

2014

# Comparing Calorie Expenditure and Rating of Perceived Exertion between the Curve and a Motorized Treadmill

Nicholas Robertson  
*Eastern Washington University*

Follow this and additional works at: <http://dc.ewu.edu/theses>

---

## Recommended Citation

Robertson, Nicholas, "Comparing Calorie Expenditure and Rating of Perceived Exertion between the Curve and a Motorized Treadmill" (2014). *EWU Masters Thesis Collection*. 268.  
<http://dc.ewu.edu/theses/268>

This Thesis is brought to you for free and open access by the Student Research and Creative Works at EWU Digital Commons. It has been accepted for inclusion in EWU Masters Thesis Collection by an authorized administrator of EWU Digital Commons. For more information, please contact [jotto@ewu.edu](mailto:jotto@ewu.edu).

COMPARING CALORIE EXPENDITURE AND RATING OF PERCEIVED  
EXERTION BETWEEN THE CURVE AND A MOTORIZED TREADMILL

---

A Thesis

Presented To

Eastern Washington University

Cheney, Washington

---

In Partial Fulfillment of the Requirements

for the Degree

Masters of Science Physical Education

---

By

Nicholas B. Robertson

Summer 2013

THESIS OF NICHOLAS B. ROBERTSON APPROVED BY

\_\_\_\_\_DATE\_\_\_\_\_  
WENDY REPOVICH, GRADUATE COMMITTEE CHAIR

\_\_\_\_\_DATE\_\_\_\_\_  
CHRISTI BREWER, GRADUATE STUDY COMMITTEE

MASTERS THESIS

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Eastern Washington University, I agree that that JFK Library shall make copies freely available for inspection. I further agree that copying of this project in whole or in part is allowable only for scholarly purposes. It is understood however, that any copying or publication of this thesis for commercial purposes, or for financial gain, shall not be allowed without my written permission.

Signature \_\_\_\_\_

Date \_\_\_\_\_

## ACKNOWLEDGEMENTS

I would first like to thank Dr. Wendy Repovich. Her knowledge, advice, and encouragement helped me complete this thesis and prepare for my future. I'm grateful that she always made time in her busy schedule to help me however she could.

I would also like to express my sincere appreciation for my family, co-workers, and fellow graduate students for their continual love and support. I would especially like to thank my wife and son who have supported me through everything and consistently believe in my success.

## ABSTRACT

The purpose of this study was to determine if any difference in Calorie expenditure and rating of perceived exertion (RPE) exists when walking on the Curve or a motorized treadmill. Recruitment of participants was done through recruitment flyers placed on campus. After indicating interest, participants' eligibility was determined by the PAR-Q and being unfamiliar with walking on the Curve. Twelve participants volunteered for the study (five males, seven females). The mean age of participants was 22.58 years  $\pm$  2.31 and mean weight was 76.96kg  $\pm$  16.19. On testing days, each participant was fitted with a polar heart rate monitor and the K4 b<sup>2</sup> metabolic gas analyzer (K4). The order of tests was randomly assigned. The warm up consisted of walking at 3 MPH until steady state heart rate was reached which took approximately three minutes. The actual test consisted of walking at 3 MPH for 10 minutes on each treadmill. Oxygen consumption was collected on a breath-by-breath basis by the K4. Calorie expenditure was reported using the formula of one liter of Oxygen consumed equals five Calories. Calorie expenditure was then totaled over 10 minutes. RPE was obtained during the last minute of each exercise bout. To determine whether there was a significant difference in Calorie expenditure and RPE while walking under the two conditions, two paired samples t-tests were performed. Alpha level was set at  $p \leq .05$ . The results of the t-tests showed a significant increase in Calorie expenditure ( $t = 17.73$ ,  $p < .0001$ ) and RPE ( $t = 5.45$ ,  $p = 0.0002$ ) while participants walked on the Curve. This study confirmed the Curve advertisement that someone walking on the Curve will burn more Calories than someone walking on a treadmill at the same speed.

## TABLE OF CONTENTS

Abstract .....	v
Introduction.....	1
Purpose of the Study .....	4
Null Hypothesis .....	4
Delimitations.....	4
Assumptions.....	5
Operational Definitions.....	5
Significance of the Study .....	5
Review of Literature .....	6
Evolutionary Perspective of Physical Activity .....	6
Rising Epidemic of Obesity .....	7
Physical Activity, Health, and Obesity .....	9
Physical Inactivity.....	10
Caloric Balance and Exercise .....	11
Weight Loss Exercise Recommendations.....	12
Exercise Machines .....	12
Metabolic Responses .....	15
Gaps and Claims .....	16
Summary .....	16
Methods.....	18
Participants.....	18
Equipment.....	18
Procedures.....	19
Statistical Analyses .....	21

Summary .....	21
Results.....	22
Participants.....	22
Data Analysis .....	22
Parametric Statistics .....	23
Summary .....	24
Discussion.....	25
Overview.....	25
Discussion.....	26
Recommendations.....	28
Overall Contributions and Summary .....	29
Appendices.....	39
Appendix A- Recruitment Flyer .....	39
Appendix B - Par-Q .....	40
Appendix C- Borg RPE 6-20 Scale .....	41
Appendix D- Informed Consent.....	43
Appendix E- Calibrations .....	45



## TABLES AND FIGURES

Table 1 Participants Physical Characteristics .....	22
Table 2 Descriptive Statistics.....	23

## **Chapter 1**

### **Introduction**

Aerobic exercise has many benefits including: improved fitness, reduced cardiovascular disease, and weight loss (CDC, 2013; Garber et al., 2011; USDHHS, 2008). Consistently participating in aerobic exercise has been shown to decrease the risk of coronary artery disease, hypertension, some cancers, type 2 diabetes, and osteoporosis (CDC, 2013; Garber et al., 2011; USDHHS, 2008). For these reasons, exercise products are becoming increasingly popular at the gym and home settings. Infomercials are dominated with exercise programs and machines guaranteeing weight loss results. This is alluring to the American public because two thirds of the U.S. population is attempting to lose weight (Serdula et al., 1999). In fact, U.S. consumers spent \$33 billion for weight loss products and services in 1998 (Cleland et al., 2001) and are expected to spend over \$40 billion by 2016 (“Weight Management”, 2013).

Research confirms that aerobic exercise is one of the best ways to expend Calories and lose weight (Donnelly et al., 2009; Saris et al., 2003; Wing & Phelen, 2005). Aerobically training on exercise machines is popular and has become a big part of the weight loss market. Recent estimates suggest that by 2018 the world will spend \$14.8 billion on exercise equipment, the majority of which are aerobic exercise machines including treadmills, bikes, and ellipticals (“Physical Fitness”, 2012). Studies showing the importance of exercise and physical activity (Blair et al., 1996; Lee, Sui, & Blair, 2009; Paffenbarger, Hyde, Wing, & Hsieh, 1986) have opened doors to diverse exercise machines advertised as being the best way to obtain these important benefits.

With the variety of aerobic exercise machines available, people are left to decide which machine best fits their needs. Machines differ in a variety of ways including impact forces, (Lee et al., 2008; Porcari, Foster, & Schneider, 2000) limb kinematics, (Lee et al., 2008) difficulty, (Zeni, Hoffman, & Clifford, 1996) and Caloric expenditure (Zeni et al., 1996). A digital display of Caloric expenditure may persuade participants to use machines that display the most Calories expended in a given period of time. This can be problematic because exercise machines tend to overestimate actual Caloric expenditure, especially at lower intensity exercises like walking because of the formulas built into the machine (Clay, 2001; Swain, 2009).

Advertising a machine that is able to burn the most Calories in the shortest time attracts attention because the number one barrier to exercise is time (Booth, Bauman, Owen, & Christopher, 1997; Reichert, Barros, Domingues, & Hallal, 2007; Salmon, Owen, Crawford, Bauman, & Sallis, 2003). According to multiple surveys, the most popular form of exercise is walking (Ham, Kruge, & Tudor-Locke, 2009; Yusuf et al., 1996). Since time is the number one barrier to exercise, and walking is the most popular form of exercise, it is important to find which aerobic exercise machine is able to expend the most Calories while walking in addition to determining if walking on that machine is significantly harder than walking on the other.

Compared to cycle ergometers, rowers, ellipticals, and stair steppers, studies show that exercising on a treadmill requires the most energy at a given rating of perceived exertion (RPE) (Clay, 2001; Zeni et al., 1996). As new equipment is created, the developers regularly advertise the equipment as burning more Calories than a conventional treadmill when speed and time are kept constant. The Curve (Woodway) is

one of these machines. Claiming to burn more Calories than a conventional treadmill is important because treadmills are the most popular exercise machine ("History of Treadmills", 2013; "Treadmills", 2013).

