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The impact of wearable weights on the cardiovascular and metabolic responses to treadmill walking

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The Impact of Wearable Weights on the Cardiovascular and Metabolic Responses to
Treadmill Walking

by

Kristine M. Fallon

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Arts
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Table of Contents

| | |
|--|-----|
| List of Tables | iii |
| List of Figures | iv |
| Abstract | v |
| Chapter One | |
| Introduction | 1 |
| Rationale | 4 |
| Purpose | 5 |
| Hypotheses | 7 |
| Chapter Two | |
| Literature Review | 10 |
| Chapter Three | |
| Methodology | 18 |
| Participants | 18 |
| Lab trials | 19 |
| Screening (visit 1) | 19 |
| Maximal exercise test (visit 2) | 19 |
| Workload establishment and familiarization (visit 3) | 20 |
| Experimental exercise trials (visit 4-11) | 21 |
| Protocol description | 23 |
| Repeated Trials | 23 |
| Instrumentation | 24 |
| Research design and data analysis | 24 |
| Inclusion/exclusion criteria | 24 |
| Chapter Four | |
| Results | 25 |
| Graded exercise test | 25 |
| VO2 Data | 26 |
| Main and interaction effects | 26 |
| Individual hypotheses | 26 |
| Heart rate data | 30 |
| Main and interaction effects | 30 |
| Individual hypotheses | 30 |

| | |
|--------------|----|
| Chapter Five | |
| Discussion | 35 |
| References | 41 |

List of Tables

| | | |
|---------|---|----|
| Table 1 | Participant Demographics | 18 |
| Table 2 | Description of Laboratory Visits | 19 |
| Table 3 | Experimental Trial Conditions | 22 |
| Table 4 | Example of Balanced Tog/Speed Sequences | 22 |
| Table 5 | Maximal Treadmill Test Data | 25 |
| Table 6 | VO2 Data: Descriptive Statistics | 29 |
| Table 7 | Follow-up Comparisons (VO2) | 29 |
| Table 8 | HR Data: Descriptive Statistics | 33 |
| Table 9 | Follow-up Comparisons (HR) | 33 |

List of Figures

| | | |
|----------|----------------------------------|----|
| Figure 1 | VO2 Responses to Exercise | 30 |
| Figure 2 | Heart Rate Responses to Exercise | 34 |

The Impact of Wearable Weights on the Cardiovascular and Metabolic Responses to
Treadmill Walking

Kristine M. Fallon

ABSTRACT

The growing public health burden associated with insufficient physical activity has resulted in the development of numerous health initiatives and products aimed at stabilizing and reversing the negative trends reported in epidemiological literature. A relatively novel product that has only recently made its way to the market are wearable weights called Body Togs®. These products are designed to be worn on the lower legs and arms along with regular clothing as a means to increase caloric expenditure.

However, no research to date has tested the efficacy of this product. **PURPOSE:** Compare the physiological responses within bouts of aerobic exercise that vary on intensity and the presence of wearable weights. **METHODS:** Seventeen (11 female, 6 male, mean age = 24 years \pm 5.92) healthy volunteers were tested for aerobic fitness on a treadmill to determine VO₂ max (mean = 42.68 ml x kg⁻¹ x min⁻¹). Participants then completed eight 30-minute walking trials on a treadmill while oxygen consumption (VO₂) and heart rate (HR) were monitored while walking at different speeds and with varying combination of upper and lower body wearable weights. The design included two intensities (slow walking and brisk walking) and four conditions (no weights, arm weights, leg weights, and arm and leg weights) for a total of eight experimental trials. **RESULTS:** Data were

analyzed using ANOVA and pair-wise comparisons. Analyses revealed that VO₂ was significantly lower without the wearable weights in comparison to wearing both upper and lower weights in the slow walk trial ($P < 0.001$; ES = 0.69) and also during the brisk walk trial ($P < 0.001$; ES = 0.62). HR was significantly higher during the brisk walk trials with togs on both the arms and legs ($P=0.029$, ES=0.31). CONCLUSIONS: Findings suggest that exercising while using wearable weights increases energy expenditure and has minimal impact on HR. PRACTICAL APPLICATIONS: This finding suggests that physical activity associated with daily living could be enhanced through the wearing of the Body Tog® weights that can be worn under clothing. Additionally, wearing the togs during exercise increases energy cost of walking, therefore allowing for possible weight loss applications.

Chapter 1

Introduction

“For all health professionals, the challenge is to leverage our professional credibility to enroll increasing numbers of participants in physical activity programs that are designed to overcome barriers to long-term adherence, using effective behavioral management and environmental change strategies, so that many more individuals will realize the benefits provided by a physically active lifestyle.”

- ACSM, 2007

The human body is designed for activity and it should naturally be part of our everyday life. Because of a more modern and demanding lifestyle, physical activity has declined, becoming less important than other activities such as work, family, or social responsibilities. Technology and economic incentives have discouraged many individuals from regular exercise in numerous ways, making sedentary behavior a hard habit to break.

As declared in the 2007 Center for Disease Control and American College of Sports Medicine physical activity recommendations, “physical activity remains a pressing public health issue.” Amounts of physical activity participation seen in adults today have continuously been on the decline, and are extremely well below those outlined by health professionals. In data from 2005, it was stated that less than half of U.S. Adults, approximately 49.1%, met the ACSM recommendations for physical activity (Haskell et al., 2007). Many feel as though they do not have sufficient time to exercise, or have

trouble adhering to a satisfactory exercise regimen. It should also be noted that many adults have misinterpreted these recommendations, either believing that health benefits are only gained through vigorous effort, or that light activity will suffice.

Presently, the National Center for Chronic Disease Prevention and Health Promotion states that at least sixty percent of U.S. adults do not engage in the proper amount of physical activity that is suggested for each day. Additionally, twenty-five percent of adults today are not active at all. In an article by Mockdad et al. 2004, it was shown that in the year 2000 poor diet accompanied with physical inactivity was one of the three highest risk factors for premature morbidity. This fact elicited a major need for new preventable mechanisms that will begin to lessen the health care burden in our country. Additionally, in the year 2005 the top causes of death were reported as follows: heart disease, cancer and stroke (Kung, 2005). Physical activity can significantly prevent and lower the risk factors for many chronic diseases, and a majority of the causes of premature morbidity listed above.

To encourage increased participation in physical activity among Americans of all ages, a public health recommendation is issued every few years outlining the type and amount of physical activity needed for health promotion and disease prevention (Pate et al., 1995). A time barrier is presently one of the biggest obstacles for sedentary adults to overcome. Many individuals are not willing to put in the time to obtain health benefits and fitness results. The consequence of this fact has led our country to become one of the most inactive nations in the world.

Efforts to begin to increase participation rates in physical activity are reflected by changes to the current ACSM exercise recommendations and guidelines. The American

College of Sports Medicine guidelines released in 2007 state that “all healthy adults ages 18 to 65 years need moderate-intensity aerobic physical activity for a minimum of 30 minutes on five days each week, or vigorous-intensity aerobic activity for a minimum of 20 minutes on three days each week” (Haskell et al., 2007). Additionally, in an effort to become more liberal, the American College of Sports Medicine has stated in these guidelines that moderate amounts of physical activity can even be achieved in smaller increments while still having the ability to elicit health benefits. For example, some individuals may exercise for only ten minute segments, and do so three different times a day. It is understood that in a busy society most can find it intimidating, or possibly discouraging, having to commit to thirty minutes of exercise each day. The new guidelines give a more comprehensive recommendation geared toward public health, and may be more inviting in terms of fitting exercise into our daily lives.

