EXAMINING THE METABOLIC REQUIREMENTS AND PHYSIOLOGIC RESPONSES OF ACTIVE-ASSISTED AND RECUMBENT CYCLING IN HEALTHY OLDER ADULTS

Skye Richards

University of Rhode Island, skye_richards@uri.edu

Follow this and additional works at: https://digitalcommons.uri.edu/theses

Recommended Citation
https://digitalcommons.uri.edu/theses/2327

This Thesis is brought to you for free and open access by DigitalCommons@URI. It has been accepted for inclusion in Open Access Master's Theses by an authorized administrator of DigitalCommons@URI. For more information, please contact digitalcommons-group@uri.edu.
EXAMINING THE METABOLIC REQUIREMENTS AND PHYSIOLOGIC RESPONSES OF ACTIVE-ASSISTED AND RECUMBENT CYCLING IN HEALTHY OLDER ADULTS

BY

SKYE RICHARDS

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN KINESIOLOGY

UNIVERSITY OF RHODE ISLAND

2023
ABSTRACT

Background Active-assisted (AA) cycling is a form of aerobic cycling exercise that utilizes specialized cycling equipment outfitted with a motor to assist individuals with maintaining their workload/intensity. AA cycling has predominantly been used in research studies to assess its effects on aspects of physical and mental health in individuals with neurodegenerative diseases. At present, there have been no published studies examining the physiological responses to a standard protocol of AA in healthy older adults. Objectives The purpose of this cross-sectional study was to examine the physiological responses in oxygen consumption (\(\text{VO}_2\)), heart rate (HR), and rating of perceived exertion (RPE) during acute bouts of AA and compare them to responses during an equivalent bout of recumbent (RB) cycling in healthy older adults (age: 58.5 ± 6.70 years. Bouts of AA and RB modes were completed at 1) 65-70% estimated maximal heart rate (HRmax) of the individual, and 2) at a self-selected pace (SSP) of the Borg RPE 12-13. Methods Ten participants (female=7, male=3) completed a baseline acclimatization session in addition to four 25-minute exercise sessions conducted at the same time of day, with at least one week between visits. The four exercise sessions included two-AA sessions and two-RB sessions conducted in randomized order. During each session, participants completed 5 minutes of warm-up cycling, followed by 15 minutes of exercise at their assigned intensity on their assigned bicycle, concluding with a 5-minute cool down. Oxygen consumption was measured using MedGraphics Ultima™ CardioO2® gas exchange analysis system (Saint Paul, MN, USA), HR was measured using a heart rate monitor, and RPE was self-reported.
using the Borg Rating of Perceived Exercise Scale. A series of 2x3 way ANOVAs were conducted to examine differences between relative VO2, HR and RPE values from AA and RB (2 modes) between minutes 3-5, 8-10, and 13-15 (3 time points) for each of the prescribed conditions (65-70% HRmax and RPE). Results VO2, HR and RPE increased from resting conditions and steady state was achieved in each of the exercise trials, regardless of cycling mode or intensity prescription and there were no statistically significant differences found between time points or trials (all p > .05) between AA and RB for 65-70% estimated HRmax and SSP. Conclusion As, AA and RB produced similar acute physiological responses to exercise prescribed using 65-70% estimated HRmax and SSP, both modes of cycling may be effective approaches for increasing moderate intensity exercise among healthy older adults.
ACKNOWLEDGMENTS

The completion of this thesis could not have been possible without the expertise and support of Dr. Christie Ward-Ritacco, my major advisor. I would also like to thank Dr. Matthew Delmonico, Dr. Christine Clarkin, and Dr. Alisa Baron for sitting on my committee.

A debt of gratitude is also owed to the research team, including Dr. Christie Ward-Ritacco, Dr. Deborah Riebe, Dr. Vanessa Harwood, Dr. Alisa Baron, Dr. Christine Clarkin, Dr. Matthew Delmonico, Dr. Mark Hartman, Dr. Susan D'Andrea, Jake Laverdiere, Aden Woods, Sofia Catalano, Tiffany Ung, Emily Jelfs, Alex Seng, Melissa Kluglein, Gabby Zuccolo, Amanda Sieck, and Emma-Leigh Lamonde.

Finally, I would like to thank my husband, Brendan Richards; my parents, Mr. and Mrs. Sloman; and my grandmother, Aurelia Scorgie. Without you, none of this would have been possible.
PREFACE

This thesis has been written in manuscript format.
# TABLE OF CONTENTS

ABSTRACT ................................................................................................................ ii

ACKNOWLEDGMENTS ........................................................................................ iv

PREFACE ...................................................................................................................... v

TABLE OF CONTENTS ................................................................................................. vi

LIST OF TABLES .......................................................................................................... vii

LIST OF FIGURES ....................................................................................................... viii

INTRODUCTORY ......................................................................................................... 1

CHAPTER 1 ...................................................................................................................... 2

INTRODUCTION ........................................................................................................... 2

CHAPTER 2 ...................................................................................................................... 6

REVIEW OF LITERATURE ........................................................................................... 6

CHAPTER 3 .................................................................................................................... 19

METHODOLOGY .......................................................................................................... 19

CHAPTER 4 .................................................................................................................... 26

FINDINGS ..................................................................................................................... 26

CHAPTER 5 .................................................................................................................... 34

CONCLUSION ............................................................................................................... 34

APPENDICES ............................................................................................................... 40

BIBLIOGRAPHY ........................................................................................................... 83
**LIST OF TABLES**

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1. Panton et al. (1996)(^1) physiological data during 60% HRmax across minutes 4-5 and 5-6 on a treadmill.</td>
<td>13</td>
</tr>
<tr>
<td>Table 2. Experimental Protocol</td>
<td>19</td>
</tr>
<tr>
<td>Table 3. Participant Demographics (n=10)</td>
<td>26</td>
</tr>
<tr>
<td>Table 4. Resting Heart Rate (HR – bpm) Values of Participants by Trial</td>
<td>27</td>
</tr>
<tr>
<td>Table 5. Participant speed and resistance values at each Trial and each time point</td>
<td>28</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1. Participant Recruitment. ................................................................. 27</td>
<td></td>
</tr>
<tr>
<td>Figure 2. VO$_2$, HR, and RPE during 65-70%HRmax during Trials A &amp; C ...... 30</td>
<td></td>
</tr>
<tr>
<td>Figure 3. VO$_2$, HR, and RPE during RPE 12-13 during Trials B &amp; D ............ 32</td>
<td></td>
</tr>
</tbody>
</table>
INTRODUCTORY

This manuscript is prepared for submission to the *Transitional Journal of the American College of Sports Medicine*. 
CHAPTER 1

INTRODUCTION

Active Assisted (AA) cycling is a mode of aerobic exercise that utilizes a mechanical assist to support individuals achieving and maintaining a workload that may be greater than their self-selected pace (SSP).\textsuperscript{31} The use of AA cycling has been predominantly studied with groups of individuals with neurodegenerative diseases, including Parkinson’s disease (PD),\textsuperscript{3,4,18,19,27,31} and post-stroke patients,\textsuperscript{10} and Down syndrome (DS)\textsuperscript{10,11}. Clinically meaningful improvements in motor function,\textsuperscript{10,11,14,19,27} cardiorespiratory fitness,\textsuperscript{10,31} and cognitive function\textsuperscript{6} have been observed for individuals with neurodegenerative diseases as a result of acute exercise sessions using AA cycling. While this mode of cycling may also be appropriate for healthy older adults, a recent thorough search of the relevant literature yielded no results for acute or chronic studies observing the effects of AA cycling in healthy older adults.

There are two forms of AA cycles that have been regularly used in studies with individuals with neurodegenerative diseases. First, stationary tandem (ST) cycling utilizes a two-person cycle that allows the trainer (front seat) to pedal and create forced exercise (FE) to the participant (rear seat).\textsuperscript{3,18,19,31} The FE intervention occurs when the participant maintains the same cadence produced by the trainer, which may be greater than their SSP.\textsuperscript{3,18,19,31} Secondly, modified motorized stationary (MMS) cycles utilize a motor which is regulated by the participant manipulating an external control (i.e., computer-based control) allowing
for FE. With this type of cycling, the cadence and workload are set externally by the participant, and the motor assists the participant in maintaining the set workout. With all AA modes of exercise, despite being assisted, individuals are instructed and encouraged to actively contribute when performing the cycling task. Thus far, these two AA cycles have primarily been utilized in clinic-based interventions, but there have been recent AA models that have been introduced in the commercial and community-based settings. The Theracycle 200 (XThera Cooperation, Franklin, MA, USA) is an AA cycle that is available for purchase for personal use. Theracycle designed their AA model with the intention of helping individuals achieve higher cadence and workloads than they may be able to achieve with a self-paced traditional cycle, due to the motorized function of the Theracycle product. The introduction of an AA cycle that can be purchased for in-home, or outpatient use, has the potential to produce similar clinically meaningful improvements as those cycles used in clinic-based setting. Increasing availability and affordability of these products may allow multiple populations to continue rehabilitation or exercise outside of clinic-based settings.