The Curve is a non-motorized treadmill and is unique as a treadmill because of the slight radius of the surface. A picture of the Curve is shown in the studies recruitment flyer (Appendix A). There is no motor to drive the belt so users must use their own musculature to pull the belt backwards. Due to the curved running surface, users move towards the front of the Curve to speed up and towards the back of the Curve to slow down. It is advertised to burn up to 30% more Calories than a conventional treadmill. At present, it appears there has only been one study conducted that Woodway is using to support this statement. The study cited is an unpublished poster presentation where actual Caloric expenditure is not presented and exact methodology is not discussed (Snyder et al., 2011). While a poster may have been peer reviewed before presentation, the review is usually only of an abstract. This is another concern that the research has not been peer reviewed and published. Published research has been conducted on observed differences of non-motorized treadmills compared to motorized treadmills, but research has focused on differences in  $VO_{2max}$ , (Moore, Lewthwaite, Dagest, & Davies, 1984; Lee et al., 2008) time to exhaustion, (De Witt, Lee, Wilson, & Hagan, 2009) and biomechanical differences (Lee et al., 2008). Sound research has not been conducted comparing the Calorie expenditure between non-motorized and motorized treadmills at a constant submaximal walking speed.

## **Purpose of the Study**

The Curve offers more benefits than just increased Caloric expenditure. The Curve is a non-motorized treadmill and therefore requires no electricity to use. With the growing green coalition and increasing money spent on energy, the Curve could be a good alternative to a motorized treadmill. Not requiring electricity could persuade individuals to use the Curve. It is therefore important to test the manufacturers' claim of expending more Calories than a motorized treadmill when speed is kept constant across conditions. Therefore the purpose of this study was to determine if any difference in Caloric expenditure and RPE exists when walking on the Curve compared to a motorized treadmill while walking at 3 MPH.

## **Null Hypothesis**

H<sub>01</sub>: There will be no significant difference in Caloric expenditure between the Curve and a motorized treadmill while walking at 3 MPH. The alpha level was set at  $p \leq .05$ .

H<sub>02</sub>: There will be no significant difference in RPE between the Curve and a motorized treadmill while walking at 3 MPH. The alpha level was set at  $p \leq .05$ .

## **Delimitations**

1. Based on a power analysis, the study was delimited to 12 participants (five males, seven females). It was a sample of convenience with no restrictions except general health determined by the PAR-Q, a physical activity readiness questionnaire, and being unfamiliar with walking on the Curve.

2. The study was delimited to walking at 3 MPH on the two exercise machines used.

## **Assumptions**

1. Participants understood the training given to use the RPE scale and answered RPE questions honestly and to the best of their ability.
2. Participants were not aware of the advertising that someone working on the Curve will be expending more Calories than an equivalent speed on a motorized treadmill which could bias their reported RPE values.
3. Since the K4 was calibrated in the lab but the test was conducted in the fitness center it is assumed the different environment in the fitness center did not impact the K4 readings.

## **Operational Definitions**

Caloric expenditure: The volume of oxygen consumed ( $VO_2$ ) was measured using the K4b<sup>2</sup> (K4) metabolic gas analyzer (COSMED, Rome, Italy).

Rating of Perceived Exertion (RPE): The RPE scale is a psychophysiological scale measuring the degree of effort, strain, and/or fatigue. The 6-20 scale (Borg, 1998) was used.

## **Significance of the Study**

With the rising variety of exercise machines, the increasing obese population, and a lack of time to exercise, individuals are looking for a way to burn the most Calories in the shortest amount of time. For this reason, companies advertise their products as burning the most Calories in the shortest time. Some of the research backing these claims is unpublished and not peer-reviewed. It was therefore beneficial to conduct an accessible study comparing Caloric expenditure and RPE differences between the Curve and a motorized treadmill.

## **Summary**

Individuals attempting to lose weight efficiently and attempting to stay healthy have opened up a competitive exercise and weight loss market valued at billions of dollars. Companies are trying to tap into this market by advertising their exercise products as burning the most Calories in the shortest time. These claims are often not peer-reviewed, published, or accessible. The purpose of this study was determining if any difference in Caloric expenditure and RPE existed while walking at 3 MPH between the Curve and a motorized treadmill. In this chapter, hypotheses were declared, delimitations presented, operational definitions listed, and assumptions stated.

## **Chapter 2**

### **Review of Literature**

The purpose of this study was to determine if any difference in Caloric expenditure and RPE exists when walking on the Curve compared to a motorized treadmill while walking at 3 MPH. This chapter addresses the evolutionary perspective of physical activity, the rising epidemic of obesity, physical activity, physical inactivity, the importance of Caloric balance, and Caloric expenditure through aerobic activity. Included in this chapter is an evaluation of aerobic exercise machines and information regarding the two specific machines utilized to complete this study.

#### **Evolutionary Perspective of Physical Activity**

From an evolutionary perspective, human movement patterns were not established by training in a gym, but by natural selection (Cordain, Gotshall, Eaton, & Eaton, 1998). Prior to the 20<sup>th</sup> century, human movement patterns were heavily influenced by necessary survival techniques (Cordain et al., 1998). These activities included hunting, gathering, running after wounded prey, building shelters, and escaping from predators (Cordain et al., 1998; Eaton & Eaton, 2003). In the modern affluent world, mechanization has reduced much of the physical labor required for daily living (Cordain et al., 1998; Eaton & Eaton, 2003). From an evolutionist's perspective, changing behavioral factors while maintaining the human genome has important pathophysiological implications (Eaton & Eaton, 2003).

Evolutionary theorists, geneticists, biologists, ecologists, and anthropologists agree that the human genome has changed minimally over the past 50,000 years (Cordain et al., 1998; Eaton & Eaton, 2003). For nearly all human experience, energy intake and energy expenditure have been strongly linked, but economic success and the industrial



revolution disrupted this link (Eaton & Eaton, 2003; Saris et al., 2003). An estimate of ancestral humans' Caloric expenditure through physical activity was 1000 Calories a day (Eaton & Eaton 2003). Modern sedentary adults expend 300 Calories a day through physical activity, which is a 700 Calorie difference in physical activity energy expenditure. This could be one of the reasons the U.S. has an increasing number of obese adults.

### **Rising Epidemic of Obesity**

Uncontrolled weight gain has become a nationwide epidemic for citizens of the U.S. The percent of obese U.S. adults has increased from 12.8% in the 1960s to 22.5% in the 1990s (Flegal, Carroll, Kuczmarski, & Johnson, 1998). Obesity rates in U.S. adults have continued to rise, with the Centers for Disease Control and Prevention (CDC) reporting 35.7% of U.S. adults were obese in 2009-2010. The dramatic increase in obese adults from the 1960s is problematic because of the associated increased risk of chronic disease and medical costs. According to the CDC (2013), obesity-related conditions include heart disease, stroke, type 2 diabetes and certain types of cancer, and these cost \$147 billion in medical expenses in 2008. Due to high medical costs and susceptibility to chronic disease, being able to prevent obesity on a personal and global scale is becoming increasingly important.

There are small genetic differences that increase the susceptibility of certain individuals to becoming obese (Wadden & Stunkard, 2004). However, the rapid increases in the obese population cannot be explained by biology alone. There are environmental and behavioral factors that also contribute to obesity, including increased

energy intake and decreased energy expenditure (McArdle, Katch, & Kath, 2009; Wadden & Stunkard, 2004).

### **Physical Activity, Health, and Obesity**

Part of the reason energy expenditure levels have lowered is because mechanization has reduced much of the physical labor required for daily living (Cordain et al., 1998; Eaton & Eaton, 2003). Early studies showed that individuals whose occupation required physical activity have lower incidences of death caused by coronary artery disease (Morris, Heady, Raffle, Roberts, & Parks, 1953; Taylor et al., 1962). It was shown that English bus conductors, who spent time walking up and down the stairs of double-decker buses, experienced half the deaths from coronary heart disease (CHD) as did the bus drivers, who spent most of the day sitting (Morris et al., 1953). A similar study was conducted in the railroad industry. It was found that jobs requiring little physical activity had significantly higher rates of death caused by CHD (Taylor et al., 1962). Since Morris's study, others have also found that physical activity helps prevent CHD and all-cause mortality. A meta-analysis conducted by Nacoon et al. (2008) showed that physically active individuals have a 35% less chance of dying from CHD.

A decline in daily physical activity levels is also a clear factor contributing to the current obesity epidemic (Fox & Hillsdon, 2007; Paffenbarger, Blair, & Lee, 2001; Saris et al., 2003). By the 1960s some experts suggested that if physical activity contributed to protecting against obesity and cardiovascular disease, the activity would have to be through leisure time exercise due to mechanization (Fox & Hillsdon, 2007; Paffenbarger et al., 2001). Fox and Hillsdon (2007) further state that the reduction in occupational activity has probably not been replaced by increased leisure-time physical activity. Since

occupations are requiring less physical activity, it is becoming increasingly important for adults to participate in leisure time exercise to protect against disease and prevent weight gain (Fox & Hillsdon, 2007; Nacoos et al., 2008 Paffenbarger et al., 2001).

