40% UBW served as the dependent variable. An ANOVA summary table is presented in Table 11. The following results were found:
1. No significant difference in mean RPE values was found between walkers and runners, $F(1, 18) = 0.65, p = .43$. The means for walkers and runners were 11.43 and 12.14, respectively.

2. A significant difference in mean RPE values was found among the UBW conditions, $F(2, 36) = 19.38, p = .00$. The means for 0%, 20%, and 40% UBW were 12.59, 11.87, and 11.01, respectively.

3. A significant difference in mean RPE values was found for the first-order interaction effect, Groups $\times$ UBW, $F(2, 36) = 5.41, p = .01$.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walkers/Runners (W)</td>
<td>7.45</td>
<td>1</td>
<td>7.45</td>
<td>0.65</td>
<td>.43</td>
</tr>
<tr>
<td>Subj. w/in groups</td>
<td>205.07</td>
<td>18</td>
<td>11.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UBW (U)</td>
<td>22.47</td>
<td>2</td>
<td>11.24</td>
<td>19.38*</td>
<td>.00</td>
</tr>
<tr>
<td>W $\times$ U</td>
<td>6.27</td>
<td>2</td>
<td>3.13</td>
<td>5.41*</td>
<td>.01</td>
</tr>
<tr>
<td>U $\times$ Subj. w/in groups</td>
<td>20.87</td>
<td>36</td>
<td>0.58</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*A simple main effects test to determine where differences occurred was calculated. The simple main effects summary table is presented in Table 12. The following results were identified from the simple main effects test:*
1. No significant difference in mean RPE values between walkers and runners was found at the 0%, 20%, or 40% UBW conditions.

2. No significant difference in mean RPE values was found among UBW conditions for walkers, $F(2, 36) = 2.31, p < .05$. The means for walkers at 0%, 20%, and 40% UBW were 11.86, 11.33, and 11.11, respectively.

3. A significant difference in mean RPE values was found among UBW conditions for runners, $F(2, 36) = 24.84, p < .05$. The means for runners at 0%, 20%, and 40% UBW were 13.19, 12.31, and 10.92, respectively.

Table 12

Simple Main Effects Summary Table for UBW RPE Values Between Groups

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W at 0%</td>
<td>8.76</td>
<td>1</td>
<td>8.76</td>
<td>2.10</td>
</tr>
<tr>
<td>W at 20%</td>
<td>4.76</td>
<td>1</td>
<td>4.76</td>
<td>1.14</td>
</tr>
<tr>
<td>W at 40%</td>
<td>0.18</td>
<td>1</td>
<td>0.18</td>
<td>0.04</td>
</tr>
<tr>
<td>Within cell</td>
<td>225.94</td>
<td>54</td>
<td>4.18</td>
<td></td>
</tr>
<tr>
<td><strong>Within Subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UBW (U) at walkers</td>
<td>2.68</td>
<td>2</td>
<td>1.34</td>
<td>2.31</td>
</tr>
<tr>
<td>U at runners</td>
<td>28.82</td>
<td>2</td>
<td>14.41</td>
<td>24.84*</td>
</tr>
<tr>
<td>U × Subj. w/in groups</td>
<td>20.87</td>
<td>36</td>
<td>0.58</td>
<td></td>
</tr>
</tbody>
</table>

*$F(2, 36) = 3.23, p < .05$. 


The descriptive data for heart rates achieved by each group during the three UBW conditions are presented in Table 13. For both groups, heart rate values remained within 40% to 70% of maximum heart rate. The following results were found from the table:

1. Heart rate values achieved for walkers during 0%, 20%, and 40% UBW conditions were all within the 40% to 70% of maximal heart rate range.

2. Heart rate values achieved for runners during 0%, 20%, and 40% UBW conditions were all within the 40% to 70% of maximal heart rate range.

3. Because the heart rates of walkers and runners at each UBW condition were within the range of 40% to 70% required for aerobic work, the chi-square test was not needed.