When comparing the ACSM exercise recommendations from the year 1995 to the ones recently given in 2007, a very important element was introduced; muscular strength and endurance. Although the 1995 guidelines mentioned the importance of muscular strength and endurance exercises, they failed to make exact recommendations. Muscular strength has been shown through a great deal of research to be a large factor in staying healthy and slowing the aging process. These activities are now fully a part of the 2007 ACSM exercise guidelines, and experts stress that individuals should perform 8-10 strength-training exercises and 8-12 repetitions of each exercise, two times each week (Haskell et al., 2007)

What’s more convincing is how the ACSM guidelines have shifted to focus not only on traditional exercise modalities, but also to include activities of daily living. So in

essence, the guidelines are still consistent with recommending a specific amount of caloric expenditure each day, but the manner in which this can be achieved has become more flexible.

Rationale

Regular physical activity is associated with various health benefits. Active individuals can lower their risk of coronary heart disease, hypertension, colon cancer and diabetes by being active for thirty minutes a day. Exercise also helps maintain a healthy weight while reducing body fat and increasing lean muscle. Along with these improvements come stronger bones, muscles and joints. In addition, regular exercise can decrease anxiety and depression while improving mood (Pate et al., 1995).

Though these health benefits suggest that exercise should be part of every person's daily routine, many Americans do not adhere to the published recommendations. According to data from NHANES in 2006, approximately 66 percent of adults over twenty years of age are overweight. Of that 66 percent, 32 percent are obese. Physical inactivity is a main risk factor for this disease, and growing numbers of obesity pose a large threat to the already elevated health care costs in this country. In order to lessen the burden of overweight and obese people in our society, new methods and ideas about physical activity need to be implemented to aid in health and fitness promotion.

Working towards developing more innovative methods to produce an increased level of energy expenditure in a moderate amount of time is needed to promote and enhance the level of physical activity seen in adults today. Individuals who do not exercise thirty minutes per day or who do not exercise at all can potentially benefit from

the addition of external resistance during an exercise bout. Adding external weight to an exercise session could increase energy expenditure and oxygen consumption, leading to a better, more efficient workout in a shorter amount of time. Additionally, adding external weight may also give the user more adequate exercise while they go about their daily living activities.

Body Togs® are wearable weights constructed to be worn comfortably during activity. These weights are worn on the lower portions of the arms and legs, and together add approximately seven and a half pounds of additional load to the extremities. The reason why Body Togs® differ from traditional hand or wrist weights used in exercise research is their practicality and safe design. They have a unique ability to distribute the same weight used in hand or wrist weights over a greater space, which allows for a flat and flexible product that can be hidden and worn directly under clothes.

Purpose

The purpose of this study was to examine the general efficacy of Body Togs® in a controlled laboratory environment with methods that are representative of what is considered realistic activity for the general public. This research was done to determine the impact of wearable weights (Body Togs®) on cardiovascular and metabolic responses such as oxygen consumption and heart rate while engaging in “slow” and “brisk” walking exercise for thirty minutes.

The ability to improve the cardiovascular, musculoskeletal, and respiratory response to aerobic exercise is directly related to the frequency, intensity and duration of the program (Evans et al., 1994). Because of the increase in sedentary behavior in

Americans today, our research will explore a new, innovative way to increase oxygen consumption and heart rate, in a limited amount of time. Total caloric expenditure may be a factor that is most crucial for achieving the necessary preventative health benefits that come from exercising. By wearing Body Togs® during daily activity, adults may be more successful in reaching the recommended amounts of physical activity needed to gain health benefits. The present research study examined the heart rate and oxygen consumption during a “slow” walking speed exercise trials in an effort to observe any changes in cardiovascular or metabolic response while wearing Body Togs®. The “slow” speed of our exercise trials attempted to portray the common walking intensity and speed of most casual lifestyle activities. It may be possible that the simple addition of Body Togs® to activities of daily living could help individuals in achieving the recommended amounts of energy expenditure needed each day.

This study also examined the heart rate and oxygen consumption during “brisk” walking exercise to determine if there was a greater cardiovascular or metabolic response while wearing Body Togs® at this speed. It may be possible that by adding the togs as a compliment to a regular exercise bout, adults could potentially increase the intensity and caloric expenditure of their workout in the same amount of time. Though the additional caloric cost from the Body Togs® may be minimal, if the exertion level is comparable and time does not increase, burning fifty extra calories each day may have the possibility of leading to substantial body composition and fitness level changes over time.

Hypotheses

The following null hypotheses were considered throughout this research study:

No togs compared to arms only

H₀₁ – Heart rate during the “slow” walk with no Body Togs® will be equal to heart rate during the “slow” walk with Body Togs® on the arms.

H₀₂ – Heart rate during the “brisk” walk with no Body Togs® will be equal to heart rate during the “brisk” walk with Body Togs® on the arms.

H₀₃ – VO₂ during the “slow” walk with no Body Togs® will be equal to VO₂ during the “slow” walk with Body Togs® on the arms.

H₀₄ – VO₂ during the “brisk” walk with no Body Togs® will be equal to VO₂ during the “brisk” walk with Body Togs® on the arms.

No togs compared to legs only

H₀₅ – Heart rate during the “slow” walk with no Body Togs® will be equal to heart rate during the “slow” walk with Body Togs® on the legs.

H₀₆ – Heart rate during the “brisk” walk with no Body Togs® will be equal to heart rate during the “brisk” walk with Body Togs® on the legs.

H₀₇ – VO₂ during the “slow” walk with no Body Togs® will be equal to VO₂ during the “slow” walk with Body Togs® on the legs.

H₀₈ – VO₂ during the “brisk” walk with no Body Togs® will be equal to VO₂ during the “brisk” walk with Body Togs® on the legs.

No togs compared to both togs

H_{0 9}- Heart rate during the “slow” walk with no Body Togs® will be equal to heart rate during the “slow” walk with Body Togs® on both the arms and legs.

H_{0 10}- Heart rate during the “brisk” walk with no Body Togs® will be equal to heart rate during the “brisk” walk with Body Togs® on both the arms and legs.

H_{0 11}- VO₂ during the “slow” walk with no Body Togs® will be equal to VO₂ during the “slow” walk with Body Togs® on both the arms and legs.

H_{0 12} – VO₂ during the “brisk” walk with no Body Togs® will be equal to VO₂ during the “brisk” walk with Body Togs® on both the arms and legs.

Both togs compared to arms only

H_{0 13} – Heart rate during the “slow” walk with Body Togs® on both the arms and legs will be equal to heart rate during the “slow” walk with Body Togs® on the arms only.

H_{0 14}- Heart rate during the “brisk” walk with Body Togs® on both the arms and legs will be equal to heart rate during the “brisk” walk with Body Togs® on the arms only.

H_{0 15} – VO₂ during the “slow” walk with Body Togs® on both the arms and legs will be equal to VO₂ during the “slow” walk with Body Togs® on the arms only

H_{0 16}- VO₂ during the “brisk” walk with Body Togs® on both the arms and legs will be equal to VO₂ during the “brisk” walk with Body Togs® on the arms only

Both togs compared to legs only

H_{0 17} – Heart rate during the “slow” walk with Body Togs® on both the arms and legs will be equal to heart rate during the “slow” walk with Body Togs® on the legs only.

H_{0 18}- Heart rate during the “brisk” walk with Body Togs® on both the arms and legs will be equal to heart rate during the “brisk” walk with Body Togs® on the legs only.

H_{0 19} – VO₂ during the “slow” walk with Body Togs® on both the arms and legs will be equal to VO₂ during the “slow” walk with Body Togs® on the legs only.

H_{0 20}- VO₂ during the “brisk” walk with Body Togs® on both the arms and legs will be equal to VO₂ during the “brisk” walk with Body Togs® on the legs only.

Arms only compared to legs only

H_{0 21} – Heart rate during the “slow” walk with Body Togs® on the arms will be equal to heart rate during the “slow” walk with Body Togs® on the legs.

H_{0 22}- Heart rate during the “brisk” walk with Body Togs® the arms will be equal to heart rate during the “brisk” walk with Body Togs® on the legs.

H_{0 23} – VO₂ during the “slow” walk with Body Togs® on the arms will be equal to VO₂ during the “slow” walk with Body Togs® on the legs.