**Physical activity guidelines.** Organizations, including the American College of Sports Medicine (ACSM), the CDC, and The American Heart Association (AHA) have reviewed the literature and prescribed physical activity recommendations to protect against chronic health conditions. These recommendations are meant to be purposeful exercise, outside the activities of daily living. It was concluded that adults should participate in at least 150 minutes a week of moderate-intensity physical activity or 75 minutes of vigorous physical activity (CDC, 2013; Garber et al., 2011; USDHHS, 2008). This exercise can even take place in 10 minute intervals. Following these recommendations has been shown to lessen the chance of having CHD by 20% and protect against type 2 diabetes (CDC, 2013; Garber et al., 2011; USDHHS, 2008).

### **Physical Inactivity**

In recent years, research on physical inactivity or sedentariness has become distinct from physical activity (Fox & Hillson, 2007; Hamilton et al., 2008; Patel et al., 2010). Much of the research has focused on how long people sit, including activities like watching television, using a computer, or playing video games. These physically inactive activities are associated with obesity, (Hamilton, Hamilton, & Zderic, 2007; Hu, Li, Colditz, Willett & Manson, 2001; Jakes et al., 2003) metabolic syndrome, (Ford, Kohl, Mokdad, & Aiani, 2005) and type 2 diabetes, (Hamilton et al., 2007; Hu et al., 2001) all of which contribute to cardiovascular disease. Further research has found that increased sitting time is associated with elevated risks of all-cause mortality, independent of

individuals meeting daily exercise recommendations previously mentioned (Katmarzyk, Church, Craig, & Bouchard, 2009; Patel et al., 2010). Both studies had large sample sizes and used questionnaires to evaluate participants' sitting time and physical activity. Patel (2010) found that women sitting for more than six hours a day in leisure pursuits had a 40% higher all-cause death rate than women who sat less than three hours a day, independent of the amount of physical activity. Katmarzyk et al. (2009) used a qualitative measure of time spent sitting (almost none of the time, one fourth of the time, half of the time, three fourths of the time, almost all of the time). It was found that more sitting time was directly associated with higher all-cause death rates independent of meeting physical activity standards.

The research on physical activity and physical inactivity indicates that for humans to combat preventable chronic diseases like cardiovascular disease, diabetes, and obesity, one must spend more time moving and less time sitting (Katmarzyk et al., 2009; Patel et al., 2010). Whether that activity takes place at work or leisure time is still up to debate; however, not increasing leisure time physical activity while sedentary time increases creates problems for achieving caloric balance.

### **Caloric Balance and Exercise.**

Caloric balance is achieved when Calories ingested equals Calories expended. Exercising increases Caloric expenditure because physical movement requires energy and therefore expends Calories (McArdle et al., 2009). The total amount of energy expended is partially dependent on the amount of muscle mass producing bodily movements and the intensity, duration, and frequency of muscle contractions (Caspersen, Powell, & Christenson, 1985). Energy output from active muscles involved in sprint running or

swimming exceeds resting levels by 120 times (McArdle et al., 2009). The scientific community agrees that physical activity requires energy and therefore aids in achieving Caloric balance. The amount of exercise required to prevent weight gain or lose excess weight is difficult to define because of differing body size and nutritional diets.

### **Weight Loss Exercise Recommendations**

The National Weight Control Registry (NWCR) is a registry of over 3,000 individuals who have maintained a minimum 30 pound weight loss for at least one year (“The National Weight Control Registry”, 2013). Ninety percent of the registry reports regular exercise as a critical component in maintaining weight loss. The NWCR members report burning 2682 Calories weekly. Saris et al. (2003) reports this as the equivalent of walking 4 miles per day. Klem, Wing, McGuire, Seagle, and Hill (1997) estimated that some NWCR members expend the amount of energy equivalent to walking 28 miles a week. Both of these estimates are closely related to ACSM recommendations, which suggest that an energy expenditure of over 2000 Calories a week may be necessary to maintain weight loss (Donnelly et al., 2009). These three weight loss maintenance recommendations require much more energy expenditure than previously stated recommendations for improving overall health. Since Caloric expenditure through physical activity is important for health, and walking is one of the most popular forms of exercise (Ham, Kruge, & Tudor-Locke, 2009; Yusuf et al., 1996) it’s important to know if walking on one type of exercise machine differs from another.

### **Exercise Machines**

The U.S. population’s interest in weight loss products and services is high. Infomercials are dominated with exercise programs and machines guaranteeing weight

loss results. In fact, U.S. consumers spent \$38 billion for weight loss products and services in 2013 (“Weight Management”, 2013). Recent estimates show that by 2018 the world will spend \$14.8 billion on exercise equipment, the majority of which are aerobic exercise machines including treadmills, bikes, and ellipticals (“Physical Fitness”, 2012). Many aerobic exercise machines advertise burning the most Calories in the shortest time; therefore it would be beneficial to know if these claims are true. Studies have shown that motorized treadmills allow for the greatest Caloric expenditure when RPE is kept constant across conditions (Zeni et al., 1996; Clay, 2001). The machines that were compared include cycles, rowers, stair steppers, and ellipticals. Reviewed here will be two weight bearing exercise machines. The machines reviewed will be a motorized treadmill and the Curve.

**Treadmill description.** The treadmill’s first use was not for aerobic activity. In 1875 a treadmill was created to transfer the energy of moving animals to devices such as butter churns, spinning wheels, or water pumps (“Treadmill History”, 2013). Humans began using treadmills as a mode of aerobic exercise in the 1960s. Since that time, treadmills have grown in popularity and sophistication. Treadmills allow users to walk, jog, and even run at a variety of speeds they choose. As technology improved, designers began creating treadmills able to simulate walking or running up or down hill by manipulating incline. These improvements in technology have led to the modern treadmill where users can now pick a predesigned workout programmed into the machine. These designed programs increase/decrease speed and incline at specified times throughout the exercise routine. Due to treadmills versatility and mode of Caloric

expenditure, they have become one of the most widely used pieces of aerobic exercise equipment (Treadmill History", 2013).

**Non-motorized treadmill description.** Motorized and non-motorized treadmills allow participants the convenience of training aerobically on a machine while staying in one place. Non-motorized treadmills have no motor and rely on the user's energy to move the belt (Lee et al., 2008). Non-motorized treadmills are usually less expensive, more portable, and offer a variety of places to exercise because electrical power is not needed to operate the machine (De Witt et al., 2009; "Treadmill History", 2013). The Curve is a unique non-motorized treadmill because the running surface is not flat, but is at a slight radius. It was originally designed for athletes to be used anaerobic interval training. Due to total manual operation and curved design, participants are able to instantly adjust their pace with a few explosive steps. To accelerate, the participants start running up the incline; and to decelerate, participants allow themselves to drift back on the machine. On a motorized treadmill the speed is controlled by the machine not the person so if an athlete is trying to do high intensity intervals they must jump to the edges when the interval is done because the belt is still moving. The Curve also has a digital screen that displays an estimated Calorie expenditure. The Curve is programmed to use the ACSM running Metabolic Equation for relative  $VO_2$  (ml/kg/min) which is converted to absolute  $VO_2$  (l/min) and finally to Calories (1 l/min = 5 Calories). The formula is  $VO_2 \text{ (ml/kg/min)} = .2(\text{speed}) + .9(\text{speed}) (\% \text{ grade}) + 3.5$ . The Calorie display uses this formula for a 180 pound male running at a 6% incline. This formula could overestimate or underestimate Calorie expenditure depending on the person's weight.

## **Metabolic Responses**

During motorized treadmill exercise, the motor drives the belt and much of the work required by the participant is to maintain position on the treadmill (Kram, 2000). A non-motorized treadmill also requires the user to support the body, but the user must also move the running surface by pushing the belt backwards (Lee et al., 2008). The amount of work performed during non-motorized training is the sum of the work to support the body and the force required to overcome the inherent friction in the treadmill system (Lee et al., 2008). The theory expressed here by Lee and colleagues suggests that comparative physical activity on a non-motorized treadmill requires greater metabolic cost than a motorized treadmill. This theory has been tested and research has consistently shown that non-motorized treadmills require greater metabolic demand than motorized treadmills (De Witt et al., 2009; Lee et al., 2008; Moore et al., 1984).