Table 13
Summary Table for Percentage of Maximum Heart Rate Achieved by Group

<table>
<thead>
<tr>
<th>Source</th>
<th>HR</th>
<th>%MHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walkers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>128.55</td>
<td>66.2%</td>
</tr>
<tr>
<td>20%</td>
<td>123.53</td>
<td>63.6%</td>
</tr>
<tr>
<td>40%</td>
<td>124.13</td>
<td>63.9%</td>
</tr>
<tr>
<td>Runners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>136.55</td>
<td>71.7%</td>
</tr>
<tr>
<td>20%</td>
<td>131.30</td>
<td>69.0%</td>
</tr>
<tr>
<td>40%</td>
<td>121.19</td>
<td>63.7%</td>
</tr>
</tbody>
</table>
Discussion

The subjects used for this study were recruited from Western Michigan University’s Health, Physical Education and Recreation Department and from various health and fitness organizations in Kalamazoo, Michigan. Therefore, the performance of these individuals may not be indicative of performance of the general “apparently healthy” population. For example, the higher mean age for runners of 29.6 years versus the mean age of 25.7 years for walkers would be the opposite of what would be expected. However, many of the older individuals in this study have been involved in physical fitness activities for many years and have developed a higher level of aerobic fitness than we would normally expect to find in the general population.

Baseline Heart Rate

One possible reason for the physiological differences between the walkers and runners may be demographic differences reflective of current fitness levels of the two groups. Baseline heart rate data collected for the two groups (see Table 1) resulted in higher resting heart rate values (79.74 bpm) for the walking group than for the running group (66.46 bpm). Researchers have shown that a higher heart rate value is usually indicative of a less fit population. With increased aerobic training, both resting and exercise heart rate levels will be reduced (McArdle et al., 1994). In aerobically conditioned individuals, lower resting and exercise heart rate values are expected. Therefore, the walkers, because their higher baseline heart rate values were closer to their maximum values, were able to reach their 70% of maximal heart rate in a walking mode due to their lack of aerobic training.
Baseline Blood Pressures

According to the ANOVA tables for baseline blood pressure (see Tables 3 and 4), there were no significant differences in systolic blood pressure or diastolic blood pressure measurements between the walking and running groups. This is probably due to the fact that the population used for the study was delimited to asymptomatic, “apparently healthy” individuals. Therefore, it would be expected that blood pressures would be within a healthy range for both groups.

UBW

No difference in diastolic blood pressure was found among the different levels of unweighting. This can be explained by past studies that showed diastolic blood pressure does not fluctuate significantly with increased exercise workloads in healthy individuals (Cooper, 1990). Therefore, diastolic blood pressure would not be expected to change significantly in the population used for this research project.

The Group × UBW interaction effect was significant for heart rate, systolic blood pressure, and RPE. These differences may support three theories:

1. Levels of fitness found within the population studied varied. Although the research subjects were all within the ACSM “apparently healthy” guidelines, their fitness levels were more heterogeneous than homogeneous. Several subjects were aerobic instructors who had taught for 15 years, but other subjects exercised at a lower intensity.

2. Different mechanics were used for running versus walking and, therefore, affected the unweighting of the harness system differently. The rise and fall of the center of gravity is approximately 2 in. for walkers and 2.5 in. for runners (Adrian &
Cooper, 1995). This difference caused more vertical work for the runners than for the walkers. The difference in vertical work may have affected the results obtained when comparing levels of UBW. Because runners experience more vertical rise in the center of gravity for a longer period of time, the runners would use more energy than walkers to cause the body to rise a greater distance regardless of the effect of unweighting. Therefore, the percentage of UBW would have a different effect on the runners than on walkers. The additional unweighting when moving from 0% to 20% UBW and 20% to 40% UBW may not affect physiological measurements of walkers as much as for runners.

3. The constriction of the harness vest that allows the subject to be unweighted may have affected the subjects' ability to inhale and exhale and may have also restricted the walkers' range of motion. The harness may have caused the stride length and stride frequency to change from that of a normal gait without the harness.