H_{0 24}- VO₂ during the “brisk” walk with Body Togs® the arms will be equal to VO₂ during the “brisk” walk with Body Togs® on the legs.

Chapter 2

Review of Literature

In prior research studies that focused on the topic of adding external weight to the body during exercise, most hypothesized that the addition of wearable weights will affect the physiological responses of the body during exercise (i.e., increase oxygen consumption and heart rate levels).

It has been acknowledged by health professionals that walking can be a satisfying modality of exercise for all ages and fitness levels. However, for some individuals, increasing walking speed and intensity can be difficult. Without the proper intensity levels being achieved, simply walking may not truly produce the responses necessary to lower the risk for chronic health problems. In a study by Lind and McNicol (1968) participants were instructed to carry additional weight while exercising. Results elicited the idea that holding 10kg and carrying 80kg on the shoulder lead to a fatigue state while blood pressure and heart rate increased. Due to the absence of equipment, oxygen consumption and energy cost were not directly observed (Lind & McNicol, 1968).

Long before the invention of products like Body Togs®, simple wrist or hand weights were used in an effort to improve one's general fitness capacity and enhance a workout session. Engels et al. (1998) investigated the effects of exercise training with and without wrist weights on an individual's functional capacities and mood states.

Twenty-three senior citizens were recruited and randomly assigned to two groups: wrist

weights and no weights. For ten weeks, the participants took part in a low-impact, aerobic dance exercise class that also combined muscular fitness, flexibility and balance exercises. This was done for one hour, three times each week. Aerobic fitness, muscular strength, flexibility, balance, skin fold measurements, and psychological mood states were assessed. Increases in peak oxygen uptake, muscular strength, and psychological mood states were observed, but no other fitness components were affected by the variable of adding wrist weights. Additionally, researchers found that there were no significant differences between the group who exercised with weights and the group who used no weights. The present observations indicate that the use of light wrist weights has no beneficial or unfavorable effects on the aforementioned fitness components (Engels et al., 1998).

Other ideas arose to compare the two different populations of both young and elderly. In a study done by Engels and colleagues (1995), 16 healthy individuals were examined to determine the physiological responses, if any, to steady-rate walking with additional weight carried at shoulder level. Each individual participated in two separate treadmill bouts, with and without additional shoulder weights (4.54 kg). The researchers found a small increase in oxygen uptake, but no significant changes in heart rate, respiratory exchange rate, or blood pressure. Therefore, the findings of this particular study show that effectiveness of using weights during exercise to increase the body's physiological responses is minor (Engels et al., 1995).

Graves et al. (1987) conducted a study where twelve untrained men completed three sub-max treadmill tests and two maximal treadmill tests with three pound hand held weights. Heart rate, respiratory exchange rate, oxygen uptake, blood pressure, ventilation

and perceived exertion rate were all found to be significantly greater when using hand weights during exercise. Overall, this study found that three pound hand weights can increase physiological responses to exercise. Using hand weights during exercise has usually been prescribed to those who do not run, but prefer to walk and reap similar fitness and health benefits (Graves et al., 1987).

Increasing the energy cost of walking may allow individuals to obtain greater benefits than those achieved from their routine exercise sessions. This is made apparent through a second study done by Graves et al. (1988) which is one of only a few that compared the physiological responses of added weight at different locations on the body. This study assessed oxygen uptake, blood pressure, and heart rate outcomes when using hand weights, wrist weights and ankle weights during exercise. Twelve males participated in three separate treadmill tests, each time with weights placed on the ankle, wrist, or hand. Participants were only included if they were considered “sedentary” or had an aerobic capacity less than 50 ml/kg/min. The authors reported that oxygen uptake and heart rates during usage of the hand weights and wrist weights was significantly greater than with the ankle weights. Surprisingly, there was approximately one MET of increase in energy cost during exercise with hand weights and wrist weights when arm swing was exaggerated. Overall, exercise intensity (expressed in terms of HR_{max} reserve) increased from 60.4% with no weights to 70.9%, 70.2%, and 66.3% with hand, wrist and ankle weights, respectively. To summarize, there were some differences in the physiological responses to exercise with weights, but it was specific to the location of the particular added weight. With one MET of increase in energy cost, a projected 14.3%

increase in energy expenditure was observed when compared with the control group, and occurred without changes in exertion ratings (Graves et al., 1988).

Claremont and Hall (1988) elaborated on the Graves (1988) investigation and compared the physiological and mechanical responses during running exercise with commercially sold hand and ankle weights, essentially loading the extremities. A small sample size which included five males and three females ran for thirty minutes on a treadmill at a self-selected pace. Each was assigned to randomized conditions consisting of hand weights, ankle weights, and both hand and ankle weights totaling 0.98kg for females and 2.7kg for males. The major objective was to assess the effects of extremity loading upon caloric expenditure and biomechanics. One main question sought out in this study was to determine in fact how large of extremity loading is required in order to significantly increase energy cost during running. As hypothesized, highest rates of energy expenditure and heart rate were obtained during the exercise trial with both hand and ankle weights. Energy expenditure increases of 5 to 10% were observed for every 1 kg of weight added. Overall, the weights allowed individuals to burn an extra 58 calories per hour of running. Because running with additional weights may cause discomfort, it would appear that with the minor responses to extremity loading, a better alternative for runners might be to increase intensity by increasing speeds or incline (Claremont & Hall, 1988).

A similar study done by Martin (1985) looked solely at exercise when loading the lower extremities in specific areas such as the thighs and feet. The main objective of this study was to determine the effect of lower extremity loading on heart rate and oxygen consumption, along with the effect on the many mechanical aspects of running. Fifteen

highly trained distance runners completed this study and participated in approximately three treadmill tests at a running speed of 12 km/hr. Five load conditions were used, including 0.50 kg and 1.00 kg weights added to either the feet or thighs, and a control group with no weights (Martin, 1985). Results illustrated that VO₂ and heart rate increased along with load on both the feet and the thighs. This is consistent with other research in stating that the highest physiological responses are seen when the most weight is added to the body. Furthermore, oxygen consumption was effected significantly more when load was added to the feet, when compared to loading of the thighs. Also, increases in oxygen consumption witnessed during foot loading were almost twice as great as during thigh loading.

Interestingly, the results suggested that the influence of loading on heart rate levels is not as significant as that on oxygen consumption. While heart rate did increase with foot loading, the changes were minor. On the other hand, these minor changes found in heart rate still provide evidence of the body's physiological response produced because of loading on the extremities. This study also concluded that during loading, the increase of biomechanical demand on the lower extremities is directly related to the increase of physiological responses such as heart rate and oxygen consumption (Martin, 1985).

Owens, Ahmed, and Moffatt (1989), looked at the physiological differences when exercising with dissimilar amounts of weight during two different modalities; walking and running. Ten males were asked to carry different sizes of hand-held weights (0.45, 1.36, 2.27 kg) when walking and running on a treadmill. Findings showed that walking with hand held weights did not significantly increase the participant's oxygen

consumption. However, when running and carrying hand-held weights, oxygen consumption increased when using the heaviest load of weights (Owens et al, 1989).

Evans et al. (1994) recruited nineteen males and females between the ages of 60 and 70 that were previously physically active and determined the physiological responses of older adults to walking with added weights. Each individual completed treadmill testing with the following conditions: no weight, 1.36 kg hand weights, and 2.27 kg hand weights. Participants walked at two specific speeds: one that was chosen by them, and one that was held at a constant intensity dependent upon their target heart rate, as calculated using the Karvonen formula. During these exercise trials the participants were encouraged to keep their elbows at a 90 degree angle, while using normal arm movements and a light grip. There was a significant difference in means for the oxygen consumption and heart rate of those who walked at a constant speed while carrying weights. Hand weights of at least 1.36 kg were required to increase the oxygen consumption of older adults. Even though this increase was shown to be minor, it represented an 18.9% increase when compared to the control group. Furthermore, when these older adults were walking at a constant heart rate, similar energy expenditure was observed across all exercise conditions. However, one advantage of walking at a target heart rate is that adults can decrease speed but increase intensity by adding more weight (Evans et al., 1994). This study shows that the use of hand-held weights may increase the metabolic responses during constant speed of walking exercise in elderly adults, thus introducing the idea that the use of Body Togs® may be beneficial to the elderly.