When speed is kept constant across conditions non-motorized treadmills seem to require greater metabolic demand. Sub-maximal  $\text{VO}_2$  and heart rate is significantly higher when running (Lee et al., 2008; Moore et al., 1984) and walking (Lee et al., 2008; Snyder et al., 2011) at sub maximal speeds, in athletically-trained and recreationally-trained participants. These studies utilized three stage ramp protocols with 5-10 minutes rest in between each stage. The treadmills used by Lee et al., (2008) were treadmills designed for space flight, and are not found in exercise facilities around the country. NASA has an interest in non-motorized treadmills because of space flight-induced deconditioning (Lee et al., 2008). The Curve was utilized by Snyder and colleagues (2011), but the poster lacks in academic depth.



## **Gaps and Claims**

The Curve is advertised as allowing participants to expend 30% more Calories while walking than a conventional treadmill when speed is kept constant across conditions. This claim is backed by insufficient evidence. The study cited is an unpublished non peer reviewed poster presentation where actual Caloric expenditure is not presented (Snyder et al., 2011). The poster lacks in sharing exact statistical methods used to show that the Curve expends 30% more Calories. There is also no discussion of the methods used to accurately measure RPE. The Curve might burn 30% more Calories but be perceived to be significantly more difficult. Published research has been conducted on observed differences of non-motorized treadmills compared to motorized treadmills, but research has focused on differences in  $VO_{2max}$  (Moore et al., 1984; Lee et al., 2008) time to exhaustion (De Witt et al., 2009) biomechanical differences, (Lee et al., 2008) and did not utilize the Curve. Sound research has not been conducted comparing Caloric expenditure at submaximal walking speeds between the Curve and a motorized treadmill.

## **Summary**

From an evolutionist's perspective, changing behavioral factors while maintaining the human genome has important pathophysiological implications, including unhealthy weight gain. The rising epidemic of obesity is caused by many factors, two of them being increased Caloric intake and decreased Caloric expenditure. It is currently believed by the scientific community that increasing physical activity increases metabolic cost and promotes health. Aerobic exercise machines are becoming increasingly popular and specific machines are advertised as burning the most Calories in the shortest amount of

time. Some of the research to back these claims is inaccessible or not explained thoroughly. It was therefore beneficial to conduct a study comparing which type of treadmill burns the most calories, and which required the greatest perceived exertion. This chapter reviewed the current literature on physical activity, energy expenditure, and comparisons between motorized and non-motorized treadmills.

## **Chapter 3**

### **Methods**

#### **Introduction**

The purpose of this study was to determine if any difference in Caloric expenditure and RPE exists when walking at 3 MPH on the Curve compared to a motorized treadmill. This chapter includes a description of the methods that were utilized to complete the study, which includes the selection of participants, equipment, procedures, data collection, and statistical design.

#### **Participants**

A power analysis using G-Power (Faul, Erdfelder, Land, & Buchner, 2007) demonstrated at least 10 participants were needed to be able to reject the null hypothesis with an alpha level of  $p \leq .05$ . Effect size was calculated using means and standard deviations from previous studies comparing energy expenditure between motorized and non-motorized treadmills (Lee et al., 2008; Snyder et al., 2011). Once effect size was calculated, effect size (.91), alpha (.05), and power (.8) were entered into G-Power to produce 10 participants. Twelve participants volunteered for the current study. Individuals were at least 18 years old who were free of health problems determined by the PAR-Q (Appendix B). Participants were recreationally active and unfamiliar with walking on the Curve.

#### **Equipment**

The equipment used in this study included: the Curve (WOODWAY USA, Waukesha, WI), and a T7xe Treadmill (Matrix, Cottage Grove, WI). Caloric expenditure was determined and read from the K4b<sup>2</sup> (K4) metabolic gas

analyzer (COSMED, Rome, Italy). The K4 measured oxygen consumption on a breath-by-breath basis and determined the volume of oxygen consumed per minute. It then converts liters of oxygen consumed into Calories. The ACSM formula states that one liter of consumed oxygen equals five Calories (ACSM, 2012). RPE was measured using the Borg 6-20 Rating of Perceived Exertion scale (Appendix C) (Borg, 1998). Heart rate was measured using a Polar heart rate monitor (Polar, Lake Success, NY).

### **Procedures**

Prior to data collection, the Institutional Review Board for Human Subjects at Eastern Washington University approved the research. Once approval was granted, recruiting flyers (Appendix A) were placed in the University Recreation Center on campus. Once at least 10 people at least 18 years of age volunteered, a group meeting was held to describe the study. Each volunteer completed the PAR-Q. If they answered no to all questions, informed consent forms were distributed (Appendix D). After the explanation, questions were answered and each candidate was given at least 48 hours to decide whether they wanted to participate in the study. Once participants turned in an informed consent a familiarization and two data collection sessions were scheduled. The sessions were 24-48 hours apart and during the same time of day.

During the familiarization session, participants practiced maintaining 3 MPH on the Curve, shown the K4, and given the standard instructions (Appendix B) in the use of the 6-20 Borg RPE scale (Borg, 1998). Maintaining correct speed was defined as staying within 2.8 and 3.2 MPH. Demonstration of the K4 equipment shown and explained to the participants included fitting the mask and showing how the analyzer is carried on the participants' chest with straps. Since a mask was placed on all participants, instructions

were given to participants on how to tell researchers their RPE when walking on the equipment. This was done by the researcher holding up an RPE scale and participants pointing to their RPE. It was confirmed by the researcher with a nod of the head. If it was not reported correctly a thumbs up or thumbs down was used to confirm the correct value. No suggestions of RPE from the principal investigator were given to participants so bias could be avoided. At no time were the participants told that the Curve was expected to expend more calories or to feel harder and because they were all novices to the Curve they would not be expected to know the research hypothesis that the advertisements suggest more Calories are expended. Also at this time, participants' questions were answered regarding any testing procedures or protocols to take place during the two data collection sessions.

Before each test the K4 was calibrated using four different calibrations. These calibrations included the turbine calibration, room air calibration, delay calibration, and reference gas calibration (Appendix E). Upon arrival, participants put on the heart rate monitor and were fitted with the K4 equipment. The analyzer was strapped to the chest, mask fitted, and straps adjusted. Treadmill order was randomly assigned. The warm up consisted of walking at 3 MPH on the assigned machine until steady state heart rate was reached (HR remained at  $\pm 6$  beats), which took 3-4 minutes (McArdle et al., 2009). During the warm up, the standard instructions on the use of the RPE scale were repeated (Appendix B).

The actual test consisted of walking at 3 MPH for 10 minutes on one of the exercise machines. Everyone was able to maintain the correct speed ( $\pm .2$  MPH) for the 10 minutes on each treadmill. RPE was recorded during the last minute of exercise. Gas

exchange was measured on a breath-by-breath basis by the K4. Once the tests were completed, the K4 was returned to the lab and the data downloaded. Data collection was continuous including the warm up, so the warm up Calories expended were subtracted from the total expenditure over the 10 minutes test. Total Calorie expenditure was then recorded for each participant's 10 minute exercise bout. Relative  $\text{VO}_2$  (ml/kg/min) and heart rate were also collected by the K4. Heart rate and relative  $\text{VO}_2$  data were also recorded to assure the work was at steady state for the 10 minutes. This testing protocol was then repeated for the other exercise machine on the next scheduled testing day.

### **Statistical Analysis**

Data were entered into Microsoft Excel and transferred into SPSS version 21.0 for analysis. Descriptive statistics were determined on the dependent variables, heart rate, and relative  $\text{VO}_2$ . To determine whether there was a significant difference in Calorie expenditure and RPE while walking under the two conditions, two paired samples t-tests were performed. The Alpha level was set at  $p \leq .05$ .

### **Summary**

This chapter included a description of the methods used to complete this study. Included in this chapter was the selection of participants, equipment utilized, procedures, and statistical design.

## Chapter 4

### Results

#### Introduction

The purpose of this study was to determine if any difference in Caloric expenditure and RPE exists when walking at 3 MPH on the Curve compared to a motorized treadmill. This chapter includes the physical characteristics of participants, statistical analysis of Calorie expenditure differences, and statistical analysis of RPE differences.

#### Participants

All participants were students attending Eastern Washington University. Table 1 provides information regarding the mean and standard deviations for all physical characteristics of the 12 volunteers (five males, seven females) participating in the study. Weight ranged from 54-107kg, age ranged from 19-26 years, and height ranged from 163-188cm.