To our knowledge, the physiologic responses (e.g., oxygen consumption - VO₂, blood pressure, heart rate) of AA cycling are not well characterized for any population, including healthy older adults. As AA cycling is gaining popularity as a training and rehabilitation tool among the healthy older adult population, a more comprehensive understanding of the physiological effects of this mode of exercise is warranted.
This study will provide us with insight into the metabolic requirements and perceptual responses to AA cycling versus traditional RB in healthy older adults at standard and SSP. As it is hypothesized that AA cycling will result in similar or less intense perceptions of effort compared to RB at the same workload/intensity, these results will provide insight long-term exercise prescription adherence. Validation of efficacy for the Theracycle would come from well designed, experimental studies enrolling at first a group of healthy individuals, where metabolic responses will be evaluated to ensure that this new form of training or exercise (i.e., the Theracycle, AA) provides an adequate mechanical stimulus to elicit physiological adaptations.

The purpose of this study was to evaluate the metabolic workload (VO$_2$) required for acute bouts of active-assisted cycling (using Theracycle) and traditional cycling (using RB) cycling in healthy older adults, performing two bouts of exercise at 1) 65-70% of the individual’s theoretical maximal heart rate (HRmax), and 2) at a SSP corresponding to 12-13 on the Borg RPE scale. We expected that in healthy older adults, RB will increase metabolic workload to a greater extent than the AA bout in both conditions. We also expected that, independently of the ergometer used, the effort at 65-70% estimated HRmax will induce a higher metabolic workload than the SSP.

In this study, comparing the physiological (VO$_2$, HR, RPE) responses to AA cycling with traditional RB at standard and SSP provided valuable insight about the effects of these modes of aerobic exercise in a small group of healthy older adults. Determining the acute metabolic responses to bouts of exercise performed
with Theracycle AA, compared to RB, provided crucial baseline information for designing future research projects utilizing AA as a training modality.
REVIEW OF LITERATURE

The following literature review will introduce the concepts related to 1) FE and AA cycles, 2) RB cycles, 3) metabolic requirements and physiological responses to cycling, 4) healthy older adults and physical activity, and 5) PD, DS, and post-stroke patients utilizing AA and RB cycles. This review seeks to describe our current understanding of this topic area, allowing for the identification of the gaps in knowledge in responses to active-assisted cycling among the healthy older adult population.

**FE and AA Cycles**

Forced exercise is defined as cycling (an aerobic exercise mode), where the rate of the exercise is mechanically augmented to assist the participant in achieving and maintaining an intensity that is higher than their preferred voluntary rate of exercise (VE).\(^3,4,11,16,17,27\) FE is performed either by human trainers maintaining the set pace, \(^3,4,11,16,17,27\) or AA devices that utilize motors maintaining the set pace.\(^10,11,14,19,31\) During FE, participants must be actively engaged in the exercise and the rate of exercise is altered to mechanically achieve the target exercise rate.\(^17\)

FE was first utilized as a mode for exercise in animal studies.\(^3,4,11,18,27,29\) Rodents with PD symptoms performed a FE treadmill intervention that required them to maintain a running speed greater than its voluntary pace.\(^3,11,23,27,29\) This rodent study found that FE improved motor function and that it was neuroprotective,
showing behavioral function recovery and a reduction in the loss of neurochemicals in Parkinson’s-treated animals compared to the sham group. Animal study protocols were then translated into human participant studies using specialized FE equipment. Stationary bicycles allowing for FE were created to allow for the exercise rate to be augmented to assist the participant in achieving a higher intensity. Currently, there are two specialized stationary bicycles typically used in human trials examining the effects of FE.

The first type of specialized stationary bicycle is the tandem bicycle. Tandem cycling is performed on a stationary, two-person bicycle, with a trainer in the front providing an augmented cycling rate to the participant seated in the rear. The cycle utilizes a drivetrain linking pedals with a timing chain, forcing the two riders to consistently pedal at the same rate. Power output is measured at the rear wheel of the stationary tandem bicycle.

The second specialized stationary bicycle that is used in research protocols is the motorized AA cycle (i.e., Theracycle). The XThera Cooperation (Franklin, MA, USA) created the Theracycle 200, a stationary bicycle that has motorized pedals and can be programmed to move at the participants selected speed. The Theracycle 200 has handlebars that move as the participant pedals. The pedals are designed to include the upper body, which is a unique feature. In published research to date using the Theracycle 200, the handlebars have been disabled and not used, as upper body movement/involvement could alter the intensity of the exercise and HR response and could be intimidating for participants. The Theracycle 200 provides
participants with motorized-assisted therapy that has been shown to reduce symptoms and improve motor skills and mobility in individuals with PD, multiple sclerosis, spinal cord injury, muscular dystrophy, cerebral palsy, down syndrome, arthritis, and/or post-stroke patients. Research utilizing the Theracycle cycle has been performed with PD participants, where researchers collected physiological response data including heart rate (HR), blood pressure, and rate of perceived exertion (RPE) but with no cycling measures collected such as the speed selected on Theracycle.

**RB Cycles**

A RB cycle is a non-weight bearing cycle that provides postural support, minimal fall risk, and constant kinematics for the user. The RB cycle’s speed is maintained by the cyclist and the resistance, determined by the manufacturer and represented by increasing number values, is selected by the cyclist. RB cycles have been utilized in research for individuals with PD and knee injuries. Currently, there is limited, if any, literature describing the metabolic requirements and physiological responses to RB cycling in adult populations.

**Metabolic Requirements and Physiological Responses to Cycling**

Commonly evaluated physiological responses to cycling exercise include: (a) Oxygen uptake (VO₂), (b) HR, (c) blood pressure [systolic blood pressure/diastolic blood pressure], (d) respiratory exchange ratio (RER), and (e) RPE. Oxygen uptake (VO₂) reflects the metabolic work being done by the participant and can be used to determine one’s prescribed training intensity. HR is positively and linearly related to VO₂ (VO₂ = Q x a-VO₂difference, where Q is the product of HR
and stroke volume).\textsuperscript{15} As HR is a relatively easy measure to obtain, when compared to VO\textsubscript{2}, it is often used in the determination and monitoring of an individual's aerobic training intensity.\textsuperscript{21} HR can be measured with a heart rate monitor or by palpation, while VO\textsubscript{2} requires a face mask and metabolic cart to capture the gases utilized and produced during exercise.\textsuperscript{21} VO\textsubscript{2} can be measured in both absolute (L/min) or relative (mL/kg/min) terms.\textsuperscript{21} Absolute VO\textsubscript{2} is the amount of liters of oxygen consumed in one minute, where relative VO\textsubscript{2} is the amount of milliliters of oxygen per kg of body weight consumed in one minute.\textsuperscript{20} During steady state bouts of cycling, VO\textsubscript{2} increases exponentially during the first few minutes and will typically reach a plateau between the third and fourth minutes if intensity is unchanged.\textsuperscript{15} Once steady state is reached, with no further adjustments in intensity, VO\textsubscript{2} will remain relatively stable for the duration of the cycling bout.\textsuperscript{15}

Blood pressure (BP) is also an important measure of health, as it reflects the body’s ability transport blood throughout the body.\textsuperscript{15} Blood pressure is measured by the systolic pressure over the diastolic blood pressure. Systolic blood pressure reflects the force exerted against the arterial walls during ventricle systole, and diastolic blood pressure reflects the force exercise during diastole and estimates facilitation of blood flow from arterioles into capillaries.\textsuperscript{15} During acute bouts of cycling, changes in blood pressure occur as vasodilation within active muscles decreases total peripheral resistance and allows for the enhancement of blood flow throughout large quantities of the peripheral vasculature.\textsuperscript{15} There is a rapid increase of systolic pressure during the first few minutes of cycling due to
increased blood flow, and for healthy adults, blood pressure typically plateaus at approximately 140 to 160 mmHg during steady-state cycling. As the steady-state cycling continues, up to 60 minutes, the systolic pressure will progressively decline due to the arterioles within the active muscles continually dilating which further reduces peripheral resistance to blood flow. Diastolic pressure during steady-state cycling typically remains relatively stable/unchanged throughout the exercise, but small decreases or increases may also be observed.