It has become increasingly important for us as fitness professionals to put an emphasis on activities that can maximize energy expenditure. The addition of overload to

a basic walking program can be a desirable way to increase intensity and energy cost. Most research that focuses on overloading the body during aerobic exercise usually includes wrist, hand, or ankle weights. Placing weights in these areas have, up until now, been the safest and most effective way to increase the intensity of walking exercise. However, Rogers et al. (1995) evaluated cardiorespiratory parameters during submaximal walking exercise while using Exerstriders®. Exerstriding is known as a modified form of walking, incorporating specially designed walking sticks. Use of these instruments has been shown in previous research to increase upper body muscular endurance, but to date there is only limited data on what their overall effect is on energy expenditure levels during walking exercise (Rogers et Al., 1995). A group of ten females participated in two randomly assigned treadmill trials, walking with and without Exerstriders®. The average weight of each of the Exerstrider poles was 13-14 ounces. Findings showed that using these tools while walking elicited a cardiorespiratory response and caused energy expenditure to significantly increase. Researchers found that oxygen consumption, heart rate, and respiratory exchange rate were all significantly greater when using Exerstriders®. Furthermore, caloric expenditure was also significantly greater in those using the Exerstrider poles (Rogers et al., 1995). The overall conclusions of this study provide the means to increase energy and caloric expenditure during exercise, therefore enhancing the health and fitness benefits of a common walking program.

In summary, the addition of weight to regular exercise poses positive benefits, and lacks any threats to a healthy individual's physical fitness status. The above literature parallels the present research project, which focuses on assessing a new wearable weight product called Body Togs®. The research team will attempt to determine if the togs can

significantly increase heart rate response and oxygen consumption during walking exercise.

Chapter 3

Methodology

Participants:

Seventeen men and women ranging from 20-45 years were recruited. The average age, height, weight and body mass index of the participants was 24.2 years, 66 inches, 73kg, and 25.04 BMI, respectively. The average “Slow” speed was 2.6mph and the average “Brisk” walking speed was 3.5mph (Table 1). The self-selected slow speeds elicited an average exercise intensity of 27% of VO₂ max. Additionally, the self-selected brisk speeds resulted in an average exercise intensity of 36% of VO₂ max. Each participant provided informed consent documents prior to involvement. All participants then completed a health status questionnaire and a physical exam administered by a sports medicine physician in accordance with standard guidelines. Participants for this study were recruited through word-of-mouth communication with current University of South Florida Exercise Science students and other healthy individuals in the USF community.

Table 1: Participant Demographics (n = 17)

| | Minimum | Maximum | Mean ± SD |
|----------------|---------|---------|--------------|
| Age | 20 | 45 | 24.23 ± 5.92 |
| Height (inch.) | 60 | 73 | 66.94 ± 3.51 |
| Weight (lbs.) | 106 | 246 | 161.0 ± 37.8 |
| BMI | 18.82 | 36.40 | 25.04 ± 4.12 |
| Slow speed | 2.0 | 3.2 | 2.62 ± 0.36 |
| Brisk speed | 2.9 | 4.0 | 3.46 ± 0.30 |

Lab Trials:

Each participant was required to visit the Health and Exercise Science Laboratory eleven times. A brief description of each laboratory visit is provided in the table below. Each laboratory visit required approximately one hour and each trial was separated by a minimum of 24 hours. On average, each participant completed all eleven trials within a three week time period.

Table 2: Description of Laboratory Visits

| Visit | Description |
|-------|---|
| 1 | Screening to include a physical exam, informed consent, and resting assessments |
| 2 | Maximal treadmill test |
| 3 | Workload establishment and familiarization with treadmill and Body Togs® |
| 4-11 | Experimental exercise trials |

Screening (Visit 1):

Each participant was screened for participation based on established criteria from *ACSM's Exercise Testing and Prescription*. The screenings included a comprehensive health history, pre-participation physical exam administered by a physician, completion of the informed consent document, and assessment of resting heart rate, weight, height, and blood pressure.

Maximal Exercise Testing (Visit 2):

Each participant completed a graded exercise maximal treadmill test that included measurements of heart rate, blood pressure, perceived exertion, and metabolic gas exchange. The "Health and Exercise Science (HES)" protocol used for this test consists

of a starting speed of 3.0mph on the treadmill with speed increases of 0.5 every minute afterward. Heart rate and RPE were recorded every minute; blood pressure was recorded every three minutes. When participants reached a speed of 7.0 (females) or 8.0 (males) on the treadmill, the incline was then increased by 2% every minute thereafter, with no additional increases in speed. Participants were encouraged to go until maximal effort and exhaustion was achieved

Workload Establishment and Familiarization (Visit 3):

Each participant was asked to walk on the treadmill to determine the exercise intensities for subsequent exercise trials. One workload corresponded to a “slow walk” which is designed to replicate walking that is associated with activities of daily living. The second workload corresponded to a “brisk walk” which is designed to replicate walking that is purposeful and associated with fitness. Workload establishment of the two separate speeds lasted approximately 30 minutes with 15 minutes designated to each walking speed. Collectively, the two workloads were self-selected and are intended to reflect public health recommendations related to lifestyle physical activity.

Familiarization with the togs included instruction on proper size, location, and fit for the legs and arms. It should be noted that all tog sizes small to extra-large weighed the same, approximately 7.5 pounds. The purpose of this portion of the trial was to provide exposure to the togs prior to the experimental manipulation to limit the perceptual impact of wearing a novel device. Following workload establishment and familiarization, the participants were informed about the exertion assessment scale that was to be used throughout the research study. Borg’s 6-20 rating of perceived exertion scale (RPE) was

explained in full detail to each participant, and the participants were then required to initial that they understood the tool clearly.

Workload establishment and familiarization were determined via the following script to be delivered by the research team.

Prior to slow walking speed selection:

“Please select a speed that represents a “Slow” walk. This should be a walk that is associated with activities of daily living. It is important for you to keep in mind that you will have to maintain this speed for 30 minutes during all exercise trials. We ask that you refrain from using the handles located on either side of the treadmill. These are for emergency use only.”

At 7 minutes 30 seconds:

“Do you still believe that this is a slow walk?” If participant desires to reduce or increase the previously selected speed they may do so at this time. Otherwise this will be the “slow walk” speed that will be maintained throughout the entire research study.

Prior to brisk walking speed selection:

“Please select a speed that represents a “Brisk” walk. This should be a walk that is purposeful and associated with fitness. It is important for you to keep in mind that you will have to maintain this speed for 30 minutes during all exercise trials. We ask that you refrain from using the handles located on either side of the treadmill. These are for emergency use only.”

At fifteen minutes:

“Do you still believe that this is a brisk walk?” If participant desires to reduce or increase the previously selected speed they may do so at this time. Otherwise this will be the “brisk walk” speed that will be maintained throughout the entire research study.

Experimental Exercise Trials (Visits 4-11):

The eight experimental trials allowed for both exercise intensities to be tested across four equipment conditions. The two exercise intensities examined were the “slow

walk” and “brisk walk” which were expected to produce metabolic responses in the 20-40% and 40-60% of maximal oxygen consumption, respectively. The four equipment conditions included: no togs, leg and arm togs, arm togs only, and leg togs only (see Table 3). All participants were placed in one of eight possible balanced sequences relative to tog condition and speed for each experimental trial. Table 4 describes the eight conditional sequences which correspond to the eight experimental trials of each participant. Each experimental exercise trial lasted for an estimated 30 minutes in an effort to replicate the duration recommended by current physical activity guidelines. Heart rate was measured every six minutes along with perceived exertion (RPE). Oxygen consumption was measured from minute 24 to minute 29. It should be noted that from minute 24 through minute 29, exertion and heart rate were not assessed. At 29 minutes and 45 seconds the last measures of exertion and heart rate were recorded by the research team. Exertion was assessed again immediately after the completion of exercise and ten minutes post exercise.