Figure 1 illustrates the effect of UBW on walkers' and runners' heart rates. Between 0% and 20% UBW the heart rate of runners and walkers dropped 5.25 bpm and 5.02 bpm, respectively. The Tukey HSD test for multiple comparisons indicated that these differences in means for both the walkers and runners were significant, HSD = 3.89. Between 20% and 40% UBW the heart rate of the runners dropped by 10.11 bpm while the heart rate of the walkers increased by 0.6 bpm. The difference for the runners was significant, HSD = 3.89; the difference for the walkers was not significant, HSD = 3.89. The higher vertical displacement of the body's center of gravity while running caused the 40% UBW condition to significantly reduce the workload from that experienced at the 20% UBW. This response did not occur for the walkers; workload remained relatively constant. Perhaps the 20% UBW condition
supported the body's weight for walkers and, therefore, the only work that would occur with UBWs greater than 20% would be horizontal work.

Figure 1. Heart Rate Interaction Effect of Walkers and Runners.

Figure 2 illustrates the effect of UBW on walkers' and runners' systolic blood pressure. As exercise intensity increases, systolic blood pressure also increases. This widely accepted fact is evident in Figure 2. For both walkers and runners the systolic blood pressure decreased between 0% and 20% UBW by 4.26 mmHg and 4.91 mmHg, respectively. These differences between the means for 0% and 20% UBW were significant for both the walkers and the runners, Tukey HSD = 3.54. Between 20% and 40%, the mean differences were 1.41 mmHg and 6.15 mmHg for walkers and runners, respectively. The difference for walkers was not significant, HSD = 3.54; the difference for runners was significant. The systolic blood pressure pattern that existed for walkers and runners between 0% and 20% UBW and 20% and 40%
UBW is the same pattern that occurred for heart rate. The exercise intensity as indicated by the change in systolic blood pressure decreased between 0% and 20% UBW about equally for walkers and runners, resulting in a lower systolic blood pressure at 20% UBW than at 0% UBW. However, the decrease in blood pressure between 20% and 40% UBW was greater for runners; the decrease was not significant for the walkers. The difference between walkers and runners at 40% UBW was attributed to the difference in vertical displacement that occurs when walking and running and the relationship of that displacement to the degree of unweighting.

Figure 2. Systolic Blood Pressure Interaction Effect of Walkers and Runners.

Figure 3 illustrates the effect of UBW on walkers’ and runners’ RPE. The difference in means for walkers’ RPE across levels of UBW was not statistically significant. The difference between 0% and 20% UBW was greater than the
difference between 20% and 40% UBW, similar to the findings for heart rate and systolic blood pressure. The difference in means for runners’ RPE across levels of UBW was statistically significant. The difference in means for runners was also the same as that found for heart rate and systolic blood pressure. Between 0% and 20% UBW, mean RPE dropped 0.88 units, and between 20% and 40% UBW, mean RPE dropped 1.39 units. These differences between means were significant according to the Tukey test, HSD = 0.83. Therefore, the work intensity measured by heart rate, systolic blood pressure, and RPE for the runners matched. The investigator believed the difference in the means for walkers and runners across the levels of UBW can be explained by fitness levels of the subjects and the mechanical differences between walking and running. Mechanical differences have been previously discussed. The work intensity, speed of the treadmill, for this study was established at 70% of the maximum heart rate at 0% UBW. The intensity was constant for all UBW conditions for each subject, and only the percentage of UBW varied. The speed of the treadmill for some subjects forced them to walk, yet others ran. Therefore, as discussed previously, it was concluded that the runners were in better cardiovascular condition than the walkers. This is probably due to the fact that many of those subjects have been involved in physical fitness setting for many years. Their years of experience in a fitness environment may have made the runners more familiar with using the Borg RPE scale. Thus, the runners’ patterns for the three variables, RPE, heart rate, and systolic blood pressure, were closely matched. Although the patterns for heart rate and systolic blood pressure for the walkers matched, the RPE patterns were not as closely matched.
Figure 3. RPE Interaction Effect of Walkers and Runners.