RER is calculated by dividing the amount of CO$_2$ produced by the volume of O$_2$ consumed, which reflects the exchange of CO$_2$ and O$_2$ under differing physiological and metabolic conditions in the pulmonary system. RER values indicate when the body is in an aerobic or anaerobic state and values range from 0.70 to 1.00. When RER is ~1.00, this theoretically indicates that 100% of the ATP generated is being produced by the anaerobic metabolization of carbohydrates, while an RER of ~0.70 indicates that theoretically 100% of the ATP produced is done so via the aerobic metabolization of triglycerides. When RER is between 1.00 and 0.70, there is a mixture of carbohydrate and triglycerides being aerobically metabolized for the production of ATP and in healthy adults resting RER is ~0.80, indicating that approximately 2/3 triglycerides and 1/3 carbohydrates are being metabolized for energy. RER can be used to estimate the amount of carbohydrates and triglycerides that are being used during steady state. During steady state exercise, RER typically ranges from 0.80 to 0.88 when triglycerides are the primary fuel. RER that reaches 1.00 can be used to determine
that submaximal VO₂ has been obtained, where the aerobic-to-anaerobic processes crossover.⁹

RPE is a self-reported indicator of exercise intensity and can be measured using one of two available validated scales - the Borg Scale which ranges from 6-20 (Appendix 7), or the Borg Category-Ratio 10 (CR-10) scale which ranges from 1-10.¹⁶,²¹,³⁴ The lower anchors of each scale (1 and 6) are associated with self-reporting associated with no exertion at all, while the upper anchors (10 and 20) correspond with self-reported associated with maximal exertion.¹⁶,²¹,³⁴ The Borg RPE scale is used to determine the combination of all psychological and physiological sensations and feelings during the activity without focus on one factor but an overall feeling of exertion.³⁴ The Borg Scale values theoretically correspond to heart rate, by multiplying the value by 10 to determine the individuals expected heart rate when providing that RPE value (e.g. a healthy adult gives a value of 6 on the Borg RPE, corresponds to a heart rate of 60 bpm).³⁴ Borg RPE of 12 to 14 suggests the individual is working at a moderate level of intensity.³⁴ RPE can vary for each individual and each trial due to physiological and psychological factors.²⁰ Two physiological factors that can influence the RPE values provided are: (a) local factors, representing the feeling of tension in the working muscles/joints, and (b) central factors, representing the feeling from the cardiorespiratory systems (heart rate, ventilation, respiratory rate, oxygen consumption, and blood lactate).⁸,²⁰ Psychological factors that can influence the RPE values include: trait factors, and behavioral factors.⁸ Trait factors allow for trait dispositions of: (a) extraversion, experience positive effects, and (b) neuroticism, experience negative effects
(anger, anxiety, self-consciousness). Behavior factors are: (a) behavioral activation, pleasant emotions activated, (b) behavior inhibition, negative emotions (withdrawal from situations and people), and (c) self-efficacy, individuals success is based on how the individual thinks, behaves, feels, and how supported they are from individuals around them.

When maximal heart cannot be determined using maximal testing, HRmax equations are commonly used, with the Fox formula (220-age) being used most often. The literature suggests that the Tanaka formula [208-(0.7*age)] may be more accurate and should be utilized to predict HRmax in healthy adults, as the Fox formula was found to underestimate HRmax in older adults, which can affect the true level of physical stress produced during exercise testing and the appropriate intensity of an individualized prescribed exercise program.

Currently there are no established normative values when evaluating physiological responses in older adults during submaximal exercise. But Panton et al. (1996) performed a study with 55 men and women, aged 60 to 80 years, to determine relative physiological values during incremental submaximal exercise conducted on a treadmill (Table 1). The purpose of this study was to examine the relationship between %HRmax and %VO2max within the older adult population, during a range of submaximal exercise intensities. The study found that for sedentary older adults the %HRmax method was a more conservative and safer method for determining the exercise intensity prescription.
Table 1: Panton et al. (1996) physiological data during 60% HRmax across minutes 4-5 and 5-6 on a treadmill.

<table>
<thead>
<tr>
<th>Measure</th>
<th>60% HRmax (Minutes 4-5)</th>
<th>60% HRmax (Minutes 5-6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPE</td>
<td>12.8 ± 1.4</td>
<td>13.1 ± 1.6*</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>168 ± 22</td>
<td>169 ± 22</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>80 ± 11</td>
<td>80 ± 11</td>
</tr>
<tr>
<td>RER</td>
<td>0.90 ± 0.07</td>
<td>0.90 ± 0.07</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>123 ± 14</td>
<td>124 ± 14*</td>
</tr>
<tr>
<td>Absolute VO$_2$ (L/min)</td>
<td>1.12 ± 0.31</td>
<td>1.13 ± 0.32</td>
</tr>
</tbody>
</table>

*Minutes 5-6 values are significantly different from corresponding minutes 4-5 values (p<0.05). RPE = rating of perceived exertion; SBP = systolic blood pressure; mmHg = millimeters of mercury; DBP = diastolic blood pressure; RER = respiratory exchange ratio; HR = heart rate; bpm = beats per minutes; VO$_2$ = oxygen consumption; L = liters.

Healthy Older Adults and Physical Activity

As regular participation in physical activity (PA) is associated with preserved mobility and physical function, and a delay the onset of chronic diseases across the life course, access to exercise programs in outpatient or at-home environments are needed to allow aging individuals, especially those with chronic conditions, to maintain behaviors that may counteract the typical age-related changes in physiological outcomes. Even though the benefits of PA on health and physical function across the lifespan are widely disseminated, only 24.2% of adults (ages 18 and over) are meeting recommended aerobic exercise recommendations included in the 2018 Physical Activity Guidelines for Americans (PA Guidelines) by 2020 estimates. The percentage of men (28.3%) who meet both the aerobic and resistance training recommendations included in the PA Guidelines was higher than women (20.4%), with a decline in both men and women as age...
increases. Twenty-one percent of older adults ages 50-64 meet both PA guidelines and 15.3% ages 65 and older meet both PA guidelines. The most recent American College of Sports Medicine (ACSM) Guidelines for aerobic PA recommend that older adults perform PA at (a) moderate intensity for at least 30 minutes per day, or up to 60 minutes per day, in bouts of at least 10 minutes each for a total 150 to 300 minutes per week, (b) vigorous intensity for at least 20 to 30 minutes per day to total 75 to 150 minutes per week, or (c) equivalent combination of both. It is well established that exercise therapy is beneficial for older adults.

**PD, Stroke, and Post-Stroke Patients Utilizing AA and RB Cycles**

The understanding of the impacts of AA cycling and RB cycling have been explored in the literature, but it is important to understand how this can translate to other populations. There has been AA cycling research performed with individuals that have PD, DS, and post-stroke patients, that can be translated in possible benefits for other individuals with neurological conditions and for relatively health older adults. Applying the current findings could allow for the creation of community and/or clinical programs for all older adults, including those with other neurological conditions.

**PD - Tandem Bike (FE)**

Indoor tandem bicycle FE programs have been found to be beneficial for PD patients with mild to moderate symptoms with results of improved physical performance with gait, balance, and mobility. This suggests that there is a potential reversal or slowing down of physical function decline due to the FE
cycling program. Tandem FE cycling (40 minute FE sessions, 3 sessions per week for 8 weeks, maintaining a cadence of 80-90 rpm) have been shown to produce similar increases in motor functions as medication (ON MEDS: data collected 1 hour after the participant took their antiparkinsonian medication; OFF MEDS: data collected 12 hours after the participant took their antiparkinsonian medication) for individuals with PD. Currently, the literature suggests that FE and antiparkinsonian medication, that promotes dopamine release, targets the utilize similar inhibitory neural pathways to improve PD symptoms. Interventions using FE on individuals with PD have been designed to engage participants in regular activity between 8 and 10 weeks. The dose of FE was similar across studies and included acute sessions that were one hour in duration, held three times a week, structured as a 10-minute warm-up, 40-minute exercise session, and a 10-minute cool down. These studies did not have control groups and were not crossover studies. Participants were given 2–5-minute breaks every 10 minutes, if needed. During VE, participants are encouraged to pedal their stationary bicycle at a comfortable pace. When participants set their VE pace, researchers encouraged them to aim for a 3-4 (moderate) on a RPE scale from 1-10. During FE, the pedaling rate of the participant would be increased by approximately 30% more than their VE pace. The pace for FE would be modified by the trainer or motorized cycle by obtaining a higher pedaling rate than the participant would during their VE (cadence increased to 80 to 90 rpm).
**PD – AA cycles**

The literature notes that AA has been found to be more effective than VE with individuals with PD. A intervention using AA on individuals with PD was designed to compare FE tandem bike studies with AA cycling. Ten participants diagnosed with idiopathic PD with the mean age of 64 performed AA cycling three sessions per week for 8 weeks. The participants were given a 5 minute warm-up and a 5 minute cool down at 40 to 50 rpm. The participants performed AA cycling with the motor set to 75 rpm and instructed to pedal at 80 to 85 rpm for 30 minutes. This cadence was determined from previous studies that noted that a cadence of at least 80 rpm has shown clinical, motor, and cognitive benefits for individuals with PD. To obtain the prescribed cadence, participants were instructed to overpower the motor and were able to see the cadence on the AA monitor. During each session, HR, RPE, and pedal power (watts) were monitored, and participants were provided with encouragement throughout the sessions. There was no control group and it was not a crossover study. This study found that there were improvements in PD tremors and bradykinesia in the upper extremity with the participants that were ON medication.

**Post-Stroke – AA cycles**

A quasi-counterbalanced cross-over intervention utilizing AA with individuals, who had at least one unilateral hemorrhagic or ischemic stroke that was within six months of the study, completed four visits which were spaced out five to 10 days apart. The participants completed a prescribed AA visit, a VE visit, and a no cycling (NC) visit. The AA visit consisted of 25 minutes of cycling,
including a 5-minute warm up without assistance from the motor, 15 minutes programmed target cadence, and a 5-minute cool down. The VE visit consisted of 25 minutes of AA cycling, including a 5-minute warm up at their preferred cadence and continued for an additional 20 minutes at their preferred cadence. The NC visit consisted of the participant sitting on the AA cycle with their feet on the pedals but they did not cycle, instead they spoke with the researcher about their PA habits. It was noted that the HR and RPE did not change between the prescribed AA and VE visits, but were significantly lower in the NC visit. The rate of movement (cadence) was the only notable difference between the prescribed AA and VE visits.