Table 3: Experimental Trial Conditions

| | | Togs | | | |
|-----------|------------|------|-----------|----------|----------|
| | | None | Arm & Leg | Leg Only | Arm Only |
| Intensity | Slow Walk | | | | |
| | Brisk Walk | | | | |

Table 4: Example of Balanced Tog/Speed Sequences

| Speed | Togs | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 |
|-------|------|-----|-----|-----|-----|-----|-----|-----|-----|
| SLOW | None | 5 | 4 | 7 | 2 | 3 | 6 | 1 | 8 |
| | Both | 3 | 6 | 5 | 4 | 1 | 8 | 7 | 2 |
| | Legs | 7 | 2 | 1 | 8 | 5 | 4 | 3 | 6 |
| | Arms | 1 | 8 | 3 | 6 | 7 | 2 | 5 | 4 |
| BRISK | None | 2 | 7 | 4 | 5 | 6 | 3 | 8 | 1 |
| | Both | 8 | 1 | 6 | 3 | 4 | 5 | 2 | 7 |
| | Legs | 4 | 5 | 8 | 1 | 2 | 7 | 6 | 3 |
| | Arms | 6 | 3 | 2 | 7 | 8 | 1 | 4 | 5 |

Protocol Description:

Prior to each exercise trial, the metabolic cart was properly calibrated by the research team. A Polar™ heart rate monitor was supplied for each participant upon arrival to the laboratory. A warm-up of 30 seconds preceded every exercise trial at a speed of 2.5mph on the treadmill. At the conclusion of the warm-up, the speed was adjusted to either the “slow” or “brisk” walking pace as previously determined, and was dependent upon what condition the participant was assigned for that day. Every six minutes heart rate and rate of perceived exertion for the legs, chest/breathing, and overall were assessed. At minute 24 of the exercise trial the VO2 mask was placed on the participant. Expired metabolic gases were collected from minute 24 to minute 29. At minute 29, the VO2 mask was removed and at 29 minutes and 45 seconds a final rating heart rate and perceived exertion of the legs, chest/breathing, and overall was recorded. At 30 minutes a 30 second cool down at 2.5mph on the treadmill transpired. Once the treadmill was stopped by the research team, immediate post exercise perceived exertion was taken and again ten minutes afterwards.

Repeated Trials:

Approximately eight participants from the study were required to return to the laboratory to repeat one or more experimental exercise trials. This was due to a few inconsistencies with the metabolic machine and oxygen consumption values. In total, the research team completed fourteen re-trials with no participants having more than two trials to repeat. It should be noted that the data obtained during these repeated trials was what was used in the completed statistical analysis.

Instrumentation:

Variables of interest during exercise include: heart rate and oxygen consumption. Heart rate (HR) was measured using a Polar™ heart rate monitor (Polar, USA). Oxygen consumption was measured by way of open circuit spirometry (VacuMed) on an industrial treadmill (Trackmaster RS-232).

Research Design and Data Analysis:

The research design utilized a 2 (intensity: slow walk and vigorous walk) x 4 (conditions: no togs, arm and leg togs, leg togs only, arm togs only) repeated measures ANOVA (see table 2). Each participant served as their own control. Main and interaction effects were followed by dependent t-tests. Criterion for significance for all tests was set at $p < 0.05$. Effect sizes were calculated by subtracting mean one from mean two and dividing by the average the two standard deviations involved (Cohen's *d*). Each p-value was reported precisely with the thought that the large amount of comparisons done in the study posed an increased risk for type 1 errors.

Inclusion/Exclusion Criteria:

All participants were required to be categorized as low risk according to ACSM's 2007 *Guidelines for Exercise Testing and Prescription* which requires absence of cardiovascular, metabolic, and pulmonary disease or related symptoms. Physical activity or fitness status and body mass index were not utilized as inclusion/exclusion criteria. The design instead allowed any range of activity and weight status.

Chapter 4

Results

Graded Exercise Testing:

Each participant was required to complete a graded exercise test prior to the experimental Body Tog trials, using the Health and Exercise Science (HES) protocol. The average maximal oxygen consumption achieved was approximately 42.7 ml/kg/min (see table 3). The average maximal heart rate reached during the graded exercise test was 186 (186.00 ± 11.67), which is above the protocol of 90% of age predicted max (220-age). The average respiratory exchange ratio was 1.19 (1.189 ± 0.088) which is above the 1.15 criterion for maximal effort. The maximal rate of perceived exertion seen during the test was approximately 19 (18.65 ± 0.786) on Borg's 6-20 scale, which also met the criterion for maximal effort. Collectively, the data collected during the graded exercise test for this research study suggests that exhaustion did occur and VO₂ max was achieved (table 5).

Table 5: Maximal Treadmill Test Data (n = 17)

| | Minimum | Maximum | Mean ± SD |
|------------------------------------|---------|---------|-------------------|
| Max VO ₂ (ml/kg/min) | 32.00 | 51.70 | 42.68 ± 6.62 |
| Max HR | 163 | 204 | 186.00 ± 11.67 |
| Max RER | 1.02 | 1.35 | 1.19 ± 0.88 |
| Max RPE | 17 | 20 | 18.64 ± 0.79 |

VO2 Data

Main and Interaction Effects

There was a significant main effect when comparing speeds (slow vs. brisk walking) irrespective of tog conditions ($p < 0.001$) There was also a significant main effect when comparing tog conditions irrespective of speeds on the treadmill ($p < 0.001$) Furthermore, when analyzing VO2 data, there was no significant interaction effect regarding speed and togs ($p = .554$). Figure 1 displays the oxygen consumption observed for each speed and tog condition.

Individual Hypotheses

As previously mentioned in chapter one, twenty-four null hypotheses were tested in the present experiment. H_{03} states that “VO2 during the “slow” walk with no Body Togs® will be equal to VO2 during the “slow” walk with Body Togs® on the arms.” The results showed there was no significant difference between these conditions ($p = 0.546$) and therefore we will accept the null hypothesis (i.e., fail to reject) that there is no difference. Additionally, H_{04} states that “VO2 during the “brisk” walk with no Body Togs® will be equal to VO2 during the “brisk” walk with Body Togs® on the arms.” Results indicated no significant difference between these conditions ($p = 0.569$) and therefore we accept the null hypothesis (i.e., fail to reject) that there is no difference.

H_{07} states that “VO2 during the “slow” walk with no Body Togs® will be equal to VO2 during the “slow” walk with Body Togs® on the legs.” A significant difference was found via the results of this present study ($p = 0.008$), and therefore we will reject the null hypothesis. Wearing togs on the legs during a slow walk ($M = 12.0$, $ES = 0.33$) elicited a greater VO2 response than wearing no togs during a slow walk ($M = 11.48$).

Furthermore, H_{08} states that “VO₂ during the “brisk” walk with no Body Togs® will be equal to VO₂ during the “brisk” walk with Body Togs® on the legs.” A significant difference was found between these conditions ($p=0.007$) and therefore we will reject H_{08} . Wearing togs on the legs during a brisk walk ($M=16.52$, $ES=0.43$) elicited a greater VO₂ response than when wearing no togs ($M=15.47$).