Table 1

*Participant Physical Characteristics*

n	Weight (kg)		Age (years)		Height (cm)	
	Mean	SD	Mean	SD	Mean	SD
12	76.96	16.19	22.58	2.31	172.72	8.94

#### Data Analysis

Descriptive statistics were determined on both dependent variables, heart rate, and relative VO<sub>2</sub> for each exercise modality and are reported in Table 2. To evaluate

normality of data, the Shapiro-Wilk test was used in conjunction with an evaluation of skewness and kurtosis. All data was determined to be normally distributed ( $p > .05$ ) for skewness and kurtosis with no values exceeding  $\pm 1.97$ . These values were determined by dividing the statistic by the standard error. The Shapiro-Wilk test showed all data was normally distributed ( $p > .05$ ). The mean Calorie expenditure of participants walking on the Curve was 44% more than the treadmill. The Curve is advertised as burning up to 30% more Calories than a motorized treadmill (Snyder et al., 2011). The mean heart rate of participants walking on the Curve was 22% more beats per minute than while walking on the motorized treadmill. The relative  $VO_2$  (ml/kg/min) of participants walking on the Curve was 41% more than when walking on the motorized treadmill.

Table 2

*Descriptive Statistics*

Variable	Curve		Treadmill	
	Mean	SD	Mean	SD
Calorie Expenditure For 10 Minutes	77.80	9.37	54.01	9.04
RPE	10.33	1.44	8.92	.90
Heart Rate (beats per minute)	123.95	11.43	101.33	8.82
$VO_2$ (ml/kg/min)	20.34	3.56	14.41	2.69

**Parametric Statistics**

Two separate paired samples t-tests were used to determine if there were significant differences in Calorie expenditure and RPE between the two conditions.

When comparing Calorie expenditure between walking on the Curve and treadmill, the



paired samples t-test showed that the null hypothesis was rejected ( $t = 17.73$ ,  $p < .0001$ ). When comparing RPE between walking on the Curve and treadmill, the paired samples t-test showed that the null hypothesis was also rejected ( $t = 5.45$ ,  $p = .0002$ ). The results of this study suggest that walking on the Curve at 3 MPH expends significantly more Calories and is perceived to be significantly more difficult than walking on a motorized treadmill.

### **Summary**

This chapter included the physical characteristic of participants, a statistical analysis of Calorie expenditure differences, and a statistical analysis of RPE differences in participants initially unfamiliar with the Curve.

## **Chapter 5**

### **Discussion**

#### **Introduction**

The purpose of this study was to determine if any difference in Caloric expenditure and RPE exists when walking on the Curve compared to a motorized treadmill while walking at 3 MPH. This chapter provides a summary of the procedures used in the study, a discussion of the results, their comparisons to other studies, and recommendations for future research.

#### **Overview**

Previous research has shown, and Woodway advertises the Curve as expending 30% more Calories than a treadmill when speed is kept constant (Synder et al., 2011). The two hypotheses for this study were (a) there would be no significant difference in Calorie expenditure between the Curve and a motorized treadmill while walking at 3 MPH, and (b) there would be no significant difference in RPE between the Curve and a motorized treadmill while walking at 3 MPH. Both of the null hypotheses were rejected.

Participants were volunteers from Eastern Washington University between the ages of 19-26 and screened for health problems by the use of the PAR-Q. Volunteers were only able to participate in the study if they answered no to all questions and were unfamiliar with walking on the Curve. Prior to any data collection, participants engaged in a familiarization session in which they were made familiar with the equipment used in the study and the procedures to be carried out. During data collection sessions, participants walked at 3 MPH for 10 minutes and Calorie expenditure was collected on a

breath-by-breath basis with the K4. RPE was reported during the last minute of the data collection session.

## **Discussion**

Studies have shown that non-motorized treadmills require greater metabolic demand than motorized treadmills (De Witt et al., 2009; Lee et al., 2008; Moore et al., 1984; Snyder et al., 2011). The present study reported similar results showing that the mean average Calorie expenditure on the Curve was 23.79 Calories (44%) more than a motorized treadmill while walking at 3 MPH for 10 minutes. Heart rate was 22% higher, and relative  $\text{VO}_2$  was 41% greater. These results align with the theory that the amount of work performed during non-motorized training is the sum of the work to support the body and the force required to overcome the inherent friction in the treadmill system (Lee et al., 2008), and therefore results in the expenditure of more Calories than a motorized treadmill. This is one of two known studies that have examined Caloric expenditure in the Curve when compared to a motorized treadmill.

A previous study (Snyder et al., 2011) found the Curve expended 30% more Calories than a conventional treadmill compared to 44% in the present study. Some major differences in methodology between the present study and Snyder et al. (2011) are: (a) in the present study participants walked at a steady 3 MPH, instead of three separate six minute bouts at 1.5, 2.5, and 3 MPH, and (b) in the present study all participants were given 24-48 hours rest between exercise bouts instead of 10 minutes. It is unknown how Snyder and colleagues (2011) calculated Calorie expenditure across the three speeds. That information is not made known in the poster presentation. Workout durations are important to note because during a six minute exercise bout, participants might not be in

steady state exercise for very long. It is unclear whether participants in the Snyder et al., (2011) study were at steady state exercise for 6 minutes because warm up procedures are not discussed in the poster presentation. Research has shown that reaching steady state exercise can take longer than four minutes when exercise intensity is great enough (McArdle et al., 2009). In the present study all participants were able to maintain steady state on both treadmills for the entire 10 minutes. Snyder et al., mentions that exercise speed was too great for some participants to walk at 3.5 MPH and had to resort to jogging. Having all exercise bouts on the same day could have also affected Calorie expenditure because of fatigue (McArdle et al., 2009).

One other condition that could have caused differing results in the present study when compared to Snyder et al., (2011) is the familiarity participants had with the exercise machines. In the present study, participants were required to be novices with the Curve and only had one familiarization session on it. It is unclear what type of familiarity Snyder and colleague's (2011) participants had on the Curve. It was just stated that all participants had experience on both the Curve and the motorized treadmill. Studies have indicated that being unfamiliar with an exercise machine's movement pattern could increase the amount of Calories needed to repeatedly complete that motion compared to familiarity with a machines movement pattern ("How Many Calorie", 1999). If participants in the present study were less familiar with the Curve than participants in Snyder and colleagues work, it could account for the greater Calorie expenditure that was observed.

The 6-20 Borg Rating of Perceived Exertion Scale was used in the present study to measure RPE. In this study participants reported a mean average RPE of 1.44 units

more while walking on the Curve when compared to the treadmill. This difference was statistically significant ( $p=.0002$ ) and according to the Borg scale is the difference between very light and light exercise. Even though this difference was statistically significant it might not be practically significant. It is unknown if participants would not walk on the Curve because of the increased perceived exertion.

One issue that might be more important than higher RPE is if the machine generated Caloric value reported by the Curve is correct, especially if it is reporting more calories than actually expended. Their advertising reports the difference of 30%. The formula built in to determine Calories is based on the ACSM running metabolic equation and not the walking metabolic equation. The formula uses the constants of a 6% grade and 180 pounds. It is likely that more users do not fit these constants than those that do. That means both under and over estimation of Calorie expenditure is more likely than it being correct. The running metabolic equation is  $VO_2$  (ml/kg/min) =  $.2(\text{speed}) + .9(\text{speed}) (\% \text{ grade}) + 3.5$ , and the walking metabolic equation is  $VO_2$  (ml/kg/min) =  $.1(\text{speed}) + 1.8(\text{speed}) (\% \text{ grade}) + 1.5$ . When these formulas are calculated for a 180 pound male walking at a 6% incline, the running formula will overestimate the actual 8.3 Calories per minute by 18.28%.

### **Recommendations**

Three recommendations for further research include

- Compare participants on a running protocol that matches the Curve formula. At the same time it would be necessary to determine whether it is possible to maintain a 6% grade on the Curve.

- Compare experienced and inexperienced Curve participants and/or a training study to determine whether experience and familiarity decreases the metabolic cost and RPE.
- The last recommendation would be to have better control of the environment being used in the study. Since the study took place in a public fitness center, the environment was different with each testing procedure. This included different music, television shows, patrons, and distractions, which could have stressed participants differently. Forsman and Linbald (1983) showed that mental stress can raise heart rate by 12.4 beats per minute and systolic blood pressure by 11.8mm Hg, both of which can affect energy expenditure (McArdle et al., 2009).

### **Overall Contribution and Summary**

The present findings agree with previous studies that non-motorized treadmill exercise requires greater metabolic demand than motorized exercise at sub-maximal levels (De Witt et al., 2009; Lee et al., 2008; Moore et al., 1984). Some variables measured in these studies included heart rate,  $VO_2$ , and RPE. The present study also agrees with Snyder and colleagues (2011) that the Curve requires greater metabolic demand than a motorized treadmill. The present study focused on Calorie expenditure, which is important to the U.S. population because two thirds of the U.S. population is attempting to lose weight. The finding that the Curve expended 44% more Calories than a motorized treadmill can help people decide which exercise machine to use. The Curve can be a useful tool for people short on time who are trying to meet physical activity recommendations to lessen the chance of having CHD and type 2 diabetes (CDC, 2013;

Garber et al., 2011; USDHHS, 2008), or trying to follow weight loss recommendations by expending 2000 Calories a week (Donnelly et al., 2009; Klem et al., 1997). This chapter included an overview of the study, a discussion drawn from the results, recommendations for future research, and the overall contribution of the study.

