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The impact of wearable weights on perceptual responses to treadmill walking

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The Impact of Wearable Weights on Perceptual Responses to Treadmill Walking

by

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A thesis submitted in partial fulfillment
of the requirements for the degree of
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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. 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 psychological 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, mean BMI = 25.0) healthy volunteers were tested for aerobic fitness on a treadmill to determine VO₂ max (mean = 44 ml x kg⁻¹ x min⁻¹). Participants then completed eight 30-minute walking trials on a treadmill while three ratings of perceived exertion (RPE – overall, RPE - chest and breathing, and RPE - legs) 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 pairwise

comparisons. Analyses revealed RPE overall was significantly elevated ($P < 0.05$), as was RPE of the legs ($p < 0.05$) while wearing upper and lower weights in the brisk walk trial but not in the slow walk trial. CONCLUSIONS: Findings suggest that exercising while using wearable weights increases RPE for the legs and overall only during the faster walking trials. PRACTICAL APPLICATIONS: This finding suggests that physical activity associated with daily living could be enhanced through the wearing of weights that can be worn under clothing without increasing perceptions of effort. In contrast, findings relative to brisk walking suggest that any beneficial increase in energy expenditure is potentially offset by significantly increased effort.

Chapter One

Introduction

Rationale

The current state of health in this nation is a crisis of great consequence and one that must be altered. Specifically, the prevalence of obesity is a problem of monumental proportion. While obesity alone is an epidemic, the sedentary lifestyle that equally prevails is a condition that will only exacerbate present circumstances. One solution remains and has the capabilities to resolve both dilemmas. Increased energy expenditure through exercise serves to assist with the elimination of the obese and sedentary lifestyle epidemics. Reputable organizations, political figures and the surgeon general have all recommended and encouraged physical activity. Yet, the recommendations set forth and the impending detriment that will ensue due to physical inactivity have not been catalysts to increase physical activity. The existence practiced by humans in days gone past is one that required larger amounts of energy expenditure. However, the technological advancements implemented within modern day society have eliminated the majority of the physical demands that were once imposed. Therefore, the current crisis presents that physical activity must be orchestrated back into the lives of every individual. The especially low rates of physical activity participation among Americans clearly indicate that exercise is likely viewed as unimportant, inconvenient and unpleasant. Exercise alone can resolve the low energy expenditure issue, yet new and innovative methods to

increase exercise participation are imperative, that exercise may become more appealing and beneficial (Pollock, et al., 1998).

Purpose

An abundance of physiological and psychological benefits are provided by regular engagement in physical activity. Despite the excessive benefits exercise provides, the majority of adult Americans live a sedentary and overweight/obese existence. Current epidemiological data attest to this reality. A sedentary lifestyle has revealed itself to be the most prevalent risk factor for premature mortality. Epidemiological data also support that a physically inactive lifestyle is among the leading three causes of death in the United States. While it is common knowledge that exercise is a vital component to a healthy lifestyle, this knowledge has not changed behavior. Thus, the present epidemic has presented itself to the nation and has produced the existing health crisis. In 1995, the Centers for Disease Control and Prevention along with the American College of Sports Medicine collaborated and produced physical activity recommendations. These recommendations were published with the hope that they would improve the health of the public. The intention of the instruction formulated in 1995 by these two organizations was to provide clear and concise exercise recommendations. The Centers for Disease Control and Prevention and the American College of Sports Medicine understood that the public had a misperception of the mode and intensity of the exercise that would produce health benefits. The public health message provided by these organizations was set forth to communicate how much and what kind of exercise to do and to provide leadership to the public in this area. Prior to the exercise recommendations of 1995, many people

assumed that exercise had to be both vigorous and continuous in order to bring about health benefits. The CDC and ACSM provided recommendations that refuted this assumption. “Every US adult should accumulate 30 minutes or more of moderate-intensity physical activity on most, preferably all, days of the week” (Russell, 1995, p. 404). This instruction was supported by an abundance of epidemiological data, which attested to how moderate intensity exercise is also of great benefit. Thus, the movement to increase physical activity participation began by altering previous recommendations with the hope that the new and more attainable recommendations would cause an increase in physical activity participation. While the recommendations in 1995 elicited a movement towards more practical and achievable exercise guidelines, the efforts of the CDC and ACSM failed to provoke the public to become more physically active. The 1995 recommendations set the stage for a shift in the exercise guidelines (Pate, et al., 1995). In 2005, one decade after the CDC and ACSM physical activity recommendation, a collection of data revealed that nearly one-quarter of adults in the United States reported no leisure-time physical activity. This data from 2005 also attested that less than half of adults in the United States met the exercise recommendation provided in 1995. Epidemiological data offers further reason as to why it is essential for individuals to lead physically active lifestyles. While the majority of Americans are sedentary, the majority of Americans are also overweight/obese. A sedentary lifestyle places an individual at increased risk of developing diseases such as cardiovascular disease and cancer, both of which are leading causes of death. A physically active lifestyle serves as disease prevention and provides greater quality of life (Haskell, et al., 2007).

In 2007 the American College of Sports Medicine and the American Heart Association created revised exercise guidelines that would further the objectives of the CDC and ACSM as provided in 1995. The updated recommendation of 2007 as provided by ACSM and AHA was created to offer more specific recommendations and to complement the exercise recommendations provided in 1995. Perhaps the greatest benefit provided by the 2007 physical activity update, are the clarifications to the 1995 recommendations that it offers. The “clear and concise” public health message of 1995 is expounded upon within the 2007 update (Haskell, et al., 2007). It should be said that the clarifications within the 2007 physical activity update endow the public with further clear direction regarding exercise frequency, mode and intensity. A succinct summary of the clarifications to the 1995 recommendation is as follows:

- The 2007 update specifies that individuals should engage in exercise a minimum of five days each week.
- Vigorous exercise is included as an option for those who opt to exercise at this intensity.
- A combination of both moderate and vigorous exercise is suggested as to provide a variety of activities.
- The recommended amount of exercise (specifically aerobic exercise) is additional to the routine activities of daily living.
- Physical activity performed in amounts larger than the recommendation will yield greater health benefits.
- 30 minutes of exercise need not be performed continuously, but can be accumulated in shorter bouts for as little as 10 minutes.