H_{011} states that “VO₂ during the “slow” walk with no Body Togs® will be equal to VO₂ during the “slow” walk with Body Togs® on both the arms and legs.” A significant difference was found in the results of the present study ($p<0.001$), and therefore we reject H_{011} . Wearing togs on both the arms and legs during a slow walk ($M=12.59$, $ES=0.69$) elicited a greater VO₂ response than when wearing no togs ($M=11.48$). In addition, H_{012} states that “VO₂ during the “brisk” walk with no Body Togs® will be equal to VO₂ during the “brisk” walk with Body Togs® on both the arms and legs.” A significant difference was found ($p<0.001$) and therefore we reject the null hypothesis of H_{012} . Wearing togs on both the arms and legs during a brisk walk ($M=16.90$, $ES=0.62$) elicited a greater VO₂ response than when wearing no togs during a brisk walk ($M=15.47$).

H_{015} states that “VO₂ during the “slow” walk with Body Togs® on both the arms and legs will be equal to VO₂ during the “slow” walk with Body Togs® on the arms only.” A significant difference was found ($p<0.001$) and therefore we reject the null hypothesis. Wearing togs on both the arms and legs during a slow walk ($M=12.59$, $ES=0.58$) elicited a greater VO₂ response than when wearing togs on the arms only ($M=11.64$). Additionally, H_{016} states that “VO₂ during the “brisk” walk with Body Togs® on both the arms and legs will be equal to VO₂ during the “brisk” walk with

Body Togs® on the arms only.” The results found a significant difference ($p=0.002$) and therefore we reject the null hypothesis. Wearing togs on the arms and legs during a brisk walk ($M=16.90$, $ES=0.50$) elicited a greater VO_2 response than wearing togs on the arms only ($M=15.68$).

H_{019} states that “ VO_2 during the “slow” walk with Body Togs® on both the arms and legs will be equal to VO_2 during the “slow” walk with Body Togs® on the legs only.” A significant difference was found in the results ($p=0.007$) and therefore we will reject the null hypothesis. Wearing togs on both the arms and legs during a slow walk ($M=12.59$, $ES=0.37$) elicited a greater VO_2 response than wearing togs on the legs only ($M=12.02$). Furthermore, H_{020} states that “ VO_2 during the “brisk” walk with Body Togs® on both the arms and legs will be equal to VO_2 during the “brisk” walk with Body Togs® on the legs only.” No significant difference was found in the results of the present study ($p=0.211$) and therefore we will accept the null (i.e., fail to reject) that there is no difference.

H_{023} states that “ VO_2 during the “slow” walk with Body Togs® on the arms will be equal to VO_2 during the “slow” walk with Body Togs® on the legs.” Results found that there is not a significant difference between these conditions ($p=0.215$), and therefore we will accept the null hypothesis (i.e., fail to reject) that there is no difference. Lastly, H_{024} states that “ VO_2 during the “brisk” walk with Body Togs® the arms will be equal to VO_2 during the “brisk” walk with Body Togs® on the legs.” A significant difference was found for this combination ($p=0.002$) and therefore we will reject the null hypothesis. Wearing togs on the legs during a brisk walk ($M=16.53$, $ES=0.33$) elicited a greater VO_2

response than wearing togs on the arms only (M=15.68). Tables 6 and 7 contain the group averages and follow-up test results for the oxygen consumption data, respectively.

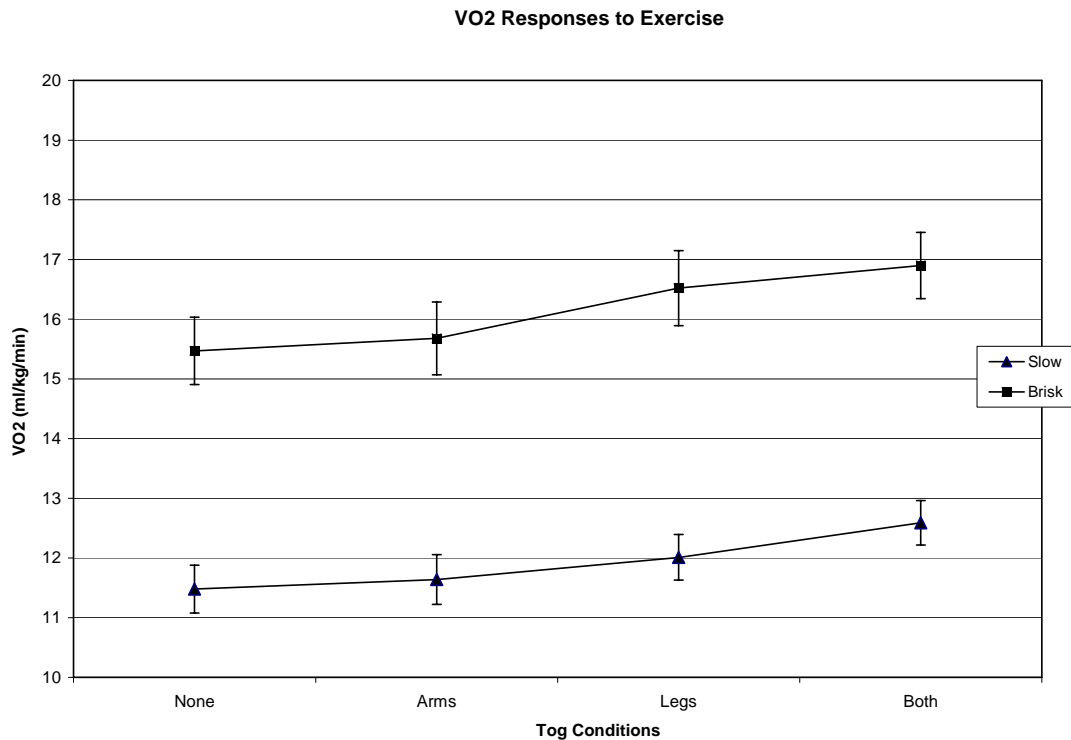
Table 6: VO2 Data: Descriptive statistics (n = 17)

| Condition | Mean \pm SD |
|------------|------------------|
| Slow-none | 11.48 \pm 1.66 |
| Slow-arms | 11.64 \pm 1.72 |
| Slow-legs | 12.01 \pm 1.57 |
| Slow-both | 12.59 \pm 1.54 |
| Brisk-none | 15.47 \pm 2.33 |
| Brisk-arms | 15.68 \pm 2.52 |
| Brisk-legs | 16.52 \pm 2.58 |
| Brisk-both | 16.90 \pm 2.29 |

Table 7: Follow-up Comparisons (VO2)

| Variable 1 | Variable 2 | P-value | Effect Size |
|------------|------------|---------|-------------|
| Brisk-none | Brisk-both | <0.001 | 0.62 |
| Brisk-none | Brisk-arms | 0.569 | 0.09 |
| Brisk-none | Brisk-legs | 0.007 | 0.43 |
| Brisk-both | Brisk-arms | 0.002 | 0.50 |
| Brisk-both | Brisk-legs | 0.211 | 0.16 |
| Brisk-arms | Brisk-legs | 0.002 | 0.33 |
| Slow-none | Slow-both | <0.001 | 0.69 |
| Slow-none | Slow-arms | 0.546 | 0.09 |
| Slow-none | Slow-legs | 0.008 | 0.33 |
| Slow both | Slow-arms | <0.001 | 0.58 |
| Slow-both | Slow-legs | 0.007 | 0.37 |
| Slow-arms | Slow-legs | 0.215 | 0.23 |

Figure 1.



Heart rate data:

Main and Interaction effects

There was a significant main effect when comparing speeds irrespective of tog conditions ($p < 0.001$) in relation to heart rate response. Conversely, no significant main effect was found when comparing tog conditions irrespective of speeds on the treadmill ($p = 0.89$). Furthermore, when analyzing HR data, there was no significant interaction effect regarding speed and togs ($p = .473$). Figure 2 displays the heart rates observed for each speed and tog condition.