## References

- Blair, S. N., Kampert, J. B., Kohl, H. W., Barlow, C. E., Macera, C. A., Paffenbarger, R. S., & Gibbons, L. W. (1996). Influences of cardiorespiratory fitness and other precursors on cardiovascular disease and all-cause mortality in men and women. *JAMA the Journal of the American Medical Association*, 276(3), 205-210.
- Booth, M. L., Bauman, A., Owen, N., & Gore, C. J. (1997). Physical activity preferences, preferred sources of assistance, and perceived barriers to increased activity among physically inactive Australians. *Preventive Medicine*, 26(1), 131-137.
- Borg, G. (1998). *Borg's Perceived Exertion and Pain Scales*. Champaign, IL: Human Kinetics.
- Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports*, 100(2), 126.
- Centers for Disease Control and Prevention. (2013). Physical Activity. Retrieved from <http://www.cdc.gov/physicalactivity>
- Clay, D. E. (2000). *Comparing kilocalorie expenditure between a stair-stepper, a treadmill, and an elliptical trainer*. Eastern Washington University, WA.
- Cleland, R., Graybill, D. C., Hubbard, V., Khan, L. K., Stern, J. S., Wadden, T. A., Daynard, M. (2001). Commercial weight loss products and programs: What consumers stand to gain and lose? A public conference on the information consumers need to evaluate weight loss products and programs. *Critical Reviews in Food Science and Nutrition*, 41(1), 45-70.



- Cordain, L., Gotshall, R., Boyd Eaton, S., & Boyd Eaton, S. (1998). Physical activity, energy expenditure and fitness: An evolutionary perspective. *International Journal of Sports Medicine, 19*, 328-335.
- Dewitt, J. K., Lee, S. M., Wilson, C. A., & Hagan, R. D. (2009). Determinants of time to fatigue during nonmotorized treadmill exercise. *Journal of Strength & Conditioning Research, 23*(3), 883-890.
- Donnelly, J. E., Blair, S. N., Jakicic, J. M., Manore, M. M., Rankin, J. W., & Smith, B. K. (2009). American College of Sports Medicine position stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Medicine & Science in Sports & Exercise, 41*(2), 459-471.
- Eaton, S. B., & Eaton, S. B. (2003). An evolutionary perspective on human physical activity: Implications for health. *Comparative Biochemistry and Physiology-Part A: Molecular & Integrative Physiology, 136*(1), 153-159.
- Faul, F., Erdfelder, E., Lang, A., & Buchner, A. (2007). G\* power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191.
- Flegal, K. M., Carroll, M. D., Kuczmarski, R. J., & Johnson, C. L. (1998). Overweight and obesity in the United States: Prevalence and trends, 1960-1994. *International Journal of Obesity and Related Metabolic Disorders, 22*(1), 39.
- Ford, E. S., Kohl, H. W., Mokdad, A. H., & Ajani, U. A. (2005). Sedentary behavior, physical activity, and the metabolic syndrome among US adults. *Obesity Research, 13*(3), 608-614.

- Forsman, L., & Lindblad, L. E. (1983). Effect of mental stress on baroreceptor-mediated changes in blood pressure and heart rate and on plasma catecholamines and subjective responses in healthy men and women. *Psychosomatic Medicine*, 45(5), 435-445.
- Fox, K. R., & Hillsdon, M. (2007). Physical activity and obesity. *Obesity Reviews*, 8(s1), 115-121.
- Garber, C., Blissmer, B., Deschenes, M., Franklin, B., Lamonte, M., Lee, I., Swain, D. (2011). American College of Sports Medicine position stand. quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Medicine & Science in Sports & Exercise*, 43(7), 1334.
- Ham, S. A., Kruger, J., & Tudor-Locke, C. (2009). Participation by US adults in sports, exercise, and recreational physical activities. *Journal of Physical Activity & Health*, 6(1), 6-14.
- Hamilton, M. T., Healy, G. N., Dunstan, D. W., Zderic, T. W., & Owen, N. (2008). Too little exercise and too much sitting: Inactivity physiology and the need for new recommendations on sedentary behavior. *Current Cardiovascular Risk Reports*, 2(4), 292-298.
- History of treadmills. (2013). Retrieved from <http://www.indepthinfo.com/treadmills/history-of-treadmills.php>
- How many calories did you burn? (1999). *Tufts University Health & Nutrition Letter*, 17(3), 1.

- Hu, F. B., Li, T. Y., Colditz, G. A., Willett, W. C., & Manson, J. E. (2003). Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. *JAMA the Journal of the American Medical Association*, 289(14), 1785-1791.
- Jakes, R., Day, N., Khaw, K., Luben, R., Oakes, S., Welch, A., Wareham, N. (2003). Television viewing and low participation in vigorous recreation are independently associated with obesity and markers of cardiovascular disease risk: EPIC-Norfolk population-based study. *European Journal of Clinical Nutrition*, 57(9), 1089-1096.
- Katzmarzyk, P. T., Church, T. S., Craig, C. L., & Bouchard, C. (2009). Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Medicine & Science in Sports & Exercise*, 41(5), 998-1005.
- Klem, M. L., Wing, R. R., McGuire, M. T., Seagle, H. M., & Hill, J. O. (1997). A descriptive study of individuals successful at long-term maintenance of substantial weight loss. *The American Journal of Clinical Nutrition*, 66(2), 239-246.
- Kram, R. (2000). Muscular force or work: What determines the metabolic energy cost of running? *Exercise & Sport Sciences Reviews*, 28(3), 138-143
- Lee, S., DeWitt, J. K., Smith, C., Laughlin, M. S., Loehr, J. A., Norcross, J., & Hagan, R. D. (2008). Physiologic responses and biomechanical aspects of motorized and nonmotorized treadmill exercise: A ground-based evaluation of treadmills for use on the International Space Station. *NASA Technical Paper, NASA/TP2006213734*. Washington, DC, National Aeronautics and Space administration.

- Lee, D. C. (2009). Does physical activity ameliorate the health hazards of obesity?  
*British Journal of Sports Medicine*, 43(1), 49-51.
- McArdle, W. D., Katch, F. I., & Katch, V. L. (2009). *Exercise Physiology: Nutrition, Energy, and Human Performance* Lippincott Williams & Wilkins.
- Moore, M., Lewthwaite, J., Daggett, A., & Davies, B. (1984). Metabolic responses to running on the motorized and nonmotorized treadmills (les reponses metaboliques a la course sur tapis roulant motorise et non motorise). *Journal of Sports Sciences*, 2(3), 206-207
- Morris, J. N., Kagan, A., Pattison, D. C., Gardner, M. J., & Raffle, P. A. B. (1966). Incidence and prediction of ischaemic heart-disease in London busmen. *The Lancet*, 288(7463), 553-559..
- Nocon, M., Hiemann, T., Müller-Riemenschneider, F., Thalau, F., Roll, S., & Willich, S. N. (2008). Association of physical activity with all-cause and cardiovascular mortality: A systematic review and meta-analysis. *European Journal of Cardiovascular Prevention & Rehabilitation*, 15(3), 239-246.
- Paffenbarger Jr, R. S., Hyde, R., Wing, A. L., & Hsieh, C. (1986). Physical activity, all-cause mortality, and longevity of college alumni. *New England Journal of Medicine*, 314(10), 605-613.
- Paffenbarger, R. S., Blair, S. N., & Lee, I. (2001). A history of physical activity, cardiovascular health and longevity: The scientific contributions of Jeremy N. Morris. *International Journal of Epidemiology*, 30(5), 1184-1192.