- Muscular strength exercises were added to the recommendation, 8-10 exercises performed on two or more nonconsecutive days each week incorporating all of the major muscle groups.
- Lastly, the language within the exercise recommendation has been altered to conspicuously differentiate between aerobic and muscular strength exercise (Haskell, et al. 2007).
- As of 2007, the public was provided with specific, practical and applicable exercise recommendations.

Both the 1995 and 2007 recommendations serve to increase physical activity levels among a largely sedentary population. Over the course of more than a decade, these publications have elicited a shift in physical activity guidelines. Despite the collaborative efforts of the various reputable organizations involved (ACSM, CDCP, and AHA) in the composition of the rendered recommendations, physical activity participation levels remain ostensibly low. It is unfortunate that the conferred public health messages have not boosted physical activity participation. Although past efforts have not yielded significant results, current and future endeavors must continue to improve the health of the nation.

It is indisputable that physical activity produces health benefits. Yet, obtaining physical activity is an incessant struggle every American adult seems to encounter. The most common lifestyle is one that is not conducive to physical activity. Technology has reduced the energy required for the activities of daily living and the occupations with the largest salaries are those that are the most sedentary. Thus, the present overweight/obese and sedentary lifestyle epidemic is the unfortunate outcome. The physical activity and

epidemiological data are disheartening and present the health and fitness field with reason to continue conducting research that creates new methods to increase participation in physical activity. The 2007 physical activity recommendations update made mention that two perceptions regarding physical activity are prevalent among Americans. Many individuals believe that physical activity must be vigorous to provide health benefits, and others believe that light activities of daily living are enough activity to provide health benefits. While both of these perceptions are false, they still persist. Past efforts have not been enough to diminish these perceptions nor have they induced increases in physical activity. Novel and inventive methods relative to physical activity are needed to issue change in this nation. A product by the name of Body Togs®, comfortable, wearable weights has recently made its way into the area of exercise science research. These easy to wear weights can be worn during routine activities of daily living, during leisure time physical activity, and also throughout planned exercise regimens. Body Togs® are wearable resistance, which serve to increase caloric expenditure without causing increases in perceived exertion. The ensuing research study investigates the effects of Body Togs® on various physiological and psychological variables during slow and brisk treadmill walking.

Objectives

The following objectives will be assessed in the present research study:

1. Determine the efficacy of Body Togs® within a controlled laboratory environment.

2. Determine the perceptual responses elicited by incorporating Body Togs® during slow and brisk walking on a treadmill.
3. Determine changes in perception related to three differentiated RPE's, chest and breathing, legs, and overall, as a result of implementation of the Body Togs®.

Hypotheses

1. The Body Togs® while worn during slow and brisk treadmill walking will cause increases in energy expenditure and heart rate without causing a change in the rate of perceived exertion.
2. Body Togs® will be efficient and practical to use during planned slow and brisk treadmill walking.
3. Body Togs® will be practical and applicable to implement within the realm of health and fitness.

Limitations

1. Participants within the general and healthy population are being used, therefore the results will not be applicable to other populations.
2. The efficacy of the Body Togs® product is unknown as the product is new and has not yet been tested.

Chapter Two

Review of Literature

Physical activity is low among Americans and, as a result, energy expenditure has also reached seemingly low levels. Past research has incorporated wearable weights to alter physiological responses and has mildly assessed perceptual responses during planned aerobic exercise regimens. Exercise science research from the late 1980's to the middle of the 1990's incorporated wearable resistance during walking and running. During this time, a popular trend was to incorporate some type of weights into aerobic exercise. Companies would often market their weights by claiming that caloric expenditure during aerobic exercise could increase by as much as 300% if their product was implemented. Post-1990's research using wearable weights was abandoned. It is essential to conduct more and current research that incorporates wearable weights as other variables exist which have not been evaluated. While the proposed study will implement Body Togs® during treadmill walking, a review and understanding of past research conducted using wearable/handheld resistance is a necessary pre-requisite. A study conducted by Graves et al. (1988) included twelve previously sedentary men between the ages of 18 and 23. The purpose of the study was to examine physiological responses, specifically hemodynamic and energy expenditure, as a result of the implementation of hand weights, wrist weights, and ankle weights. Hemodynamic evaluation was accomplished via three submaximal treadmill tests. Each of the three tests

was performed with one of the various types of weights. All tests were performed with a minimum of 48 hours between them and all conditions were randomly assigned. Energy cost of the various types of weights was measured using four separate 8-minute exercise trials. One trial was completed with no weights, one with hand weights, one with wrist weights, and one with ankle weights. These exercise trials were all completed at 60% of heart rate maximum reserve. The results of this study revealed that hemodynamic differences only exist if hand weights are used. The only distinct difference that existed was an increase in diastolic blood pressure and this existed only for the hand weight submaximal exercise test. Relative to energy expenditure, it was found that the implementation of hand weights, wrist weights and ankle weights yields a 14.3% increase in energy expenditure when compared to the no weight exercise trials. Throughout the various exercise trials rate of perceived exertion (RPE) was assessed. An interesting and reputable finding of this study is that while energy expenditure for all of the weighted conditions was greater than the no weight condition, no change in RPE was found. While the hemodynamic findings of this study are not relevant to the proposed study, the energy expenditure and RPE results are of particular benefit. It is encouraging to the study at hand that no change in RPE existed for any of the weighted exercise trials. A second study relevant in this review of literature is one that was conducted by Martin (1985). This study examined mechanical and physiological responses when weight was added to the lower extremities during running. The study incorporated fifteen healthy male long-distance runners with an average age of 29. Five different load conditions were utilized in this study. The different loaded conditions included: 1) a baseline condition in which no load was added, 2) 0.25 kg added to each thigh, 3) 0.25 kg added to each foot, 4) 0.50 kg