*Down’s Syndrome (DS) – AA*

The literature notes that AA has been found to be more effective in improving motor function and cardiorespiratory fitness than VE with individuals with DS. In a randomized study, 43 adolescents were randomly assigned to 8 weeks of AA (n=17), VE (n=16) or NC (n=11). The AA session included cycling 80% faster than the VE group. The study determined that there were cortical benefits from both the AA and VE groups. Another study examined eight adults diagnosed with DS (mean age of 39.2 ± 6.4 years old) using an intervention requiring three sessions a week for eight weeks, totaling 24 sessions. Each participant was randomly assigned to either eight weeks of AA using Theracycle or eight weeks of VE. Each session included a five minute warm-up, 30 minutes of cycling, and a 5 minute cool down. The AA cycling session consisted of 30 minutes at 35% faster than their voluntary warm-up pace. The VE session
consisted of 30 minutes of a voluntary pace. The study found that the AA group established an improved aerobic fitness and exercise capacity due to their six-meter walk test (6MWT) results improving compared to the VE group. This implies that AA cycling may assist individuals with DS in their ability to perform activities of daily living and potentially keep their functional independence.

**Summary**

Incorporating new technology, like FE cycling, into available exercise programming for older adults and those with chronic disease conditions may be one strategy for increasing PA levels among these cohorts. Specifically, FE is a tool that can be used to physically train older adults and those with neurogenerative diseases using AA. AA allows may individuals to exceed their self-selected cadence and increase their total workload to a level that results in improved motor function, cardiorespiratory fitness, and cognitive function. Therefore, examining the physiological requirements of using novel forms of AA, such as the Theracyle, is warranted to provide us with a greater understanding of the utility of this mode of exercise for all adults, including relatively healthy older adults interested in increasing their physical activity levels for the improvement or maintenance of their health status.
CHAPTER 3

METHODOLOGY

The Effects of Assisted vs. Traditional Cycling in a Cohort of Healthy Adults

The study was approved by the Institutional Review Board at the University of Rhode Island (IRB1920-138) in February 2020. Principal investigators of the study were Christie L. Ward-Ritacco, Ph.D., FACSM; Christine Clarkin, PT, DPT, Ph.D.; Alisa Baron, PhD; and Vanessa Harwood, PhD.

Study Design:

This cross-sectional study required enrolled participants to visit the University of Rhode Island's Kinesiology Laboratory for five in-person visits. The baseline visit required approximately three hours, while the remaining four visits required approximately 1.5-2.0 hours. Table 2 demonstrates the experimental protocol for each of the five visits and assessed at each trial.

Table 2: Experimental Protocol. Each participant completed Trials A-D in a randomized order.

<table>
<thead>
<tr>
<th>Baseline (3 hours)</th>
<th>Trial A (1.5 hours) AA: 65-70% HRmax</th>
<th>Trial B (1.5 hours) AA: RPE 12-13</th>
<th>Trial C (1.5 hours) RB: 65-70% HRmax</th>
<th>Trial D (1.5 hours) RB: RPE 12-13</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Informed consent</td>
<td>• Resting HR &amp; BP</td>
<td>• Resting HR &amp; BP</td>
<td>• Resting HR &amp; BP</td>
<td>• Resting HR &amp; BP</td>
</tr>
<tr>
<td>• Anthropometrics &amp; personal characteristics measurement</td>
<td>• AA at prescribed intensity (including warmup and cool down)</td>
<td>• AA at self-selected intensity (including warmup and cool down)</td>
<td>• RB at prescribed intensity (including warmup and cool down)</td>
<td>• RB at self-selected intensity (including warmup and cool down)</td>
</tr>
<tr>
<td>• Resting HR &amp; BP</td>
<td>• VO₂ measurement</td>
<td>• VO₂ measurement</td>
<td>• VO₂ measurement</td>
<td>• VO₂ measurement</td>
</tr>
<tr>
<td>• Familiarization with ergometers, VO₂ &amp; RPE</td>
<td>• Exercise HR, BP, &amp; RPE</td>
<td>• Exercise HR, BP, &amp; RPE</td>
<td>• Exercise HR, BP, &amp; RPE</td>
<td>• Exercise HR, BP, &amp; RPE</td>
</tr>
</tbody>
</table>
Location

All study activities were conducted in room 230J, on the second floor of the Independence Square building, at the University of Rhode Island in Kingston, RI.

Study Population:

Older adults, aged 50-85 years, were recruited from the area surrounding the University via flyers, social media, and by word of mouth. Interested individuals were emailed an online pre-screening questionnaire (Appendix 1) to assess initial eligibility based on identified inclusion and exclusion criteria.

Inclusion Criteria:

Individuals were qualified to participate if they were adults, aged 50-85 years old with a body mass index (BMI) between 18.5 – 40 kg/m². Participants self-reported that they were able to 1) walk without the use of assistive devices (e.g., cane, walker, etc.), 2) ride a stationary cycle for 25 minutes of aerobic exercise, 3) read, speak, and understand English, and 4) secure transportation to URI for five in-person visits. Prior to participation, all participants were also cleared to exercise using the criteria set forward by the ACSM exercise pre-participation screening (Appendix 6).⁴

Exclusion Criteria:

Individuals were excluded from study participation if they self-reported a diagnosis of any chronic condition that affected their balance and/or diagnosis of a balance condition (e.g., Parkinson’s disease, vertigo, tumor, Meniere’s disease, etc.). Additionally, participants were unable to participation if they reported taking medications known to affect balance or heart rate (e.g., beta blockers).
Study Protocol:

Eligible participants were invited for an onsite baseline visit. During the baseline visit, eligibility was confirmed, and in case of positive outcomes, individuals were asked to provide written consent. A teach-back exercise was used to ensure participant understanding of study requirements, including time commitment and potential risks. After obtaining written consent, anthropometric measures were assessed [height, weight, body mass index (BMI), and body composition]. Resting heart rate and blood pressure were assessed after five minutes of seated rest; this evaluation was performed at each of the five visits. Next, the participants were familiarized with both the Theracycle (no handlebars) and recumbent cycle on seating position, pedaling requirements, and intensity adjustments that were to be utilized in each of the remaining four visits. Participants were also familiarized with oxygen consumption (VO\textsubscript{2}) measurements and practiced cycling while wearing the required face mask/respiratory gas collection equipment (Hans Rudolph Series 7450 V2 Mask Face PC/Brace RV2 SI Blue, and headgear for HRI ORO-Nasal Masks, Shawnee, KS, USA). Participants were also familiarized with the Borg Rating of Perceived Exertion (RPE) 6 to 20 scale to rate their self-reported level of effort.

For the remaining four visits, trials were conducted in randomized order for each participant to be completed within four weeks, determined using computer generated randomization. Each trial was performed at least 7 days apart, around the same time of day. During the 7 days between the baseline trial and first exercise trial, physical activity levels were assessed using accelerometry.
ActiGraph GT9X. Data was valid if participant had 7 days of step data. All cycling trials consisted of a five-minute warm-up, 15 minutes of cycling at a prescribed intensity, and a five-minute cool down for a total of 25 minutes of aerobic activity. The four trials included: 15 minutes of AA cycling at 65-70% HRmax (Trial A), 15 minutes of AA at a self-selected pedaling rate and resistance that elicited a 12-13 rating on the Borg RPE scale (Trial B), 15 minutes of RB cycling at 65-70% HRmax (Trial C), and 15 minutes of RB at a self-selected pedaling rate and resistance that elicited a 12-13 rating on the Borg RPE scale (Trial D). The speed on the Theracycle and the resistance on the RB were adjusted throughout the trial to ensure that the participant maintained the prescribed intensity. The participants were blinded to their metrics with the cycle screens covered, HR monitor was out of view, and computer screens were not visible.

Prior to each experimental trial, researchers calibrated the metabolic cart and pneumotach using standardized procedures (MedGraphics Ultima™ CardioO2® gas exchange analysis system, Saint Paul, MN, USA). Also, prior to each session, researchers calculated 65-70% of the participants estimated HRmax, with HRmax calculated using the Tanaka formula. Throughout the trials, breath-by-breath data collection occurred continuously with data then calculated and presented as 30 second averages. Heart rate was continuously measured by the researchers out of view from the participants with a Polar Heart Rate Monitor (H1, Kempele, Finland) in beats per minute (bpm) and recorded every minute, to ensure participants maintained prescribed intensity and ensure participant safety. Blood pressure was measured using an automated blood pressure cuff (Omron, BP785,
Wake Forest, IL, USA) every five minutes during exercise to ensure an appropriate blood pressure response. RPE was assessed every five minutes utilizing the Borg Scale (6-20), to measure subjective intensity and for appropriate trials to ensure participants maintained their self-selected pace requirement.

**Outcome Measures:**

All testing sessions were standardized with participants arriving at their assigned time, which was held steady for all sessions. Participants were instructed to arrive well hydrated (3L of water the day before, and drink some the day of), to refrain from drinking caffeine 24 hours prior, and to refrain from engaging in structured physical activity three hours before reporting to the laboratory.