Individual Hypothesis

H_{01} stated that “Heart rate during the “slow” walk with no Body Togs® will be equal to heart rate during the “slow” walk with Body Togs® on the arms.” The results of the present study indicate that there was no significant difference between these two heart

rate variables ($p=0.670$), and therefore, we will accept the null hypothesis (i.e., fail to reject) that there is no difference. Also, H_{0_2} stated that “Heart rate during the “brisk” walk with no Body Togs® will be equal to heart rate during the “brisk” walk with Body Togs® on the arms.” The results of the study again indicated that there was no significant difference between these two heart rate variables ($p=0.543$), and therefore we accept the null hypothesis (i.e., fail to reject) that there is no difference.

H_{0_5} stated that “Heart rate during the “slow” walk with no Body Togs® will be equal to heart rate during the “slow” walk with Body Togs® on the legs.” The results indicate there is no significant difference between the heart rates of these variables ($p=0.060$), and therefore we will accept the null hypothesis (i.e. fail to reject) that there is no difference. H_{0_6} states that “Heart rate during the “brisk” walk with no Body Togs® will be equal to heart rate during the “brisk” walk with Body Togs® on the legs.” The results of the present study indicate there is not a significant difference between no togs and togs on the legs during the brisk walking speed ($p=0.233$) and therefore we will accept the null hypothesis (i.e., fail to reject) that there is no difference.

H_{0_9} states that “Heart rate during the “slow” walk with no Body Togs® will be equal to heart rate during the “slow” walk with Body Togs® on both the arms and legs.” The results of the present study indicated no significant differences ($p=0.892$) and therefore we will accept the null hypothesis (i.e., fail to reject) that there is no difference. Additionally, $H_{0_{10}}$ states that “Heart rate during the “brisk” walk with no Body Togs® will be equal to heart rate during the “brisk” walk with Body Togs® on both the arms and legs.” The results of the study showed a significant difference ($p=0.029$) and we will reject the null hypothesis. Wearing togs on both the arms and legs during a brisk walk

(M=118.12, ES=0.31) elicited a greater heart rate response than when wearing no togs (M=114.29)

H_{0 13} states that “Heart rate during the “slow” walk with Body Togs® on both the arms and legs will be equal to heart rate during the “slow” walk with Body Togs® on the arms only.” The results of the study show no significant difference between heart rate during these two conditions (p=0.663), therefore we will accept the null hypothesis (i.e., fail to reject) that there is no difference. Additionally, H_{0 14} states that “Heart rate during the “brisk” walk with Body Togs® on both the arms and legs will be equal to heart rate during the “brisk” walk with Body Togs® on the arms only.” The results show there was no significant difference found (p=0.255) and therefore we will accept the null hypothesis (i.e., fail to reject) that there is no difference.

H_{0 17} states that “Heart rate during the “slow” walk with Body Togs® on both the arms and legs will be equal to heart rate during the “slow” walk with Body Togs® on the legs only.” The results showed no significant difference between heart rate during these conditions (p=0.154) therefore we will accept the null hypothesis (i.e., fail to reject) that there is no difference. Furthermore, H_{0 18} states that “Heart rate during the “brisk” walk with Body Togs® on both the arms and legs will be equal to heart rate during the “brisk” walk with Body Togs® on the legs only.” The results show no significant difference (p=0.630) therefore we will also accept the null hypothesis (i.e., fail to reject) that there is no difference.

H_{0 21} states that “Heart rate during the “slow” walk with Body Togs® on the arms will be equal to heart rate during the “slow” walk with Body Togs® on the legs.” Results showed no significant difference was found (p=0.062) and therefore we will accept the

null hypothesis (i.e., fail to reject) that there is no difference. The final hypothesis regarding heart rate states that “Heart rate during the “brisk” walk with Body Togs® on the arms will be equal to heart rate during the “brisk” walk with Body Togs® on the legs.” Results from the present study indicate no significant difference was found ($p=0.615$) and therefore we will accept the null hypothesis (i.e., fail to reject) that there is no difference. Tables 8 and 9 contain the group averages and follow-up test results for the heart rate data, respectively.

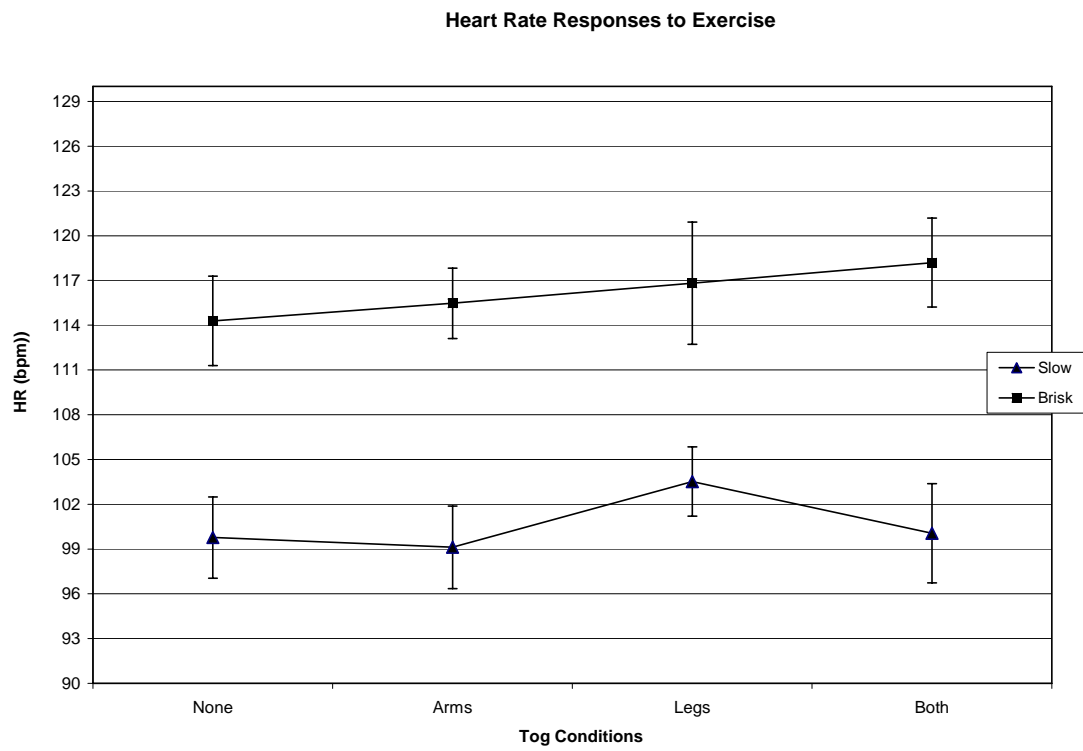
Table 8: HR Data: Descriptive statistics (n = 17)

| Condition | Mean \pm SD |
|------------|--------------------|
| Slow-none | 99.76 \pm 11.24 |
| Slow-arms | 99.12 \pm 11.40 |
| Slow-legs | 103.53 \pm 9.57 |
| Slow-both | 100.06 \pm 13.70 |
| Brisk-none | 114.29 \pm 12.37 |
| Brisk-arms | 115.47 \pm 9.72 |
| Brisk-legs | 116.82 \pm 16.89 |
| Brisk-both | 118.12 \pm 12.28 |

Table 9: Follow-up Comparisons (Heart Rate)

| Variable 1 | Variable 2 | P-value | Effect Size |
|------------|------------|---------|-------------|
| Brisk-none | Brisk-both | 0.029 | 0.31 |
| Brisk-none | Brisk-arms | 0.543 | 0.11 |
| Brisk-none | Brisk-legs | 0.233 | 0.17 |
| Brisk-both | Brisk-arms | 0.255 | 0.24 |
| Brisk-both | Brisk-legs | 0.630 | 0.09 |
| Brisk-arms | Brisk-legs | 0.615 | 0.10 |
| Slow-none | Slow-both | 0.892 | 0.02 |
| Slow-none | Slow-arms | 0.670 | 0.06 |
| Slow-none | Slow-legs | 0.060 | 0.36 |
| Slow both | Slow-arms | 0.663 | 0.07 |
| Slow-both | Slow-legs | 0.154 | 0.30 |
| Slow-arms | Slow-legs | 0.062 | 0.42 |

Figure 2.