added to each thigh, 5) 0.50 kg added to each foot. All conditions were accomplished via running on a treadmill. Changes in oxygen consumption, heart rate and body mechanics were all measured. For all loaded conditions, both oxygen consumption and heart rate increased significantly. Relative to mechanical work increases, no changes were found in the mechanics of the shank of the leg or the foot as a result of added loads. However, the mechanical work of the thigh increased by 9.5% with the heaviest loaded condition when compared to baseline conditions. A secondary finding of this study is that the metabolic cost of running increased by a maximum of 15%. While RPE was not assessed, the increase in energy expenditure as a result of added load is expected and relevant to the Body Togs® research. This finding is also consistent with the finding of the previously reviewed study. In a study conducted by Claremont and Hall (1988), similar, but not identical variables, when compared to the Martin study were assessed. This study examined the effects of extremity loading upon energy expenditure and running mechanics. Five males and three females with an average age of 42 were selected to participate in this study. All participants had regularly included running in their personal exercise regimens for many years and thus were experienced with the selected mode of exercise. The loaded exercise trials were 30 minutes in duration and were performed at each participant's self-selected pace. Four different conditions existed: 1) a no-load, control run, 2) carrying barbell hand-weights weighing 0.45 kg for women and 0.90 kg for men, 3) 0.45 kg weights strapped to each ankle, 4) carrying both hand and ankle weights totaling 0.98 kg for women and 2.7 kg for men. Relative to the kinematic findings of this study, results were consistent with the study conducted by Martin. Little to no changes were found in the body mechanics involved in running despite added loads.

Energy expenditure increased by a maximum of 8% as a result of the highest loaded condition. The results described here are relevant to the present research study in that the loaded conditions implemented are similar to the conditions that will be used with Body Togs. It is also a positive finding that added loads do not compromise body mechanics and likely prove that the Body Togs® will be safe and effective. However, this study fails to incorporate RPE relative to all of the various loaded trials. Another study of relevance within this review of the literature is a study that was conducted by Rodgers, Vanheest, and Schachter (1995). This study evaluated energy expenditure during submaximal walking with Exerstriders®. Exerstriding is a form of walking that is modified by the incorporation of specially designed walking sticks (Exerstriders®). It is important to mention that each Exerstrider® weighed approximately 13-14 ounces, a total of an additional two pounds. Ten moderately active females participated in this study. All participants received training in Exerstrider® use prior to the study. Each participant completed two randomly assigned trials. Both trials completed were two, 30 minute treadmill walking trials one of which included the Exerstriders® while the other trial did not. Throughout each exercise trial, expired air was collected for two minute periods in Douglas bags using open circuit spirometry. VO₂ and RER were calculated to account for overall caloric expenditure during both exercise trials. RPE was also obtained every two minutes using the original Borg 6-20 scale. Exercise trials were separated by a minimum of 48 hours and were conducted at the same time of day. Results yielded that the average heart rate during walking with the Exerstriders® was 132 bpm while walking without the Exerstriders® yielded an average heart rate of 121 bpm. There was no significant difference in RPE relative to the two exercise conditions. The results of this

study are similar to the findings discussed in all of the previously reviewed studies. Energy expenditure increased (an average of 5.8 kilocalories per minute) as a result of the Exerstriders® while RPE remained unchanged. This study is significantly relative to the Body Togs® research in that it incorporated a novel device rather than just implementing traditional hand or ankle weights. It also reveals that once again, caloric expenditure can increase without any change occurring in RPE. Increases in energy expenditure absent of changes in RPE allow the time spent in exercise to be of greater benefit. A final study to be reviewed examined the metabolic and hemodynamic responses to walking with hand weights in older individuals (Evans, et al., 1994). The participants in this study were 19 physically active males and females between the ages of 60 and 70. All were free of cardiovascular diseases and were not taking medication that would interfere with heart rate and blood pressure during exercise. All participants were allowed to practice walking on the treadmill prior to participation in the study. Additionally, two separate speeds were assigned to each participant. Each participant was given the opportunity to select a speed and a second speed was assigned via 70% of heart rate reserve as determined by the Karvonen formula. Participants performed each exercise trial for ten minutes at the self-selected speed and for ten minutes at the 70% of heart rate reserve speed. Each exercise trial was randomly assigned using four various conditions: 1) no weight ,2) 0.45 kg hand weights, 3) 1.36 kg hand weights, 4) 2.27 kg hand weights. Expired gases were collected every 60 seconds and were used to determine oxygen uptake, ventilation and the respiratory exchange ratio. RPE was also assessed during the last ten seconds of each minute of exercise. Blood pressure was measure via traditional auscultation using a sphygmomanometer and was taken at rest and every two minutes during exercise trials.

The results of the study yielded no difference between self-selected speed and 70% of heart rate reserve speed for heart rate, oxygen consumption, ventilation, systolic blood pressure, and diastolic blood pressure. Therefore, it was concluded that any changes were as a result of the addition of the hand weights. Heart rate increased significantly across all four exercise conditions. Both systolic and diastolic blood pressure increased for all of the weighted conditions when compared to the no weight trial. Additionally, hand weights had to be 1.36 kg or greater in order to create increases in VO₂. Also, metabolic increases as great as 18.9% occurred as a result of the hand weights. Changes in RPE did occur as a result of the added hand weights. However, the highest RPE was 12 and this was found only during the 2.27 kg hand weight trial. Thus, it can be concluded that while RPE did change, the work being performed by the participants was perceived to be light. The researchers in this study concluded that the addition of hand held weights does not alter RPE. Finally, this study confirmed the various findings of the previously reviewed studies. It is significant that an older population was used for this study, as this is something to consider using in future research endeavors. All in all, the various findings not only support the hypotheses of the Body Togs® Research study, but support the need for the assessment of the other variables that have yet to be addressed in past research.