Percentage of Maximum Heart Rate Obtained

Heart rate values achieved during the 20% and 40% UBW conditions in both
runners and walkers were within the 40% to 70% of maximum heart rate range
proposed at the beginning of this study. This range is indicative of a training range
that is beneficial to increasing physical fitness levels and decreasing high blood
pressure through exercise, as discussed earlier.

Table 13 indicates the heart rate levels dropped to lows of 63.6% of MHR for
walkers at 20% UBW and 63.7% of MHR for runners at 40% UBW. The highest
heart rate achieved was 128.55 bpm at 0% UBW for walkers, which is 66.2% MHR,
and 136.55 bpm for runners at 0% UBW, which is 71.7% MHR. These data present a
5 bpm UBW heart rate difference for walkers and a 15 bpm UBW heart rate
difference for runners. Therefore, unweighting seems to be more effective for lowering the heart rate in the runners than in the walkers. As stated earlier, this is probably due to different horizontal and vertical gait patterns, restriction of range of motion, and energy expenditure difference between walking and running.

**Systolic Blood Pressure Values Achieved by Group**

Systolic blood pressure values decreased with each increase in UBW level. This agrees with the original hypotheses that systolic blood pressure would have an inverse relationship to UBW. The highest systolic blood pressure achieved by the walkers was 138.04 mmHg at 0%, and the lowest was 132.37 mmHg at 40%, equal to approximately a 6-point difference in blood pressure measurement. For the runners, the highest systolic blood pressure was 146.79 mmHg at 0% UBW, and the lowest reading was 135.73 mmHg at 40% UBW, equal to approximately an 11-point difference in blood pressure. Therefore, once again the running group experienced a higher level of physiological difference during the UBW conditions than did the walking group. Again, these differences are probably attributable to the previously mentioned factors.
CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, IMPLICATIONS
AND RECOMMENDATIONS

Summary

This study was performed to determine the effects, if any, on blood pressure, heart rate, and RPE by unweighting 0%, 20%, and 40% of body weight during treadmill exercise at 70% of maximum heart rate. It was hypothesized that increasing UBW would be inversely related to heart rate, blood pressure, and RPE. In addition, initial data collection showed a possible difference in runners and walkers; hence, subjects were analyzed in groups.

Twenty “apparently healthy” individuals, 9 males and 11 females between the ages of 18 and 42 years, were the subjects. Submaximal treadmill tests were performed to determine the treadmill speed needed to obtain 70% of each subject’s maximum heart rate, as predicted by Karvonen’s formula, 220 – age. Subjects were weighed to determine 20% and 40% of body weight to be used during the unloaded conditions of testing.

Subjects participated in 3 trials. For each trial, the subject was first asked to rest for 5 min so that accurate baseline measurements of blood pressure and heart rate could be collected. Then, subjects put on the harness system, and the first of the 3 conditions, 0%, 20%, or 40%, was randomly measured. After a brief warmup, the treadmill speed was adjusted to their 70% of maximum heart rate treadmill speed. At the end of the 5th min, 6th min, and 7th min at this speed, blood pressure, heart rate,
and RPE were measured. Subjects were then cooled down to a heart rate of 100 bpm or lower, and then the second condition was administered. This same procedure was then repeated for the last condition for that trial day. At the end of the trial session, subjects were taken through a series of stretches to combat any possible soreness experienced from the exercise.

Various statistical procedures were used to analyze the raw data collected during the study. Split-plot factorial ANOVAs with fixed effects were used on nine different variables. When significant differences resulted, a simple main effects or Tukey HSD test was applied to determine where the significant differences were located. The independent variables for this design included runners versus walkers and the three UBW conditions, 0%, 20%, and 40%. The dependent variables for this design consisted of the recorded heart rate, systolic and diastolic blood pressure, and RPE measurements collected during testing.

Findings and Conclusions

Significance for the findings of this study was determined at the .05 level. The ANOVA and multiple comparison tests indicated the following:

1. No significant differences in pre-exercise measurements of heart rate, systolic blood pressure, and diastolic blood pressure were found across trial days.