Chapter 5

Discussion

The present experiment was designed to examine the cardiovascular and metabolic responses of walking with a novel type of wearable weight called Body Togs®. These particular devices are worn on the forearms and lower legs, which decreases the resistance arm. Because of their practical design, Body Togs® fit around the arms and legs without the need to be carried, making them ideal for use during exercise. Together, arm and leg Body Togs® collectively add about 7.5 extra pounds of resistance in a sleek, flexible fashion, allowing for a comfortable fit underneath clothes. It should also be noted that Body Togs® come in various different sizes to fit all types of statures, but regardless, total weight of the togs remains constant.

Variables measured in the present study included heart rate and oxygen consumption, which were investigated across two intensities (slow and brisk) with four different combinations of Body Togs® (Table 3). The research design included eight balanced experimental trials which incorporated walking for thirty minutes at a self-selected slow or brisk speed with either no togs, arms only, legs only, or both arm and leg togs. Results showed a significant increase in oxygen consumption while wearing Body Togs® during exercise. Wearing these additional weights while walking elicited a linear rise in oxygen consumption, and more specifically, the largest responses were seen during trials with Body Togs® on both the arms and legs. An approximate 10% increase

in energy cost was seen during the “slow” walk when both sets of togs were added to the body. While walking without togs at a “slow” speed, 126 total calories were burned over thirty minutes. With the addition of togs on both the arms and legs, about 13 extra calories were burned throughout the walking trial. Furthermore, a 10% increase in energy cost was also seen when adding arm and leg togs during the “brisk” trials. When walking at a “brisk” speed with no togs, participants burned on average about 169 calories. When arm and leg Body Togs® were added, it resulted in an average of 16 more calories burned over thirty minutes.

Conversely, heart rate did not significantly increase while wearing Body Togs®. A linear pattern in heart rate only resulted during the brisk walking trials, but the increases were minimal and non-significant. Because the scale from resting heart rate to maximal heart rate only increases three-fold, but resting oxygen consumption can have increases of up to fifteen-fold, significant changes in heart rate are more difficult to detect. Though heart rate is frequently used to measure exercise stress levels, it is not commonly used to measure the effects of additional resistance added to exercise (Martin, 1985). According to a study done by Martin (1985), heart rate was consistent with changes in oxygen consumption but was a less sensitive measure of the influence of adding wearable weights. The present study found a similar result, and although the changes seen in heart rate were minimal, they still provide evidence of the metabolic adjustments produced by the addition of Body Togs®. It is unknown at this time why significant increases in heart rate were not seen, but the considerable energy cost increase from Body Togs® is more vital to sedentary individuals working to improve body composition.

There have been a small number of other studies, similar to the present one, which examined the cardiovascular and metabolic responses of wearing additional weights during exercise. Engels et al. (1995) studied a similar sample size while carrying 4.54 kg (9.98 lbs) at the shoulder level. Researchers found small changes in oxygen consumption and only minor changes in heart rate when additional weight was carried during exercise. Overall, the present Body Togs® study supports these findings as we discovered a significant increase in oxygen consumption while wearing togs but only slight changes in heart rate. Graves et al (1987) examined the metabolic responses of exercising with a combined six pounds of hand-held weights. Results reported significant differences in both oxygen consumption and heart rate while carrying the additional weights. Though our study shows increases in both variables, only oxygen consumption was significantly different when wearing Body Togs®. Graves et al. (1988) focused on the metabolic responses of wearing 1.36kg (2.99 lbs) hand, wrist and ankle weights during exercise. The results showed significant increases in heart rate and oxygen consumption, reporting that exercising with the hand weights or wrist weights increased the energy cost of walking more than the ankle weights. Overall, a 14.3% (approximately 1 MET) increase was seen in total energy expenditure. Though exercising with Body Togs did not have as immense an impact on cardiovascular or metabolic responses as the Graves study (1988), the results of the study pose a similar trend.

Our findings show higher oxygen consumption during trials when both the arm and leg togs were worn as opposed to not wearing any additional resistance. Claremont and Hall (1988) also reported that the highest rate of energy expenditure was observed during trials with wearable weights on both the hand and ankles, however this study used

running as a modality, which may have produced higher responses than walking. Martin (1985) also reported that oxygen consumption and heart rate were highest during trials with the most external resistance added. Their participants used running as a modality and weights of 0.50 or 1.00 kg were added during the exercise trials. Though the last two studies differ in methods, the findings by Martin (1995) and Claremont and Hall (1988) were consistent with ours which report that heart rate level was not influenced as significantly as oxygen consumption. Additionally, all the abovementioned studies are in agreement that adding external weights during exercise can lead to increases in these metabolic responses.

The outcome of this study has many valuable implications for exercise prescription. It seems apparent that adding wearable weights to an exercise session increases oxygen consumption which leads to an increase in caloric expenditure. This response is ultimately the goal of most overweight individuals. With obesity and physical inactivity levels continuing to rise in our country, Body Togs® can provide a means for previously sedentary individuals to achieve the recommended energy expenditure each day. Since the present study observed that oxygen consumption increased even during the “Slow” walking speed, individuals can wear the togs underneath their clothes while going about their daily activities, still continuing to burn more calories. Body Togs® can also give more options to those individuals with physical limitations who desire a more intense workout. Both the present and past research shows that using this type of product will allow individuals to increase their energy cost while walking. Therefore, those individuals who cannot participate in other modalities such as running can still achieve the appropriate intensity recommended by health professionals.

Taken as a whole, the results of the present study support many previous findings that exercising with additional resistance added to the extremities produces a greater metabolic response. Though the responses from Body Togs® may only represent small changes, it is still a practical application in a society that is growing more sedentary with each passing day. An article written by James O. Hill (2009) suggested that one way to address the current obesity epidemic is to promote small changes in both diet and physical activity to prevent further weight gain. Body Togs® can help to implement these small but vital changes. There has continuously been a lack of success seen from most overweight individuals, mostly due to the discouragement they experience from the amount of maintenance required to stay healthy and fit. Small changes such as what was observed while wearing Body Togs® during exercise can be more easily achieved, leading to higher self-efficacy in the exerciser. Over time, even small changes can have a major impact on regulation and maintenance of body composition. As stated in the article by James O. Hill (2009), regardless of someone's weight, further weight gain can be prevented by making small increases in physical activity. Therefore, a useful application of this research study is that Body Togs® can provide minimal but significant increases in metabolic responses during exercise, hopefully allowing overweight sedentary individuals to begin to make small changes in their daily energy expenditure.

One obvious limitation of this study is that we are solely looking at a low-risk healthy population of adults ages 20-45, therefore the findings cannot be generalized to other groups such as the elderly, adolescent or hypertensive. Additionally, the Body Togs® product is designed to implicate small changes for those individuals who are sedentary, and may not provide a large metabolic response due to the little amount of

weight that they add. Therefore, the metabolic machine used in the present study may have had difficulty in consistently reporting such a sensitive amount of change in oxygen consumption. Recommendations for future research include experimenting with individuals of different fitness levels and also testing the product on overweight or obese participants. Furthermore, it may be necessary to test this product during a more intense exercise modality such as running or cycling to see if Body Togs® can improve fitness levels when used as a compliment to a regular exercise session.

In summary, the metabolic responses of wearing external resistance during walking exercise significantly increased during trials with both the arm and leg Body Togs® worn. Wearing the togs on the arms and legs burns an additional 13 and 16 calories over the 30 minute session, eliciting an approximate 10% improvement over exercise sessions when no togs were worn. Cardiovascular responses were not significantly increased by wearing the togs, but an important and significant increase in oxygen consumption and caloric expenditure did occur at both the slow and brisk speeds, making Body Togs® a practical and useful tool to implement into the fitness industry.

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