Chapter Three

Methodology

Participants

Twenty five men and women aged 18-45 years were recruited (mean age = 24.2 ± 5.92 years, mean height = 66.9 ± 3.50 inches, mean BMI = 25.0 ± 4.12). Each participant provided informed consent and completed a health status questionnaire, to determine risk stratification, and completed a physical exam administered by a sports medicine physician in accordance to standard guidelines.

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.

Table One – 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 togs
4-11	Experimental exercise trials

Screening (Visit 1)

Each participant was screened for participation based on established criteria. The screening included a comprehensive health history, pre-participation in a physical exam administered by a physician, completion of the informed consent document, assessment of resting heart rate and blood pressure, and assessment of body composition by way of skinfold calipers.

Maximal Exercise Testing (Visit 2)

Each participant completed a maximal treadmill test that included measurements of heart rate, blood pressure, perceived exertion, and metabolic gas exchange. The protocol that was utilized was a ramp-style test that began with a slow walk and increased in speed each minute by 0.5 miles per hour until volitional exhaustion.

Workload Establishment and Familiarization (Visit 3)

Each participant was asked to walk on the treadmill to determine the exercise intensity for subsequent exercise trials. One workload corresponded to a “slow walk” which was designed to replicate walking that is associated with activities of daily living. The second workload corresponded to a “vigorous walk” which was designed to replicate walking that is purposeful and associated with fitness. Workload establishment of the two separate speeds took place over a 30 minute time period with 15 minutes designated to each walking speed. Collectively, the two workloads were self-selected and were 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 leg and wrist. 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. Workload establishment and familiarization was determined via the following script and was delivered by the research team.

Prior to slow walking speed selection:

“It is important for you to remember that the walking speed you select should be the equivalent of a slow walk. It is also essential for you to keep in mind that you will have to maintain this speed for a duration of 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 desired to reduce or increase the previously selected speed they did so at this time. Otherwise this was the “slow walk” speed that was be maintained throughout the entire research study.

Prior to brisk walking speed selection:

“It is important for you to remember that the walking speed you select should be the equivalent of a brisk walk. It is also essential for you to keep in mind that you will have to maintain this speed for a duration of 30 minutes. 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 brisk walk?” If participant desired to reduce or increase the previously selected speed they did so at this time. Otherwise this was the “brisk walk” speed that was maintained throughout the entire research study.

Experimental Exercise Trials (Visits 4-11)

The eight experimental trials allowed for both exercise conditions/intensities to be tested across four equipment conditions/combinations. The two exercise conditions 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 combinations included: no togs, leg and arm togs, arm togs only, and leg togs

only. Each experimental exercise trial lasted for 30 minutes in an effort to replicate the duration recommended by current physical activity guidelines. Heart rate was measured continuously. Oxygen consumption was measured from minute 24 to minute 29. Exertion was assessed every six minutes during the trial. It should be noted that from minute 24 through minute 29, exertion was not assessed. At 29 minutes and 45 seconds the last measure of exertion was reported. Exertion was assessed again after the completion of exercise. All trials were organized into balanced sequences for participants relative to speed and tog conditions.

Table 2 – Exercise Trial Conditions

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

Protocol Description

Prior to each exercise trial, the metabolic cart was properly calibrated. A polar heart rate monitor was supplied to each participant upon arrival to the laboratory. Brief instruction was provided on where to place the heart rate monitor and how to wear it correctly. A warm-up of 30 seconds preceded every exercise trial. At the conclusion of the warm-up the treadmill was adjusted to either the slow or brisk walking speed as previously determined. Every 6 minutes rate of perceived exertion was assessed. At minute 24 of the exercise trial the air cushion mask was placed on the participant.

Expired metabolic gases were collected from minute 24 to minute 29. At minute 29, the air cushion mask was removed. At 29 minutes and 45 seconds a final rate of perceived exertion was recorded. At 30 minutes the exercise trial concluded and a 30 second cool-down with an intensity equal to that of the warm-up transpired.

Instrumentation

Variables of interest during exercise included: heart rate, perceived exertion, and oxygen consumption. Heart rate (HR) was measured using a Polar™ heart rate monitor (Polar, USA). Rating of perceived exertion (RPE) was measured with Borg's CR-10 scales (Borg, 1998). This scale allows for the differential assessment of exertion reflecting overall, legs, and chest. Assessment of exertion in this manner allowed for inspection of how the various tog conditions differentially impacted various aspects of effort sense. Oxygen consumption was measured by way of open circuit spirometry.

Research Design and Data Analysis

The research design utilized a 2 (intensity: slow walk and brisk walk) x 4 (equipment: no togs, arm and leg, leg only, arm only) repeated measures ANOVA. Each participant served as their own control. The table below depicts the basic design features. Main and interaction effects were followed by dependent t-tests. Criterion for significance for all tests was set at $p < 0.05$. The sample size was based on basic power calculations and related literature. While a smaller sample size may have been plausible for physiological variables where larger effects can be expected, perceptual variables tend

be have smaller effect sizes and require a larger sample size. Exact p-values are reported that the reader may use discretion and take heed to possible Type 1 error.

Inclusion/Exclusion Criteria

All participants were low risk according to ACSM's Guidelines for Exercise Testing and Prescription which requires absence of cardiovascular, metabolic, and pulmonary disease or related symptoms (ACSM, 2006). Participants' age ranged from 18 to 45 years. Physical activity/fitness status and body mass index was not utilized as inclusion/exclusion criteria. The design instead allowed any range of activity and weight status.

Chapter Four

Results

Graded Exercise Testing

All participants completed a graded maximal exercise test on a treadmill. A maximal effort is indicated by 90% of age predicted maximal heart rate, an RER of 1.15 or greater and an RPE of 19 (on the 6-20 scale). All must be achieved for the exercise test to qualify as a maximal effort. The mean data indicate that the conducted maximal exercise tests were a maximal effort ($VO_2 = 42.7 \text{ mL} \times \text{kg}^{-1} \times \text{min}^{-1} \pm 6.62$). Maximal heart rate ($186 \pm 11.7 \text{ beats} \times \text{min}^{-1}$) met the criterion for a maximal effort based on age (90% of age predicted maximal heart rate). Peak respiratory exchange ratio ($\text{RER} = 1.19 \pm 0.09$) was above the criterion of 1.15 for a maximal effort. Peak RPE (18.6 ± 0.79) was equal to the criterion of 19 (6-20 scale) for maximal effort. Collectively, it can be inferred as illustrated by the heart rate, RER, and RPE that a maximal effort was obtained.