2. A significant difference was found between walkers and runners in pre-exercise measurements of heart rate, $F(1, 18) = 8.95, p = .01$. The runners' mean heart rates were lower than the walkers.

3. No significant differences were found in mean exercise heart rate, systolic blood pressure, diastolic blood pressure, or RPE values among trial days at 0%, 20%, 44
and 40% UBW. Therefore, the dependent variables used in subsequent ANOVAs were the means across 3 trial days.

4. No significant differences in mean exercise heart rate, systolic blood pressure, diastolic blood pressure, and RPE values were found between groups (walkers versus runners).

5. Significant differences across UBW conditions in mean heart rate, systolic blood pressure, and RPE values were found.

6. Significant differences in mean heart rate, systolic blood pressure, and RPE values were found for the interaction effect, Group × UBW.

7. Significant differences across UBW conditions were found for heart rate, systolic blood pressure, and RPE values for runners.

8. Significant differences across UBW conditions were found for heart rate and systolic blood pressure for walkers.

9. No significant differences were found for diastolic blood pressure values between walkers and runners or across UBW conditions.

10. Heart rate values in both runners and walkers were maintained within 40% to 70% of maximal heart rate, with 40% UBW lowering the heart rate to a minimum level of 63% of maximal heart rate for both walkers and runners.

Implications

The researcher embarked on this study with the expectation that as UBW was increased the physiological measurements of heart rate, systolic blood pressure, and RPE would decrease inversely. However, the researcher did not take into account the different gait patterns and energy expenditures between walkers and runners at 70% of MHR. By performing a separate analysis of each of the groups, differences were
found for both groups, yet larger differences were found in the running group than in the walking group. These differences may be due to biomechanical differences in the vertical and horizontal displacements of walking and running gait patterns, a lower energy cost used in walking than in running, and a harness-restricted range of motion that may force a walking subject to increase his or her speed to accommodate to the treadmill speed.

Because a larger difference across UBW conditions was experienced in heart rate and systolic blood pressure measurements for runners during UBW conditions than for walkers, the use of the unloading apparatus for the populations of medically obese and hypertensives as suggested earlier may need to be reevaluated. Both the obese and hypertensive populations would most likely have a fitness level lower than the levels achieved by this study’s subjects. Because this study has shown that the walkers experienced a significantly lower level of heart rate and blood pressure, the benefits of unloading weight may not override the discomfort and inconvenience of using the unloading equipment. However, for a patient who has experienced joint, ligament, or leg muscle pain, this equipment may be a viable option for aerobically beneficial exercise.

Recommendations

As a result of this study, several recommendations can be made for future unweighting studies. Suggestions are as follows:

1. Subjects found the harness vest to be uncomfortable, so researchers and health care professionals may want to investigate different types of vests to increase both the comfort and the range of motion of the subject when exercising.
2. Due to the significant differences in data collected between the walking group and the running group, future studies should include, if not focus solely on, the effect of walking and running gait differences during UBW exercise. Videotaping and digitizing would prove useful in explaining the physiological measurement differences.

3. Collection of EMG data to determine the energy expenditure difference experienced during UBW of walkers versus runners would also be beneficial in explaining the significant physiological differences between runners and walkers.

4. Investigators should delimit future studies to special populations, such as hypertensives, medically obese, physical therapy patients, or generally less-fit populations to determine the resulting physiological effects on these groups.
Appendix A

Subject Recruitment Form
Subject Recruitment

My name is Carolynn Bolander and I am a graduate student in Exercise Science at Western Michigan University. I am currently in the process of recruiting subjects for a research project I will be conducting in the HPER lab at Western for my master's thesis. The research will involve subjects running on a treadmill while partially suspended in an unloading system, consisting of a harness device that removes specified percentages of body weight. Treadmill procedures will include, (a) a submax test to determine steady-state treadmill speed necessary for 70% of maximum heart rate, and (b) three trials with the unloaded condition at the predetermined 70% maximum heart rate speed. I am looking for subjects who are regularly or occasionally active, between the ages of 18 and 40 years of age. Subject participation in the project will involve 30 min the first day and 45 min a day for the next three consecutive days. Anyone interested in participating will be asked to fill out a questionnaire to screen for any health risks or conditions which may effect the subject or the study. If you are interested, please sign up below or on the sheet located at the HPER lab or call me at 345-2548 for more information.