- Patel, A. V., Bernstein, L., Deka, A., Feigelson, H. S., Campbell, P. T., Gapstur, S. M., Thun, M. J. (2010). Leisure time spent sitting in relation to total mortality in a prospective cohort of US adults. *American Journal of Epidemiology*, 172(4), 419-429.
- Physical fitness equipment: a global strategic business report. (2012, November). Retrieved from <http://www.companiesandmarkets.com/Market/Leisure/Market-Research/Physical-Fitness-Equipment-A-Global-Strategic-Business-Report/RPT610320>
- Porcari, J., Foster, C., & Schneider, P. (2000). Exercise response to elliptical trainers. New research shows effectiveness of elliptical-motion trainers. *Fitness Management*, 50-53.
- Reichert, F. F., Barros, A. J., Domingues, M. R., & Hallal, P. C. (2007). The role of perceived personal barriers to engagement in leisure-time physical activity. *American Journal of Public Health*, 97(3), 515.
- Salmon, J., Owen, N., Crawford, D., Bauman, A., & Sallis, J. F. (2003). Physical activity and sedentary behavior: A population-based study of barriers, enjoyment, and preference. *Health Psychology*, 22(2), 178-188. doi:10.1037/0278-6133.22.2.178
- Saris, W. H. M., Blair, S. N., van Baak, M. A., Eaton, S. B., Davies, P. S. W., Di Pietro, L., Wyatt, H. (2003). How much physical activity is enough to prevent unhealthy weight gain? Outcome of the IASO 1st stock conference and consensus statement. *Obesity Reviews*, 4(2)

- Serdula, M. K., Mokdad, A. H., Williamson, D. F., Galuska, D. A., Mendlein, J. M., & Heath, G. W. (1999). Prevalence of attempting weight loss and strategies for controlling weight. *JAMA the Journal of the American Medical Association*, 282(14), 1353-1358.
- Snyder, A., Myatt, C., Weiland, N., & Bednarek, J. (2011). Energy expenditure while walking on a non-motorized treadmill. *The Journal of Strength & Conditioning Research*, 25, S109.
- Swain, D. P. (2009). Assessing the advertised claims. *ACSM's Health & Fitness Journal*, 13(5), 8-11.
- Taylor, H. L., Klepetar, E., Keys, A., Parlin, W., Blackburn, H., & Puchner, T. (1962). Death rates among physically active and sedentary employees of the railroad industry. *American Journal of Public Health and the Nations Health*, 52(10), 1697-1707.
- The National Weight Control Registry. (2013). Retrieved from <http://www.nwcr.ws/Research/default.htm>
- Treadmills. (2013). *Consumer Reports*. Retrieved from <http://www.consumerreports.org/cro/treadmills.htm>
- United States Department of Health and Human Services. (2008). 2008 Physical Activity Guidelines for Americans. Be active, healthy, and happy. US Government Printing Office. 21-28
- Wadden, T. A., & Stunkard, A. J. (Eds.). (2004). *Handbook of Obesity Treatment*. Guilford Press.

Weight management market will top \$40 Billion by 2016. (2013). Retrieved from <http://www.packagedfacts.com/about/release.asp?id=3158>

Wing, R. R., & Phelan, S. (2005). Long-term weight loss maintenance. *The American Journal of Clinical Nutrition*, 82(1), 222S-225S.

Yusuf, H. R., Croft, J. B., Giles, W. H., Anda, R. F., Casper, M. L., Caspersen, C. J., & Jones, D. A. (1996). Leisure-time physical activity among older adults: United States, 1990. *Archives of Internal Medicine*, 156(12), 1321.

Zeni, A. I., Hoffman, M. D., & Clifford, P. S. (1995). Energy expenditure with indoor exercise machines. *JAMA the Journal of the American Medical Association*, 275(18), 1424

## Which Machine Burns the Most Calories?

- ◆ Help us find the answer by participating in the study
- ◆ What do you need to do?  
Walk at 3 MPH for ten minutes on each machine
- ◆ Contact Nick Robertson on how to participate  
[nrobertson@ewu.edu](mailto:nrobertson@ewu.edu)



Curve



Treadmill



## Appendix B: Par-Q

Physical Activity Readiness  
Questionnaire - PAR-Q  
(revised 2002)

# PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
<input type="checkbox"/>	<input type="checkbox"/>	1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
<input type="checkbox"/>	<input type="checkbox"/>	2. Do you feel pain in your chest when you do physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	3. In the past month, have you had chest pain when you were not doing physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
<input type="checkbox"/>	<input type="checkbox"/>	5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
<input type="checkbox"/>	<input type="checkbox"/>	7. Do you know of any other reason why you should not do physical activity?

If  
you  
answered

## YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

## NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

### DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
- if you are or may be pregnant — talk to your doctor before you start becoming more active.

**PLEASE NOTE:** If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

**Informed Use of the PAR-Q:** The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

**No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.**

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME \_\_\_\_\_

SIGNATURE \_\_\_\_\_

DATE \_\_\_\_\_

SIGNATURE OF PARENT  
or GUARDIAN (for participants under the age of majority) \_\_\_\_\_

WITNESS \_\_\_\_\_

**Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.**



## Appendix C: Borg 6-20 Scale and Instructions

---

# RPE Scale

rating of perceived exertion

rating	description
6	NO EXERTION AT ALL
7	EXTREMELY LIGHT
8	
9	VERY LIGHT
10	
11	LIGHT
12	
13	SOMEWHAT HARD
14	
15	HARD (HEAVY)
16	
17	VERY HARD
18	
19	EXTREMELY HARD
20	MAXIMAL EXERTION

## Borg's RPE Scale Instructions

While exercising we want you to rate your perception of exertion, i.e., how heavy and strenuous the exercise feels to you. The perception of exertion depends mainly on the strain and fatigue in your muscles and on your feeling of breathlessness or aches in the chest.

Look at this rating scale; we want you to use this scale from 6 to 20, where 6 means "no exertion at air" and 20 means "maximal exertion."

- 9 corresponds to "very light" exercise. For a normal, healthy person it is like walking slowly at his or her own pace for some minutes.
- 13 on the scale is "somewhat hard" exercise, but it still feels OK to continue.
- 17 "very hard" is very strenuous. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired.
- 19 on the scale is an extremely strenuous exercise level. For most people this is the most strenuous exercise they have ever experienced.

Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. Don't underestimate it, but don't overestimate it either. It's your own feeling of effort and exertion that's important, not how it compares to other people's. What other people think is not important either. Look at the scale and the expressions and then give a number.

Any questions?

## Appendix D: Informed Consent

---



Wendy E. S. Repovich, Ph.D., FACSM  
 Director, Exercise Science  
 PEHR Department  
 PEB 200  
 Cheney, WA 99004-2476

Cheney • Spokane

---

### **Comparing Calorie expenditure and RPE between the Curve and a motorized treadmill** In partial fulfillment of the Master's Thesis for Nicholas Robertson

Principal Investigator: Nicholas Robertson, Graduate candidate for the MS in Exercise Science, EWU PEHR, (509) 947-7970;

Responsible Project Investigator: Wendy Repovich, PEHR Department, (509) 359-7960

#### **Purpose and Benefits**

The purpose of this study is to determine if any difference in calorie expenditure and rating of perceived exertion (RPE) exists while walking at three MPH between the Curve and a treadmill. This study will add to the limited research on calorie expenditure and Rating of Perceived Exertion differences between the Curve, and a conventional motorized treadmill. Your participation in this study is voluntary. This research may help solidify claims made by the Curve. In addition, this research will help the principal investigator meet the requirements for a Masters Degree in Exercise Science.

#### **Procedures**

To participate in this study you must be relatively healthy. To determine health status you will complete a PAR-Q, an activity readiness questionnaire. You will be required to attend one familiarization session and three data collection sessions. During the familiarization session you will practice walking on the three exercise devices. You will also be shown the machine that will measure calorie expenditure. The machine consists of a rubber mask to be worn on the face and a gas analyzer to be carried on the chest. No severe discomfort should be noticed while using the machine. Standard instructions will be given to you on how to rate your perceived exertion. When you arrive on testing days you will be fitted with the breathing mask, and the machine will be strapped to your chest. The walking warm up will take 3-4 minutes. The actual test consists of walking at a comfortable pace (3 miles per hour) for 10 minutes. Your perceived exertion will be recorded at five and ten minutes. This testing protocol will then be repeated for the other exercise machine on specific testing days. Your participation is voluntary and you can stop the test at any time.

---

voice: (509) 359-7960 fax: (509) 359-4833 email: wrepovich@mail.ewu.edu

Eastern Washington University is committed to affirmative action and equal opportunity.

---

#### **Risk, Stress or Discomfort**

This study consists of submaximal walking on two separate aerobic exercise machines. Due to submaximal efforts, there should be no overwhelming stress or discomfort during any session. Calorie expenditure will be measured indirectly through oxygen consumption. To measure oxygen consumption a mask will be put over the face and nose. A gas analyzer will be carried on the chest and measure oxygen consumption on a breath-by-breath basis. A heart rate monitor will also be worn underneath clothing. If you have not had oxygen consumption measured or worn a heart rate monitor you may experience some discomfort.

#### **Inquiries**

Any questions about the procedures used in this study are encouraged. If you have any concerns, questions, or would like more information please contact Wendy Repovich or Nick Robertson prior to signing the informed consent form. We can be reached at (509)-359-7960, [wrepovich@ewu.edu](mailto:wrepovich@ewu.edu); and (509) 947-7970, [nickabodcrane21@gmail.com](mailto:nickabodcrane21@gmail.com) respectively.

#### **Other Information**

Identifiable information gathered from the research will only be known to the principal investigator and responsible project investigator. You are expected to give truthful information on the PAR-Q form. You are able to withdraw from this study at any time without repercussions. If you have any concerns about your rights as a participant in this research or any complaints you wish to make, you may contact Ruth Galm, Human Protections Administrator ([rgalm@ewu.edu](mailto:rgalm@ewu.edu); 509-659-6567).