Self-Selected Speed

The average self-selected slow speed was $2.6 \pm 0.36 \text{ mph}$. The minimum slow speed selected was 2.0 mph and the maximum slow speed selected was 3.2 mph. The average self-selected brisk speed was $3.5 \pm 0.30 \text{ mph}$. The minimum brisk speed selected was 2.9 mph and the maximum brisk speed selected was 4.0 mph. T-tests indicate that the two self-selected speeds were significantly different ($p < 0.00$; $ES = 2.56$).

Rate of Perceived Exertion

Within the study design, rate of perceived exertion (RPE) was assessed via the Borg 6-20 scale. However, the present study implemented RPE as a differentiated measure. RPE was assessed separately for the chest and breathing, the legs, and overall. The purpose of the differentiated RPE was to determine a variety of different perceptual responses related to different regions of the body. The Body Togs® are worn on the arms and the legs and specific perceptions of exertion as opposed to simply general exertion were pertinent to the research study.

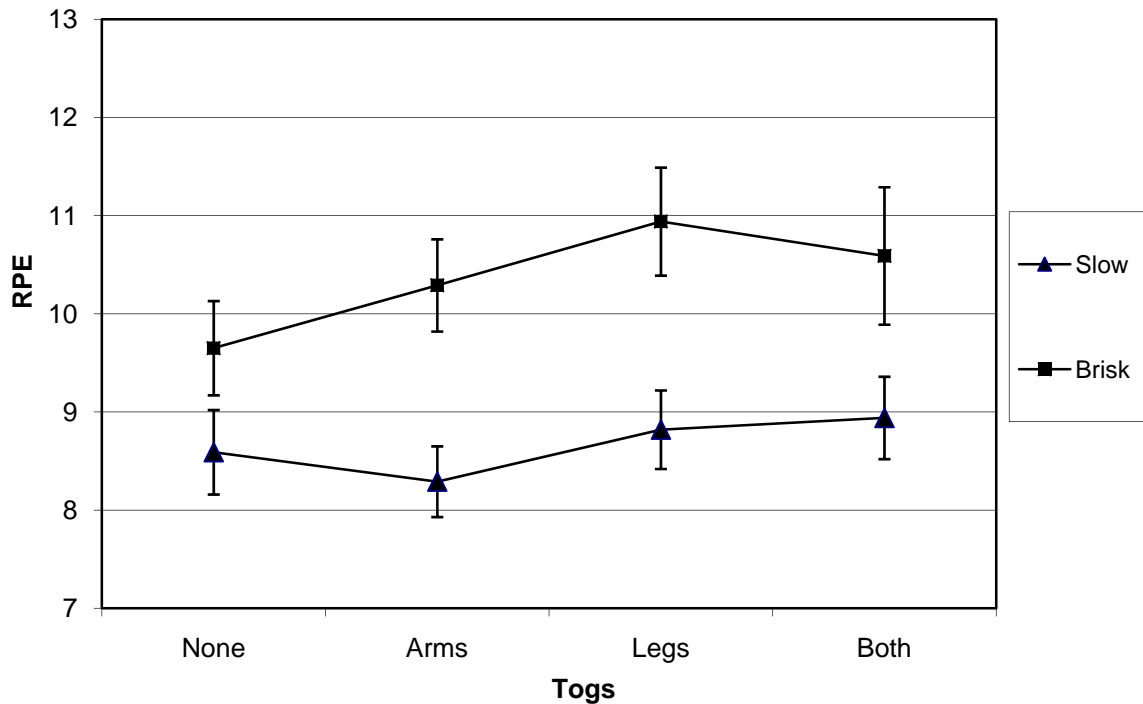
RPE - Overall

For the variable of RPE – overall, results indicate that there was a significant main effect for speed ($p < 0.001$). A significant main effect also existed for differences in Body Tog® conditions for RPE - overall ($p = 0.014$) (see Figure 1). A significant interaction effect was not found ($p = 0.174$). The data indicate that participants experienced higher levels of overall exertion at the brisk speeds than at the slow speeds. Furthermore, participants also experienced higher levels of overall exertion when wearing the Body Togs®. Follow-up dependent t-tests yielded significant p-values for comparison of trials at a brisk speed with no togs compared to trials at a brisk speed with leg togs ($p = 0.018$; $ES = 0.62$) and for trials at a slow speed with both togs compared to trials at a slow speed with arm togs ($p = 0.029$; $ES = 0.40$) (see Table 3 and Figure 1).

Table 3 Rate of Perceived Exertion - Overall

Variable 1	Mean/SD1	Variable 2	Mean/SD2	P-value	Effect size
Brisk None	9.65 ± 1.97	Brisk Both	10.59 ± 2.87	.108	.39
Brisk None	9.65 ± 1.97	Brisk Arms	10.29 ± 1.93	.135	.33
Brisk None	9.65 ± 1.97	Brisk Legs	10.95 ± 2.28	.002	.62
Brisk Both	10.59 ± 2.87	Brisk Arms	10.29 ± 1.93	.463	.13
Brisk Both	10.59 ± 2.87	Brisk Legs	10.94 ± 2.28	.303	.14
Brisk Arms	10.29 ± 1.93	Brisk Legs	10.94 ± 2.28	.127	.31
Slow None	8.59 ± 1.77	Slow Both	8.94 ± 1.75	.370	.20
Slow None	8.59 ± 1.77	Slow Arms	8.29 ± 1.49	.206	.18
Slow None	8.59 ± 1.77	Slow Legs	8.82 ± 1.63	.410	.14
Slow Both	8.94 ± 1.75	Slow Arms	8.29 ± 1.49	.029	.40
Slow Both	8.94 ± 1.49	Slow Legs	8.82 ± 1.75	.768	.07
Slow Arms	8.29 ± 1.49	Slow Legs	8.82 ± 1.63	.108	.34

Figure 1. RPE Overall



RPE – Chest and Breathing

The variable of RPE – chest and breathing revealed a significant main effect for speed ($p < 0.001$) but not for Body Togs® conditions ($p = 0.058$) (see Figure 2).