Name: ___________________________ Phone #: ___________
Name: ___________________________ Phone #: ___________
Name: ___________________________ Phone #: ___________
Name: ___________________________ Phone #: ___________
Name: ___________________________ Phone #: ___________
Name: ___________________________ Phone #: ___________
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Name: ___________________________ Phone #: ___________
Name: ___________________________ Phone #: ___________
Name: ___________________________ Phone #: ___________
Appendix B

Human Subjects Institutional Review Board Approval
Date: 12 December 1996

To: Carolynn Bolander

From: Richard Wright, Chair

Re: HSIRB Project Number 96-11-14

This letter will serve as confirmation that your research project entitled "The Effect of Unloading Body Weight During Aerobic Exercise on Blood Pressure" has been approved under the full category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you must seek specific approval for any changes in this design. You must also seek reapproval if the project extends beyond the termination date. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: 10 December 1997

xc: Mary Dawson
Appendix C

Consent Form
Western Michigan University  
Department of Physical Education Health and Recreation  

Principal Investigator: Dr. Mary Dawson  
Student Investigator: Carolynn Bolander

I have been invited to participate in a master’s thesis research study entitled “The effect of unloading body weight during aerobic exercise on blood pressure.” I understand that this research is intended to study the effect of unloading body weight using an unloading machine while performing submaximal treadmill exercise on blood pressure, heart rate and perceived exertion. I further understand that this project is Carolynn Bolander’s master’s thesis research project; a project required for the Master of Arts Degree in Exercise Science.

My consent to participate in this project means that I will be asked to attend 4 consecutive research testing days. The first day will consist of a 30 min period to establish a treadmill speed that maintains a steady-state at 70% of my maximum heart rate. (Also, a treadmill orientation if necessary.) The next 3 days will consist of 45-min treadmill sessions at the established speed using three different levels of body weight “unloading” by use of a harness device. I understand that I will be screened by questionnaire for any health problems that may limit my abilities during the tests or endanger my health, such as hypertension, diabetes, asthma, etc. I will be disqualified as a subject if any problems are found in the screening that may endanger my health or limit my abilities during testing.

As in all research, there may be unforeseen risks to the participant. I understand that there is a risk of injury when participating in any type of exercise activity. If an accidental injury does occur, appropriate emergency procedures will be taken; however, no compensation or treatment will be made available to me unless otherwise specified in this consent form. I understand that there are no known risks for exercising on a treadmill using an unloading hoist system, such as the one used in this study, beyond the normal risks associated with cardiovascular exercise mentioned above. Muscle soreness may be experienced after testing, but with stretching periods between testing conditions and after conclusion of the test, these effects should be minimal. It is understood that the student investigator is certified in CPR and that every precaution will be taken to prevent a possible injury from occurring.

I may benefit from participating in this study by learning my exercise fitness through the results of the submaximal test, and if not known before, learn how to exercise correctly and comfortably on a treadmill. Plus, I realize that my participation in this study may lead to the creation of more studies and the possibility of this method of exercise training to be used by special at-risk populations such as hypertensives or the extremely obese.
I understand that all information collected from me is confidential. This means that only Carolynn Bolander and the principal investigator will have access to this information. All research information will be retained for 3 years in a locked file in the principal investigator's office.

I understand that I may refuse to participate or quit anytime during the study without penalty or prejudice. If I have any questions or concerns about this study, I may contact either Carolynn Bolander at 345-2548, or Dr. Dawson at 387-2710. I may also contact the Chair of Human Subjects Institutional Review Board at 387-8293 or the Vice President for Research at 387-8298 with any questions or concerns I may have. My signature at the bottom indicates that I understand the purpose and the requirements of the study and that I agree to participate.

Signature Date
BIBLIOGRAPHY