---

Signature of Principal Investigator

---

Date

#### **Subjects Statement**

The study described above has been explained to me, and I voluntarily consent to participate in this study. I have had many opportunities to ask questions; I understand that by signing this form I am not waiving my legal rights. I understand that I will receive a signed copy of this form

---

Signature of Subject

---

Date

---

## Appendix E: Calibration

### Calibration

Please refer to the software manual for the set up and a calibration overview.

#### ► Set the reference values

To set reference values from the K4 b<sup>2</sup> Portable Unit go to the main menu, choose **Calibration** and scroll tasks up to choose **Set Cal. Predicted Values**, type the values using the arrow keys and press **Enter** to confirm changes.

#### ► Turbine calibration

Before starting the calibration procedure, be sure that the turbine type is properly selected.

Please select on the portable unit **1.Settings/8.Turbine 18/28** and set *Turbine 18* or *Turbine 28*.

1. Screw up the adapter for the calibration syringe to the optoelectronic reader.
2. Connect the optoelectronic reader to the calibration syringe. Before starting the calibration be sure to have inserted the right reference value for the syringe. To check it, select **Volume Syringe** from the **Set predicted value** menu.

```
Syringe volume
vol:3000 ml
```

3. Then choose **Calibration** from the main menu and press **Enter**.
4. Scroll the menu, choose **Turbine Calibration** and press **Enter**.
5. Start moving the syringe till the message "*Operate syringe*" will disappear on the display. The display will show expired (E) and inspired (I) readings for each stroke.

```
Operate syringe
#x/8E:2926I:2936
```

6. When the display visualizes the message "*Calibration done*" the Turbine has been calibrated, press **Cancel** to return to the main menu, the new calibration factor will be automatically stored.

#### ► Room air calibration

**Note:** After turning on the unit, wait 45 minutes warm up time before starting the calibration procedure.

**Important:** During calibration always remove the sampling tube from the optoelectronic reader. Do not remove the sampling tube from the Portable Unit otherwise calibration could be affected.

**Caution:** During Room Air calibration be sure to put the sampling line far from the expired gas otherwise calibration could be affected.

**Caution:** Room Air calibration performed in small rooms (high concentration of CO<sub>2</sub>) affects the calibration results and the accuracy of the following test.

1. Remove the sampling plug from the flowmeter.
2. In the main menu choose **Calibration** menu, choose **Room Air Calibration** and confirm by pressing **Enter**.

```
Do not breath..
O2:20.7 CO2: 0.4
```

3. The procedure is automatically performed until the message "*Calibration done*" appears, the O<sub>2</sub> and CO<sub>2</sub> values will be visualized on the display.

```
Calibration done
O2:20.9 CO2:0.0
```

4. Exit the Calibration menu by pressing **Enter** or **Cancel**.

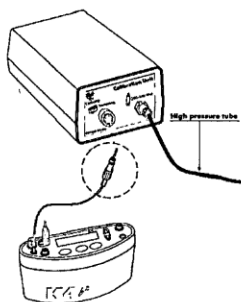
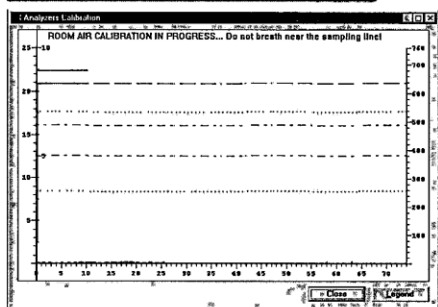
#### ► Reference gas calibration

**Notice:** Do not use mixtures with a O<sub>2</sub> concentration above 24% (out of the O<sub>2</sub> sensor range) or under 15%.

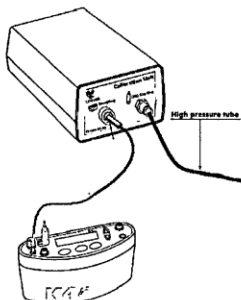
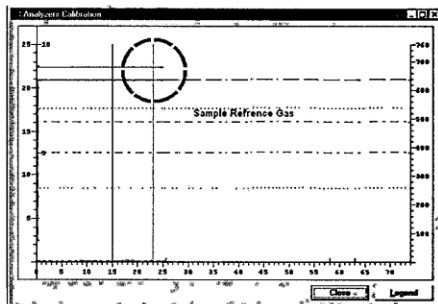
**Notice:** Before calibrating be sure the "Reference values" of room air and reference gas are properly entered.

1. Remove the sampling plug from the flowmeter.
2. In the main menu choose **Calibration** menu, choose **Reference gas calibration** and confirm by pressing **Enter**.

**Do not breath..**  
**O2:20.7 CO2: 0.4**

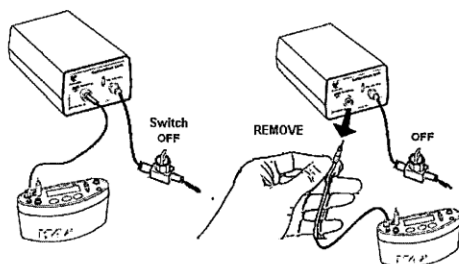


3. The K4 b<sup>2</sup> runs first the Room Air calibration, so do not connect the sample plug to cylinder output until the message "Sample reference gas..." will be displayed. At the end of the procedure the message "Calibration done" will be visualized.



**Calibration done**  
**O2:16.0 CO2:5.0**

4. Exit the Calibration menu by pressing **Enter** or **Cancel**.
5. Remove the sampling line from the kit and close the cylinder.



#### ► Delay calibration

1. On the main menu scroll the commands, choose **Calibration** and press **Enter** to confirm the choice.
2. Choose **O<sub>2</sub>/CO<sub>2</sub> delay calibration** and press **Enter** to confirm.
3. The following message appears, and the software automatically run the Room air Calibration.

### ► Reference gas calibration

The software allows to automatically calibrate zero, gain and alignments of the gases sensors. Even if the program doesn't force you to carry out the calibration, the system should be calibrated before each test. To perform a sensor calibration, a cylinder with a known concentration of mixed gas is necessary. It is suggested to use CO<sub>2</sub> 5,00% , O<sub>2</sub> 16% concentrations and N<sub>2</sub> for balance.

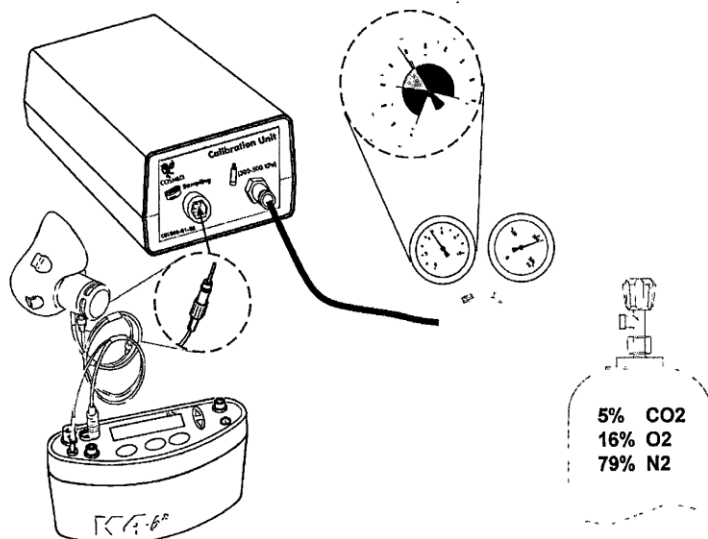
**Notice:** Do not use mixtures with a O<sub>2</sub> concentration above 24% (out of the O<sub>2</sub> sensor range) or under 15%.

**Notice:** Before calibrating be sure the "Reference values" of room air and reference gas are properly entered.

#### The calibration unit

The gas regulator has an adjustable second stage that must be open every time the cylinder is used for the calibration. This is necessary to avoid a small leakage in the connections can discharge the bottle in few time.

1. Make sure you wait for warm-up time before starting calibrating. Be sure the high-pressure tube supplied together with the system is connected to the "Cylinder" plug.
2. Open the cylinder valve by turning the valve counter-clockwise, the pressure value must be set within a range of 300-500 Kpa (3-5 bars or 44-73 Psi).



**Caution:** Be sure that the cylinder pressure out is regulated to 3 and 5 bar.



## VITA

Author: Nicholas B. Robertson

Place of Birth: Columbia, South Carolina

Undergraduate Schools Attended: Brigham Young University-Idaho

Degrees Awarded: Bachelor of Science, 2012, Brigham Young University-Idaho

Honors and Awards: Graduate Assistantship, Physical Education Health and Recreation Department, 2012-2014