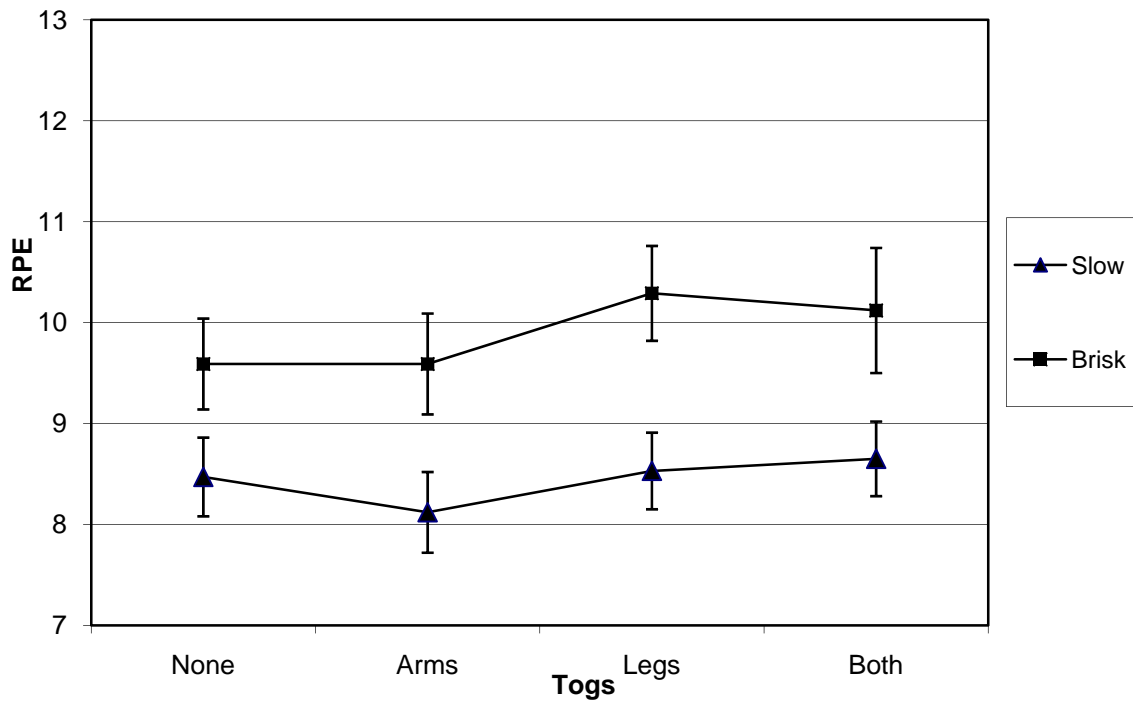
Additionally, no interaction effect was found for RPE – chest and breathing ($p = 0.657$).

Thus, participants experienced higher levels of exertion in the chest and breathing during the brisk speed exercise trials as compared to the slow speed exercise trials. While higher levels of exertion were experienced in the chest and breathing due to an increase in speed, the addition of the togs did not produce higher levels of exertion in this region. Follow-up dependent t-tests were conducted and were significant for exercise trials conducted at a brisk speed with no togs compared to trials at a brisk speed with leg togs ($p = 0.018$; $ES = .018$) and for exercise trials conducted at a slow speed with leg and arm togs compared to trials conducted at a slow speed with arm togs ($p = 0.034$; $ES = .034$) (see Table 4 and Figure 2).

Table 4 Rate of Perceived Exertion – Chest and Breathing

Variable 1	Mean/SD1	Variable 2	Mean/SD2	P-value	Effect Size
Brisk None	9.59 ± 1.84	Brisk Both	10.12 ± 2.55	.326	.24
Brisk None	9.59 ± 1.84	Brisk Arms	9.59 ± 2.06	1.000	.00
Brisk None	9.59 ± 1.84	Brisk Legs	10.29 ± 1.93	.018	.37
Brisk Both	10.12 ± 2.55	Brisk Arms	9.59 ± 2.06	.236	.23
Brisk Both	10.12 ± 2.55	Brisk Legs	10.29 ± 1.93	.661	.08
Brisk Arms	9.59 ± 2.06	Brisk Legs	10.29 ± 1.93	.111	.35
Slow None	8.47 ± 1.62	Slow Both	8.65 ± 1.54	.565	.11
Slow None	8.47 ± 1.62	Slow Arms	8.12 ± 1.65	.111	.21
Slow None	8.47 ± 1.62	Slow Legs	8.53 ± 1.55	.805	.04
Slow Both	8.65 ± 1.54	Slow Arms	8.12 ± 1.65	.034	.33
Slow Both	8.65 ± 1.54	Slow Legs	8.53 ± 1.55	.707	.08
Slow Arms	8.12 ± 1.65	Slow Legs	8.53 ± 1.55	.130	.26