*Metabolic Workload:* VO\textsubscript{2} was measured with the utilization of the Ultima Series Cardiorespiratory Diagnostics System (MedGraphics Ultima\textsuperscript{TM} CardioO2, Saint Paul, MN, USA), in liters per minute (L/min). Relative VO\textsubscript{2} raw data (mL/kg/min), corrected for kilograms of body weight, was exported from the system. Relative VO\textsubscript{2} values were then averaged at three time points across each trial at minutes 3-5, 5-10, and 10-15.

*Heart Rate and Rating of Perceived Exertion:* HR in bpm was collected every minute and the Borg RPE values was collected every five minutes. These values were averaged for at three time points across the trial at minutes 3-5, 5-10, and 10-15 for each of the four exercise trials.

The warm-up and cool down data were collected but not reported, as is standard practice, as HR and RPE have been reported to be lower and fluctuate more during these time periods.\textsuperscript{11}
**Statistical Analysis:**

Descriptive statistics (mean and standard deviation) was utilized to characterize the participants. Data, of a difference of 3.0 (SD = 3.0) mL/kg/min, was assessed for normality using skewness (<3) and kurtosis (<10). No abnormal data were identified; therefore, no transformations were necessary prior to analysis. Sample size calculation was completed for potential mean differences in VO₂ between AA and RB utilizing Panton et al. (1996)²¹ stage 2 relative VO₂ standard deviation of 3.0 mL/kg/min (18%) with approximately 16.5 mL/kg/min as the measured value. A series of 2 x 3-way ANOVA (2 modes and 3 time points), with the p-value set at <0.05, was utilized to assess differences between the average relative VO₂, HR, and RPE from Theracyle and recumbent cycle (2 modes) between minutes 3-5 (T1), 8-10 (T2), and 13-15 (T3) (3 time points) for each of the prescribed conditions (RPE and 65-70% HRmax). Analyses were also conducted to assess difference between HR and RPE at the same time points across trials. Commercial software was used for statistical analysis (SPSS v26, IBM, USA).

**Resources Required:**

Funding for the study was provided by the Rhode Island Foundation (PI: C. Ward-Ritacco). The Theracyle 200 (AA) was provided by XThera Corporation (Franklin, MA, USA). Funding for cleaning supplies was provided by the Dr. Thomas “Doc” Manfredi Scholarship through the Department of Kinesiology at the University of Rhode Island. Additional resources required for the study were available within the Department of Kinesiology and include the InBody 770 BIA device (Biospace Co, Ltd, Korea), ActiGraph GT9X (ActiGraph, Pensacola, FL,
USA), the Ultima Series Cardiorespiratory Diagnostics System (MedGraphics Ultima™ CardioO2, Saint Paul, MN, USA), Polar H1 heart rate monitor (Polar Electro Co, Kempele, Finland), Omron upper arm blood pressure monitor (Omron Healthcare Inc, USA), Precor C846i recumbent cycle (Precor, Woodinville, WA, USA) and the Borg RPE scale.
FINDINGS

Participants:

Participant demographics are displayed in Table 3. Twenty individuals expressed interest in participating, and of those, 18 completed the screening survey. Sixteen were eligible to participate in the study. Two were not eligible for participation - one did not finish screening survey; and one had a known heart condition. Two were lost to follow-up. Of the 16 eligible participants, 10 completed all five study visits (3 males; 7 females), as four declined to enroll in the study, and two were lost to follow-up. Recruitment and retention information is displayed in Figure 1.

Table 3: Participant Demographics (n=10)

<table>
<thead>
<tr>
<th></th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (%)</td>
<td>30% Male; 70% Female</td>
<td>---</td>
</tr>
<tr>
<td>Age (years)</td>
<td>58.5 ± 6.7</td>
<td>50.0 – 74.0</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.9 ± 7.7</td>
<td>155.3 – 178.9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>77.9 ± 20.3</td>
<td>54.7 – 126.3</td>
</tr>
<tr>
<td>Body Mass Index (kg/m²)</td>
<td>28.5 ± 6.1</td>
<td>21.6 – 39.5</td>
</tr>
<tr>
<td>% Body Fat</td>
<td>37.4 ± 8.4</td>
<td>21.5 – 44.4</td>
</tr>
<tr>
<td>Steps/day</td>
<td>7194.1 ± 4564.1</td>
<td>2913.0 – 17059.1</td>
</tr>
<tr>
<td>MVPA/week (minutes)</td>
<td>210.6 ± 194.9</td>
<td>34 – 680</td>
</tr>
<tr>
<td>MVPA/day (minutes)</td>
<td>23.6 ± 27.1</td>
<td>4.9 – 97.1</td>
</tr>
</tbody>
</table>

MVPA = moderate to vigorous intensity physical activity
Participants (70% female) were 58.5± 6.7 (mean± SD) years of age and had a BMI of 28.5± 6.1 kg/m². Average resting heart rate values for participants at each visit are displayed in Table 4. The average estimated 65-70% HRmax for participants ranged from 107.3 ± 3.7 bpm to 116.6 ± 3.2 bpm. Workload for each participant during each trial is shown in Table 5.

Table 4: Resting Heart Rate (HR – bpm) Values of Participants by Trial

<table>
<thead>
<tr>
<th>Visit</th>
<th>HR (bpm) Mean ± SD</th>
<th>HR (bpm) Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>68.7 ± 13.9</td>
<td>49.0 - 89.0</td>
</tr>
<tr>
<td>Trial A</td>
<td>66.2 ± 10.7</td>
<td>52.0 – 83.0</td>
</tr>
<tr>
<td>Trial B</td>
<td>66.6 ± 8.3</td>
<td>54.0 – 78.0</td>
</tr>
<tr>
<td>Trial C</td>
<td>71.4 ± 12.7</td>
<td>45.0 – 90.0</td>
</tr>
<tr>
<td>Trial D</td>
<td>70.0 ± 12.6</td>
<td>54.0 – 85.0</td>
</tr>
</tbody>
</table>
Table 5: Participant speed and resistance values at each Trial and each time point. Participant (P) speed (unknown unit) values for Theracycle trials (Trial A: 65-70% HRmax and Trial B: RPE 12-13). Participant (P) speed (mph) and resistance (Res - unknown unit) values for recumbent trials (Trial C: 65-70% HRmax and Trial D: RPE 12-13).

<table>
<thead>
<tr>
<th></th>
<th>Trial A</th>
<th></th>
<th>Trial B</th>
<th></th>
<th>Trial C</th>
<th></th>
<th>Trial D</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1 Speed</td>
<td>T2 Speed</td>
<td>T3 Speed</td>
<td>T1 Speed</td>
<td>T2 Speed</td>
<td>T3 Speed</td>
<td>T1 Speed</td>
<td>T2 Speed</td>
</tr>
<tr>
<td>P1</td>
<td>14.0</td>
<td>9.4</td>
<td>9.0</td>
<td>7.0</td>
<td>8.0</td>
<td>8.0</td>
<td>9.4</td>
<td>8</td>
</tr>
<tr>
<td>P2</td>
<td>6.0</td>
<td>6.0</td>
<td>6.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>12.2</td>
<td>4</td>
</tr>
<tr>
<td>P3</td>
<td>6.0</td>
<td>6.0</td>
<td>6.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>9.5</td>
<td>9.5</td>
</tr>
<tr>
<td>P4</td>
<td>14.0</td>
<td>14.2</td>
<td>15.0</td>
<td>11.0</td>
<td>11.0</td>
<td>11.0</td>
<td>10.6</td>
<td>5</td>
</tr>
<tr>
<td>P5</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>7.0</td>
<td>7.0</td>
<td>6.0</td>
<td>10.0</td>
<td>9</td>
</tr>
<tr>
<td>P6</td>
<td>7.0</td>
<td>7.4</td>
<td>8.0</td>
<td>7.0</td>
<td>5.0</td>
<td>5.0</td>
<td>13.6</td>
<td>8.5</td>
</tr>
<tr>
<td>P7</td>
<td>5.0</td>
<td>5.8</td>
<td>6.2</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>10.2</td>
<td>7</td>
</tr>
<tr>
<td>P8</td>
<td>6.0</td>
<td>5.4</td>
<td>5.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>14.3</td>
<td>13</td>
</tr>
<tr>
<td>P9</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>11.0</td>
<td>7</td>
</tr>
<tr>
<td>P10</td>
<td>12.0</td>
<td>13.0</td>
<td>13.0</td>
<td>11.0</td>
<td>11.0</td>
<td>11.0</td>
<td>16.0</td>
<td>13</td>
</tr>
</tbody>
</table>
The 2 x 3-way mixed ANOVA examining VO$_2$ for Trials A and C, violated the sphericity assumption, therefore the Greenhouse-Geisser correction was utilized when interpreting the results. There was no significant main effect for time \([F(1.3, 23.4) = 1.61, \ p=0.22]\) and no significant interaction effect between time and trials for VO$_2$ \([F(1.3, 23.4) = 1.44, \ p=0.25]\) with values of 12.62 ± 2.68 mL/kg/min, 12.94 ± 2.79 mL/kg/min, and 12.23 ± 2.65 mL/kg/min at T1, T2, and T3, respectively, for trial A and 14.04 ± 3.13 mL/kg/min, 14.68 ± 3.23 mL/kg/min, and 14.60 ± 3.09 mL/kg/min at T1, T2, and T3, respectively, during trial C (displayed in Figure 2A).