Figure 2 RPE – Chest and Breathing



RPE - Legs

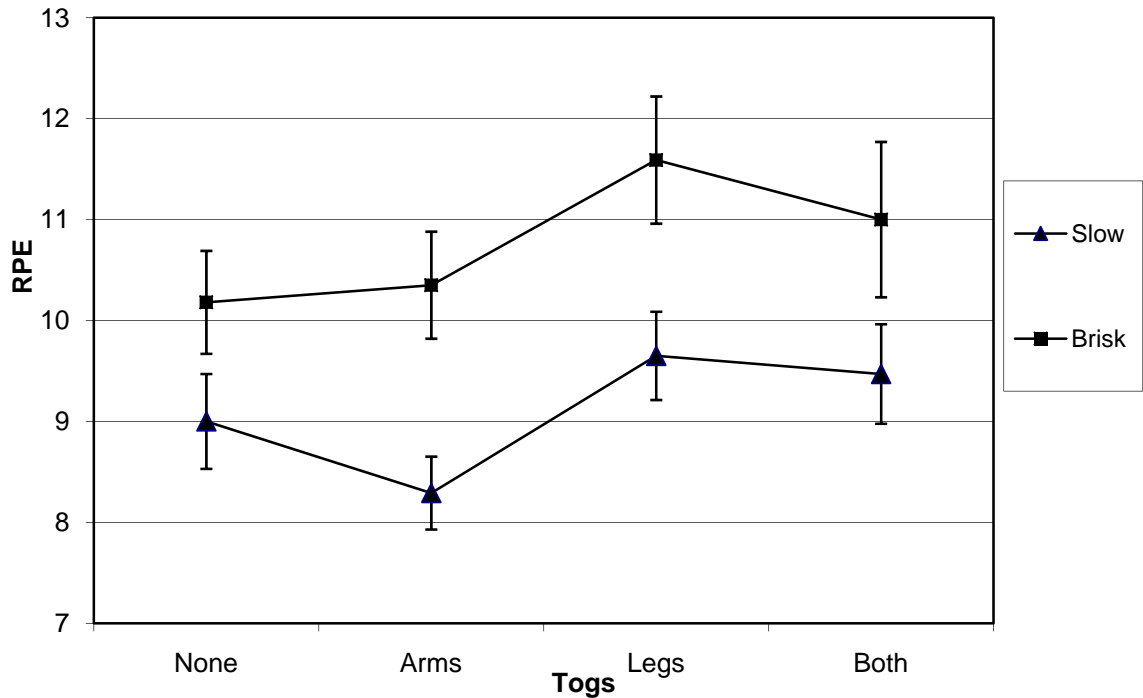
The variable of RPE – legs also revealed a significant main effect for speed ($p = 0.002$) and for Body Togs conditions ($p < 0.001$) (see Figure 3). However, no interaction effect was found for RPE – legs ($p = 0.375$). At the brisk speeds the exertion of the legs was greater than that of the slow speeds. When the Body Togs® were worn the exertion of the legs was also greater. Dependent t-tests were conducted and proved to be significant for exercise trials conducted at a brisk speed with no togs compared to trials conducted at a brisk speed with leg togs ($p = 0.002$; $ES = .37$), brisk speed with arm togs compared to the brisk speed with leg togs ($p = 0.007$; $ES = .35$), slow speed with no togs compared to the slow speed with arm togs ($p = 0.023$; $ES = .21$), slow speed with leg and arm togs compared to the slow speed with arm togs ($p = 0.004$; $ES = .33$), and slow

speed with arm togs compared to the slow speed with leg togs ($p = 0.002$; $ES = .26$) (see Table 5 and Figure 3).

Table 5 Rate of Perceived Exertion – Legs

Variable 1	Mean/SD1	Variable 2	Mean/SD2	P-value	Effect Size
Brisk None	10.18 ± 2.10	Brisk Both	11.00 ± 3.16	.140	.31
Brisk None	10.18 ± 2.10	Brisk Arms	10.35 ± 2.18	.627	.08
Brisk None	10.18 ± 2.10	Brisk Legs	11.59 ± 2.58	.002	.30
Brisk Both	11.00 ± 3.16	Brisk Arms	10.35 ± 2.18	.094	.24
Brisk Both	11.00 ± 3.16	Brisk Legs	11.59 ± 2.58	.172	.21
Brisk Arms	10.35 ± 2.18	Brisk Legs	11.59 ± 2.58	.007	.52
Slow None	9.00 ± 1.94	Slow Both	9.47 ± 2.03	.270	.24
Slow None	9.00 ± 1.94	Slow Arms	8.29 ± 1.49	.023	.41
Slow None	9.00 ± 1.94	Slow Legs	9.65 ± 1.80	.085	.35
Slow Both	9.47 ± 2.03	Slow Arms	8.29 ± 1.49	.004	.67
Slow Both	9.47 ± 2.03	Slow Legs	9.65 ± 1.80	.693	.09
Slow Arms	8.29 ± 1.49	Slow Legs	9.65 ± 1.80	.002	.83

Figure 3 RPE – Legs



Chapter Five

Discussion

The present study was designed to examine three differentiated rates of perceived exertion (RPE) at two different self-selected speeds (slow and brisk) under four various Body Togs® conditions. A total of eight different experimental trials were completed by all participants. RPE for the chest and breathing, the legs, and overall was measured every six minutes during all exercise trials. The findings of this research study reveal that overall exertion and leg exertion increased among participants as a result of increases in speed and as a result of adding the Body Togs®. RPE of the chest and breathing also increased as a result of speed increases, but was found to be unchanged by the addition of Body Togs®. It is plausible that perceptual responses of the chest would be unchanged by the Body Togs® as this is not an anatomical region where the togs are worn and thus exertion would not increase for this variable during the exercise trials. The Body Togs® are worn on the forearms and the lower leg. It is feasible that RPE overall and RPE legs would increase due to the added weight of the togs. With the addition of the togs to the legs, an increase in exertion in this region seems possible. Overall exertion would also increase simply because weight was added to the body. However, RPE chest and breathing was likely unchanged because the togs were not added to this region of the body and because the mode of exercise was walking.

The assessment of RPE overall indicated that trials performed at a brisk speed with no togs as compared to trials performed at a brisk speed with leg togs had higher exertion responses. Also, when exercise trials performed at a slow speed with both leg and arm togs were compared to exercise trials performed at a slow speed with arm togs a difference in perceived effort also existed. It is unexpected that exertion would increase during both the slow and brisk walking for the above trial comparisons and not also for others. Walking with added weight adds effort to the endeavor, still, it cannot be explained why RPE – overall increases were significant for trial comparison of no togs and leg togs at the brisk speed, in addition to, arms only and leg and arm togs at the slow speed, but were not significant for other trial comparisons. It seems more likely that a pronounced and significant difference would have existed for trial comparisons with no togs and leg and arm togs for both the slow and brisk speed. Yet, the data did not present this finding.