There was no significant main effect for time \([F(2,36) = 3.18, \ p=0.053]\) and no significant interaction between time and trials for HR \([F(2,36) = 0.86, \ p=0.43]\). HR values achieved during Trial A were 106.23 ± 16.58 bpm, 108.08 ± 14.65 bpm, 107.24 ± 13.13 bpm at T1, T2, and T3, respectively. During Trial C HR values were 107.95 ± 15.08 bpm, 110.26 ± 16.32 bpm, was 111.40 ± 16.53 mL/kg/min at T1, T2, and T3, respectively (displayed in Figure 2B).

There was no main effect for time \([F(2,36) = 1.75, \ p=0.19]\) in addition to no significant interaction between time and trial for RPE \([F(2,36) = 1.49, \ p=0.24]\). RPE values achieved during Trial A for T1 were 13.20 ± 1.75, 14.70 ± 1.89, and 13.40 ± 1.75 for the three measured time points. RPE values achieved during Trial C were 12.60 ± 2.27, 12.90 ± 1.97, and 13.20 ± 2.35, at T1, T2, and T3, respectively (displayed in Figure 2C).
Figure 2: Oxygen Consumption (VO₂), Heart Rate (HR), and Rating of Perceived Exertion (RPE) during 65-70% HRmax during Trial A & C.

A: Comparing VO₂ (mL/kg/min) for Trials A and C at Timepoint 1 (T1; 3-5 minutes), Timepoint 2 (T2; 8-10 minutes), and Timepoint 3 (T3; 13-15 minutes);
B: Comparing HR (bpm) for Trials A and C at T1, T2, and T3; and C: Comparing RPE for Trials A and C at T1, T2, and T3.

There was no significant main effect for time \([(F_{2,36}) = 0.186, p=0.83]\) and no significant interaction between time and trials for \(\text{VO}_2\) \([(F_{2,36}) = 1.157, p=0.34]\) with values of 11.58 ± 3.82 mL/kg/min, 11.04 ± 3.41 mL/kg/min, and 11.40 ± 3.37 mL/kg/min at T1, T2, and T3, respectively, for trial B and 13.87 ± 4.06 mL/kg/min, 14.10 ± 3.95 mL/kg/min, and 13.73 ± 3.48 mL/kg/min at T1, T2, and T3, respectively during Trial D (displayed in Figure 3A).

There was no significant main effect for time \([(F_{2,36}) = 0.561, p=0.58]\) and no significant interaction between time and trials for HR \([(F_{2,36}) = 1.13, p=0.34]\). HR values achieved during Trial B were 100.65 ± 19.93 bpm, 98.14 ± 15.96 bpm, and 100.42 ± 17.27 bpm at T1, T2, and T3, respectively. During Trial D HR values were 109.83 ± 22.73 bpm, 110.64 ± 22.13 bpm, and 110.66 ± 20.46 bpm at T1, T2, and T3, respectively (displayed in Figure 3B).

There was no main effect for time \([(F_{2,36}) = 0.093 p=0.91]\) in addition to no interaction between time and trials for RPE \([(F_{2,36}) = 0.592, p=0.56]\). RPE values achieved during Trial B were 12.80 ± 0.79, 12.60 ± 0.70, and 12.80 ± 1.03 at T1, T2, and T3, respectively. RPE values achieved during Trial D were 12.70 ± 0.68, 13.00 ± 1.16, and 12.90 ± 1.20 at T1, T2, and T3, respectively (displayed in Figure 3C).
Figure 3: Oxygen Consumption (VO\textsubscript{2}), Heart Rate (HR), and Rating of Perceived Exertion (RPE) during RPE 12-13 during Trials B & D.
A: Comparing VO\textsubscript{2} (mL/kg/min) for Trials B and D at Timepoint 1 (T1; 3-5 minutes), Timepoint 2 (T2; 8-10 minutes), and Timepoint 3 (T3; 13-15 minutes);
B: Comparing HR(bpm) for Trials B and D at T1, T2, and T3; and C: Comparing RPE for Trials B and D at T1, T2, and T3.
CHAPTER 5

CONCLUSION

Contrary to our hypotheses, it was determined that the metabolic demand of AA and RB are not significantly different when used to complete acute bouts of moderate intensity activity prescribed using relative intensity, objectively (via HRmax) or subjectively (via RPE). These findings are valuable in light of the aging demographics facing our state, nation and the world, as advances in medicine and health care, are allowing individuals to live longer, and consequently, is resulting in a rapidly increasing older adult population.\textsuperscript{7,16,22} As it is recommended that older adults perform 150 minutes of physical activity per week.\textsuperscript{22} at a moderate to vigorous intensity to gain health benefits, such as reduction in fat mass, increase in lean mass, and increase in cognition\textsuperscript{7,16,22}, it is beneficial to know that both traditional recumbent cycling and cycling using AA technology can produce effective moderate intensity bouts of aerobic activity.

Incorporating new technology into exercise programming for older adults and those with chronic disease conditions may be one strategy for increasing PA levels among these cohorts.\textsuperscript{7,16} Specifically, AA is a tool that can be used to physically train older adults and those with neurogenerative diseases using FE.\textsuperscript{3,18,19,31} AA may allow individuals to exceed their SSP (cadence) and increase their total workload to a level that results in improved motor function,\textsuperscript{10,14,19,31} cardiorespiratory fitness,\textsuperscript{10,31} and cognitive function.\textsuperscript{10} Therefore, examining the physiological requirements of using novel forms of AA, such as the Theracycle,
was warranted to provide us with a greater understanding of the utility of this mode of exercise.\textsuperscript{7,16}

While the current investigation examined acute bouts of cycling in healthy adults and there is no comparative literature to our knowledge, there are available studies describing the utilization of AA with randomized group conditions, FE or voluntary cycling (VC) both acutely and across 8 weeks, describing the chronic effects of cycling in individuals with PD.\textsuperscript{4,25,30} These studies demonstrate that a single bout of cycling is associated with immediate improvement in PD tremors and bradykinesia\textsuperscript{25} and that 8 weeks of cycle training with FE is as effective suppressing PD symptoms as antiparkinsonian medications\textsuperscript{4}, and improves PD reaction time and instrumental activities of daily living as VC cycling.\textsuperscript{30}

When comparing FE and VC, studies have found that FE may be more beneficial in for improving motor control than VC for individuals with PD\textsuperscript{3,26,27}, and DS\textsuperscript{10,30} with the utilization of one of the assisted cycle types (AA or tandem cycles).\textsuperscript{10} Studies examining adults with PD and DS that utilized HR response as a comparative measure of FE and VC, found no significant differences in HR response between the conditions, even with a marked difference between cadence rates between the cycles (i.e., FE 40-50% faster than VC).\textsuperscript{11,26,27,30} Overall, these studies demonstrate that a minimum cadence rate of 80 rpm is associated with improvements in clinical, motor, and cognitive function in these specific clinical populations.\textsuperscript{11,26,27,30}

As available studies have demonstrated similar HR values in response to FE and VC regardless of the study design or mode of cycle, these previous findings
support the HR responses experienced by participants in the present study.\textsuperscript{10} A limitation in the current literature is that the FE and VC intensities are not matched to one another to allow for a proper comparison between the two conditions.\textsuperscript{4,10,25,30} It is important to note that previous studies utilizing AA have compared FE and VC approaches utilizing cadence as the comparator between the different modes.\textsuperscript{4,25,30} These studies found that the benefits of FE originate from cadence being at least 73\% or 28 rpm faster than the VC cadence and improvements are associated with neurological stimulation rather than increased cardiorespiratory stress and arousal.\textsuperscript{10} Holzapfel et al. (2016) observed post-stroke patients using an AA cycle across two cycling visits, FE and VC, and with a standard washout period.\textsuperscript{10} There were no significant differences identified between cardiorespiratory responses (HR and percent heart rate reserve) or perception of intensity between the two cycling visits, even with a marked cadence rate difference.\textsuperscript{10} The current study was unable to compare workload between the AA and RB cycles using cadence, as the cycles do not utilize the same metrics (i.e., speed and/or resistance) to determine workload for the participant.

The present study has several limitations. The first limitation is that our sample is comprised of white, community dwelling, relatively healthy older adults. This may limit the generalizability of these findings to other demographic groups. However, as the cohort ranged from 50 and 74 years, there is excellent representation from middle-age to older adulthood across the sample. Additionally, as the participants ranged from relatively sedentary to highly active, this range illustrates that people with varying physical activity levels were safely able to engage in acute bouts of
cycling using either of the modes provided. Also, the average BMI ($28.48 \pm 6.07$ kg/m$^2$) for the cohort was lower than the reported average BMI of adults, 20 years old and older, in the United States which was $33.5$ kg/m$^2$ in 2021$^2$ The average BMI of the females ($n=7$) was $27.8 \pm 6.1$ kg/m$^2$, placing them in the overweight category for BMI, above recommendations for healthy adults. Average BMI of males ($n=3$) was $30.2 \pm 6.1$ kg/m$^2$ putting their BMI in the obese category and above the recommendations for healthy older adults (healthy weight 18.5-24.9 kg/m$^2$).$^2$ The characteristics of the recruited participants may allow the findings to be applied to healthy middle-aged and older adults across this age spectrum and provides support for the use of either of these modes in both active and inactive people in this age range.