RPE – chest provided two trial comparisons which presented meaningful differences. Exercise trials executed at a brisk speed with no togs compared to exercise trials executed at a brisk speed with leg togs were significantly different when RPE of the chest was considered. While this outcome can be explained by the added weight of the togs, it is surprising that the same outcome did not exist for exercise trials completed at a brisk speed with no togs compared to trials completed at a brisk speed with both leg and arm togs. Another significant finding related to RPE – chest was found for the comparison of exercise trials accomplished at a slow speed with arm togs and exercise trials completed at a slow speed with both arm and leg togs. It is slightly difficult to fathom why a difference existed for trials at a slow speed with arm togs compared to

trials at a slow speed with both arm and leg togs, yet did not exist for trials at a slow speed with no togs compared to trials at a slow speed with both arm and leg togs. Again, as was present with RPE – overall, differences were found for some trial comparisons but not for all trial comparison in which differences would be expected.

Finally, RPE – legs revealed more differences in RPE than did the other two RPE variables. Exercise trials completed at a brisk speed with no togs compared to exercise trials completed at a brisk speed with leg togs were significantly different when considering RPE – legs. Also exercise trials performed at a brisk speed revealed a significant difference for those with arms togs when compared to those with leg togs. Once again, it seemed likely that a difference would exist between exercise trials performed at a brisk speed with no togs when compared to trials performed at a brisk speed with both arm and leg togs, yet this did not transpire. RPE – legs for exercise trials at a slow speed revealed differences for comparison of no togs compared to arm togs only, arm togs only compared to leg togs only, and arm togs only compared to both leg and arm togs.

The hypotheses of the present study included that RPE would not be altered, but the findings reveal that RPE did increase. Collectively, it was expected that if differences in RPE were found, trial comparisons for the various RPE's would reveal a pattern in which changes in RPE occurred. It seemed likely that for both speeds, increases in RPE would be found for all trials that were performed with no togs when compared to trials that were conducted with both leg and arm togs. It also seemed less likely that increases in RPE would be found for trials performed with no togs when compared to trials performed with only arm togs. While a sequential increase in RPE is what seemed

probably if changes were to occur, the data did not indicate a sequence that explains how or as to why some trial comparisons were significant and others were not.

In reviewing similar research studies of the past in which wearable weights were added to exercise and RPE was assessed, the results of the present study prove to be quite unique. Graves (1988) examined the impact of handheld weights weighing approximately two pounds during treadmill running. RPE was measured and was found to be unchanged by the added weight. Rodgers, Vanheest and Schachter (1995) evaluated the impact of Exerstriders®, walking sticks which equate to an added two pounds. These were added to treadmill walking and RPE was assessed every two minutes during exercise trials. The results of this study also found that while implementing the Exerstriders® added body weight and increased heart rate, RPE remained unchanged. A final study similar to the present study was conducted by Evans (1994). This study included a unique population in that the participants were older individuals. Treadmill walking was the selected mode of exercise and various amounts of weight were added to the exercise. RPE was measured and was found to be unchanged except during the trials in which the highest amount of weight (2.27 kg) was added. The present study is similar to the previous studies in that weight was added to exercise and RPE was measured. However, the Body Togs® research study is unique in that three differentiated RPE's were measured during the exercise. The findings of the study present relatively inconsistent results as compared to the previously reviewed studies. The preceding studies were fairly consistent in that they found RPE to be unchanged despite the weight added to the exercise. The present study found that RPE was changed first due to differences in speed and also due to differences in Body Togs® conditions. It is imperative to mention that the leg togs and arm togs

together add approximately 7.5 pounds (3.4 kg) of extra weight. Past studies added no more than 5 pounds of weight and thus the extra 2 pounds included in this study likely accounts for some of the changes in RPE. It is pertinent to mention that while Body Togs® come in an assortment of sizes, all arm togs are equal in weight as are all leg togs.

The strengths of the research study include that all participants were low risk as defined by ACSM's risk stratification qualifications. All exercise trials were conducted in the same environment and the research team made every effort to keep trial protocol consistent. Additionally, RPE is most commonly reported as an overall measure of exertion. To assess how the Body Togs® impacted other areas of the body as it relates to exertion, three differentiated measures of RPE were included. The limitations of the study include that this is the very first research study of its kind in that Body Togs® are a novel device and prior to this study had not been included in any scientific research. The variable of measure in the study was RPE and perceptual responses are often unpredictable and highly individualized. This alone is merit for a repeat research study, as well as, future research which includes Body Togs®.

Future research with Body Togs® should include perceptual responses during brisk treadmill walking compared with treadmill running. The differences in perception of exertion would likely be more pronounced and may present a more consistent relationship than was found in the present study. Other Body Togs® research studies could also include wearing the togs during activities of daily living (ADL's) and measuring perceptual responses as they relate to adding the togs to ADL's.

Practical application of adding Body Togs® to exercise include that adding weight to the body, whether it be during exercise or during ADL's, increases caloric

expenditure. If an individual weighs more, without question, that individual burns more calories performing ADL's and during exercise. As discussed in the introduction, the obesity epidemic is a great feat that the health and fitness professional is avidly trying to combat. New and innovative products such as Body Togs® are appropriate to include in exercise regimens, as well as, daily living in order to induce small, meaningful changes.

Conclusions of the study include that more research is necessary in order to thoroughly assess the perceptual responses Body Togs® produce during exercise. The togs are a new device and more research is necessary because they are an up and coming product. More research is also necessary to confirm or refute the inconsistent perceptual response relationship that was found in the present study. A more consistent relationship between adding Body Togs® to exercise and exertion perceptions could exist but will never be discovered without future research.

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