Additionally, as the two cycles utilized in this protocol use varying methods to set workload, it is difficult to directly compare workload (i.e., resistance, speed) using the pre-set values determined by the bicycle manufacturers. Theracycle workload is determined based on speed of pedaling set by the “motor” (unknown units) and rotations per minute (rpm), but the true workload is determined by this speed and the resistance supplied by the rider (the slower the speed, the heavier the resistance; the faster the speed, the lighter the resistance). Workload for the recumbent cycle is based on resistance, that can be chosen and set on the cycle, and the self-propelled rpm generated by the rider on speed (mph) and resistance (unknown units). To overcome this limitation, future studies aiming to assess workload -equivalency among these modes should implement the use of technology, such as instrumented insoles, to determine the amount of force the
participant is applying during cycling with both modes. Finally, as participants complete only a series of short, acute bouts of cycling in the present study, the physiologic responses recorded may not be reflective of longer bouts of cycling with either of these modes and/or changes that may occur in response to a chronic program of cycling with either of these modes.

In light of its limitations, we should also address the strengths of the current approach. The repeated measures crossover design allowed each participant to act as their own control for both modes of intensity determination and cycle. Additionally, the research team conducting each trial provided similar verbal and physical cuing for all participants, including the use of standardized scripts, environment, and approach to all measurements, increasing the reliability and validity of the data collected by increasing internal validity. Finally, as the participants ranged from highly active to primarily sedentary, the heterogeneity of PA levels among the participants allows for our results to be applied to a range of older adults with varying activity levels.

To our knowledge, this was the first study to examine acute physiologic effects and related metabolic requirements of AA and RB in healthy older adults. As the older population grows to an estimated 19% (72.1 million) by 2030, there is an increasing need to find modes of activity that can be engaged in safely by older adults. Additionally, as one ages there is typically an increase in sedentary behavior, decrease in physical activity behavior, and relatedly, changes in body composition, including a decrease in lean mass and increase in fat mass, which all impact quality of life in older age. Therefore, it is essential that older adults be
encouraged to adopt or maintain a physically active lifestyle. Finally, as declines in physical and cognitive function are often observed, along with the associated reductions in the quality of life, and when physical activity recommendations are not met, the overall wellness of older adults could be enhanced by adopting a regular program of moderate physical activity, including both self-propelled and AA cycling.

In conclusion, both AA and RB produce similar increases in VO\(_2\), HR, and RPE when moderate intensity exercise is prescribed using relative intensity, via both relative HR methods and self-reported exertion (65-70% HR\(_{\text{max}}\) and self-selected RPE 12-13). These findings support the use of either self-propelled or forced exercise modes when recommending non-weight bearing methods of aerobic exercise for individuals interested in adopting cycling into a physically active lifestyle for healthy older adults.
The purpose of the current research study is to examine the effects of two types of cycling on how you feel during exercise: active-assisted cycling using a specialized stationary bike called a Theracycle, which has a small motor, and a traditional recumbent cycle.

During the study, we will non-invasively measure how much oxygen you use during cycling, how you feel before and after cycling, assess your heart rate and blood pressure during cycling, and ask you how hard you’re working. In order to measure how much oxygen you’re using, you will wear a specialized face mask that covers your mouth and nose allowing us to measure how much air you are breathing in and out. We will also assess your cognitive performance with the use of a specialized cap that allows us to measure the activity of your brain, which is called an EEG, at each of the visits. You will be audio/video recorded. Finally, we will ask you to wear a physical activity monitor on your hip, for 7 days in between 2 of your visits.

The investigators hope the results will enhance the understanding of the energy requirements of these types of cycling and how these types of cycling make people feel. This information could help us to design more optimal exercise programs for people with Parkinson’s Disease.

The study will ask you to visit the University of Rhode Island for 5 in person measurement visits that will take approximately 9 hours total. The first visit will take approximately 3 hours and the other visits will take approximately 1 hour to 1.5 hours.

You will be compensated with $125 ($25 at the end of every visit).

Would you like to learn more about the study?

- [ ] Yes
- [ ] No

Some of these questions pertain to sensitive topics; therefore, there is a possibility that some of these questions may make you uncomfortable. If so, you can skip any questions that you wish not to answer.

All information that you share in this screening process, including your name and any other information that can possibly identify you, will be strictly confidential and will be kept under lock and key.

If we determine that you are not eligible for the study, we will ask for your permission to keep your screening information in a password protected computer file. In the event our eligibility criteria change, and you become eligible for participation in the current study, we will contact you. If you do not want us to keep your information on file, we will record the reason for your ineligibility, without any of your identifying information and destroy your screening information.

If you are eligible for the study and you decide to participate, your information will be coded with an identifying number, and we will contact you to schedule your first visit. Remember, your
participation is voluntary; you can refuse to answer any questions or stop the screening process at any time without penalty or loss of benefits to which you are otherwise entitled.

Do we have your permission to ask you these questions?

☐ Yes

☐ No

Before enrolling you in our study, we need to ask you some questions to determine if you are eligible. Please answer the following questions about yourself and your health history. This should only take approximately 15 minutes of your time.

Are you between the ages of 50-85?

☐ Yes

☐ No

What is your date of birth? (mm/dd/yyyy) ________________________

Do you identify as Male, Female, or Other?

☐ Male

☐ Female

☐ Non-binary/Other gender

☐ Prefer not to say

What is your current body weight in pounds? (lbs) ________________

When was the last time your weight was measured? (mm/dd/yyyy) ________________

What is your current height?
When was the last time that your height was measured? (mm/dd/yyyy)________________

Are you currently FULLY VACCINATED and UP TO DATE for COVID-19. [According to the CDC, fully vaccinated means a person has received all recommended doses in their primary series of COVID-19 vaccine. Up to date means a person has received all recommended doses in their primary series COVID-19 vaccine, and a booster dose when eligible.]

- Yes, I am fully vaccinated AND up to date.
- No, I am not fully vaccinated.
- I am fully vaccinated, but I am not eligible to obtain the booster dose yet.

When will you be eligible to receive your booster dose? (mm/dd/yyyy) _________________

Are you able to read and follow directions given in English?

- Yes
- No

Do you speak any other languages FLUENTLY, besides English?

- Yes
- No

Do you currently walk with an assistive device (i.e., cane, walker, etc.)?

- Yes
- No

Are you able to secure transportation to URI for five WEEKLY measurement visits?
Have you been diagnosed with a balance disorder?

- Yes
- No

Do you take any medications that affect your balance?

- Yes
- No

Do you take any medications that affect your heart rate (i.e., Beta Blocker)?

- Yes
- No

Do you have a pacemaker or any other type of implanted electronic medical device?

- Yes
- No

Display This Question:

If Do you have a pacemaker or any other type of implanted electronic medical device? = Yes

One of the assessments in our study uses bio-electrical impedance analysis to examine your body composition and this type of testing is not recommended for people who have pacemakers and implanted electronic devices. If you participate in the study, we will have you skip this portion of the testing.

Do you think you have the ability to ride a seated stationary bicycle for 25 minutes?

- Yes
- No

Are you currently exercising in a structured exercise program on two or more days per week?
If you are currently exercising in a structured exercise program on two or more days per week? = Yes

If yes, please tell us a little bit more about your exercise routine.

____________________________________

The following questions are intended to ask you about signs and symptoms you may have experienced, your physical activity habits and about chronic conditions that you may have.

**Signs and Symptoms**

Do you experience:

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chest discomfort with exertion</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Unreasonable breathlessness or fatigue</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Dizziness, fainting, blackouts</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. Ankle swelling</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5. Unpleasant awareness of a forceful, rapid, or irregular heartbeat</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>6. Burning or cramping sensations in your lower legs when walking short distance</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7. Known heart murmur</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

**Medical Conditions**
Have you had or do you currently have:

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A heart attack(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Heart surgery, cardiac catheterization, or coronary angioplasty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Pacemaker/implantable cardiac defibrillator/rhythm disturbance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Heart valve disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Heart failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Heart transplantation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Congenital heart disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Diabetes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Renal disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Stroke/transient ischemic attack (TIA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Epilepsy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Other heart/medical condition</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Have you performed planned, structured physical activity for at least 30 minutes at moderate intensity on at least 3 days per week for at least the last 3 months?

○ Yes
○ No

You have successfully completed this questionnaire. Thank you very much for your time. Can we keep your information on file? If yes, we will ask for contact information.

○ Yes
○ No

Personal Information

○ First Name ________________________________

○ Last Name ________________________________

○ Email Address ________________________________

○ Phone Number ________________________________

Preferred form of communication.

○ Email
○ Phone

Display This Question:

If Preferred form of communication = Phone

When is the best time to reach you by phone?

○ AM (after 8 AM)
○ PM (before 5 PM)
○ Either
If you qualify for the study and you accept to participate in this study, what day of the week would you prefer to come in? Please check all that apply.

- [ ] Monday
- [ ] Tuesday
- [ ] Wednesday
- [ ] Thursday
- [ ] Friday

If you qualify for the study and you accept to participate in this study, what time of day would you prefer to come in? Please check all that apply.

- [ ] Mornings (after 7 AM)
- [ ] Afternoons
- [ ] Evenings (before 6 PM)

End of Block: Survey Intro

---

Appendix 2: Baseline Visit Script

**KEY:**
- NON-VERBAL CUES/ACTIONS
- Verbal cues

**THERACYCLE BASELINE SCRIPTS**

**Welcome** (2 minutes)

Welcome to URI, my name is *name* and this is *name*, we are working on this study for the Kinesiology department. These are *Speech names* who are working on this study for the Speech and Communication department. You will meet *PT names* who are working on this study for the Physical Therapy department. We greatly appreciate your interest in our study.  
[Go to Body Composition Room]
**Head Measure** (2 minutes)

Next, *name* needs to measure your head size. Is it okay if *name* measures your head, to get the proper sized cap that will be required for the second portion of this visit?

**Screening** (6 minutes)

First, we’re going to review your screening and the answers you provided. Here is a copy of the answers that you provided, we are going to review them together to confirm, and sign the bottom as a confirmation. Please stop and correct me if any of the following are not true or have changed since you completed the forms.

[GO OVER THE QUESTIONS THAT ARE RELATED TO THE INCLUSION AND EXCLUSION CRITERIA. HAVE PARTICIPANT READ THROUGH THEIR ANSWERS AND SIGN OFF ON IT]

[IF PARTICIPANT HAS SIGNED OFF ON THE SCREENING FORM AND MEETS THE INCLUSION AND EXCLUSION CRITERIA]

We have deemed that you are a qualified candidate for our study.

**Informed Consent** (10 minutes)

This is your informed consent. This goes through the details of the study, and your rights as a participant in the study, including your right to terminate participation at any time. Please read through this form, carefully. If you have any questions or concerns regarding the information on this form, please let us know. After you have read this form, I will ask you to briefly summarize the informed consent to confirm that you understand it.

Can you briefly summarize what you have read?

- If NO - Was it that you did not understand what you read? [EXPLAIN WHAT THEY DID NOT UNDERSTAND]
- If YES - Please sign two copies of the informed consent, one for your records and one for our records.

Thank you for signing the informed consent. We will put one of the signed informed consents in your take home folder for your records.

[ONE COPY FOR GOES IN THEIR TAKE HOME FOLDER AND ONE THE OTHER SHOULD GO INTO THEIR BASELINE VISIT FOLDER UNTIL THE END OF THE VISIT]

**Resting Measurements** (4 minutes)
Next, we need to take a few resting measurements, including blood pressure and heart rate. We will need access to your upper arm to measure blood pressure, is this, okay? Please do not talk while we take these measures.

[PLACE BLOOD PRESSURE CUFF ON LEFT ARM, AND RECORD RESTING BLOOD PRESSURE AND HEARTRATE THEN REMOVE BLOOD PRESSURE CUFF]

**Height** (30 seconds)

Please take off your shoes and follow me to get your height measured.

Please stand with your back to the ruler with your heels as far back as possible. Please stand tall while keeping your shoulders back, head up, and eyes forward. I will first demonstrate how I would like you to stand, then I will have you do it [DEMONSTRATE]. If you need assistance, please let me know.

[OBTAIN HEIGHT-- HAVE PARTICIPANTS STEP OUT - MEASURE HEIGHT AGAIN] [TAKE TWO MEASUREMENTS - A THIRD IF THE TWO MEASUREMENTS VARY]

Thank you, please keep your shoes off and follow me to the InBody to obtain your body composition.

**InBody** (5 minutes)

[MOVE BLUE STABLE CHAIR A FOOT IN FRONT ON INBODY]

Do you have any medically implanted devices?

- If NO- complete InBody
- If YES/UNSURE- do NOT complete InBody

We will now do the InBody. Please sit in this chair and remove your socks. Also, remove all metal objects from your person, including jewelry, belts, and electronic devices. I will give you a wipe for you to first wipe the palms of your hands, then the bottoms of your feet. We will then ask you to stand on the InBody platform, if you need assistance, we can assist you on it or we can get a walker.

The InBody will measure your body composition. It will instruct you to put your heels on the metal circles. It will then instruct you to pick up the hand grips with your arms not touching your sides. It will play elevator music during the test. Please follow the prompts.
[HAVE THE PARTICIPANT STAND ON INBODY AND FOLLOW THE PROMPTS]

A copy of your body composition scan will be placed inside your take home folder for your records. There will also be a paper describing what your scan means in your folder.

**BioSway** (10-15 minutes)

[ENSURE BIOSWAY PLATFORM IS MOVED BACK FROM THE SCREEN]

Please keep your shoes off. We will now perform the BioSway. The BioSway measures your center of gravity and balance. We will perform a balance game.

[HAVE PARTICIPANT START 3 FEET FROM THE PLATFORM]

Please walk on to the platform.

[MAKE SURE THE PARTICIPANT'S CIRCLE IS AT THE TARGET CENTER. HAVE THEM STEP FORWARD OR BACKWARD DEPENDING ON WHERE THE CIRCLE IS. MAKE SURE THE PARTICIPANT’S FEET ARE PARALLEL TO THE 10% LINE WITH THE USE OF THE RULER (TOP DRAWER). ADJUST THE FEET POSITION ON THE SCREEN]

We ask that you stand up tall with your hands relaxed by your side. We will have you perform a practice trial. The goal is to keep the dot as close to the target center as possible for 20 seconds. After the practice trial, we will begin the test. The test will consist of three trials with 10 second rests. The screen will prompt you. Please do not talk during the testing trials.

Now we will start the testing trials.

[START TESTING TRIAL 1]

Now you have a 10 second rest, please do not move your feet but you may relax and rest. Are you ready for your next testing trial? [REPEAT FOR THE NEXT PAUSE]

Please step off. We will now put a foam pad on top of the platform that you were just on; this will mimic an uneven surface. If you want to feel it, you can. We will adjust your feet close to where they were in the original trial. If this foam pad feels too unstable or you feel uncomfortable, we can skip this portion.

Do you feel comfortable trying this foam pad? If at any point you feel unstable, please let us know and we will stop the test.

- If NO - Skip
- If YES - Please step onto the foam pad. We will give you a practice trial, then we will begin the three trials. Again, the test will consist of three 20 second trials with 10 second rest. The screen will prompt you.

Now we will start the testing trials.

START TESTING TRIAL 1

Now you have a 10 second rest, please do not move your feet but you may relax and rest. Are you ready for your next testing trial? [REPEAT FOR THE NEXT PAUSE]

You may step off now. You may put your socks and shoes back on.

**Heading to Communicative Disorders** (2-5 minutes)

Thank you for completing this portion of the visit. We will now walk you down to perform the EEG and a few cognitive function tests with *names*. During this portion of the visit, they will have you perform the non-invasive EEG that measures your brain’s electrical activity while you listen to sounds. They will also perform cognitive and memory tasks with you. Do you have any questions or concerns?

**Communicative Disorders** (30-40 minutes)

**10-Meter Walk Test (10MWT)** (8-10 minutes) [MAKE SURE HAVE TWO CHAIRS & STOPWATCH]

This measurement is called the 10-meter walk test. You will be walking from here to the mark at the far end [walk length of test to indicate]. We will complete two trials. The first set of two, we’ll ask you to walk at a comfortable pace. The pace that you typically use when walking to and from places (similar to walking into the grocery store from the car on a sunny day). The second set we’ll ask you to walk as quickly, but as safely, as you can. This might be a pace similar to how you’d walk into the store from the parking lot on a rainy day.

- **Trial 1** (normal pace):
  Please stand with your feet at the starting line. When I say ‘begin,’ walk at your own comfortable walking pace and stop when you reach the far mark. Ready, set, begin
  [SUBJECT PERFORMS TRIAL 1]
  Please take a seat in this chair and rest for one minute before completing the next trial. If you need more time for rest or need assistance sitting or getting up, please let me know.
[RECORD TRIAL 1 RESULTS]

- **Trial 2** (normal pace):
  Now we will do a second trial at the same pace. Please stand with your feet level with this starting mark. When I say ‘begin,’ walk at your own comfortable walking pace and stop when you reach the far mark. Ready, set, begin.

[SUBJECT PERFORMS TRIAL 2]
Please take a seat in this chair and rest for one minute before completing the next trial. If you need more time for rest or need assistance sitting or getting up, please let me know.

[RECORD TRIAL 2 RESULTS]

- **Trial 3** (fast pace):
  Please stand with your feet at the starting line. When I say ‘begin,’ walk as fast as you can safely walk and stop when you reach the far mark (similar to walking into the grocery store from the car when it is raining). Ready, set, begin.

[SUBJECT PERFORMS TRIAL 3]
Please take a seat in this chair and rest for one minute before completing the next trial. If you need more time for rest or need assistance sitting or getting up, please let me know.

[RECORD TRIAL 3 RESULTS]

- **Trial 4** (fast pace):
  Now we will do a second trial at the same pace. Please stand with your feet level with this starting mark. When I say ‘begin,’ walk as fast as you can safely walk and stop when you reach the far mark (similar to walking into the grocery store from the car when it is raining). Ready, set, begin.

[SUBJECT PERFORMS TRIAL 4]
Please take a seat in this chair and rest for one minute before completing the next trial. If you need more time for rest or need assistance sitting or getting up, please let me know.

[RECORD TRIAL 4 RESULTS]
Good job!

[Escort participant to KIN Lab]

**Surveys in Lab** (20 minutes)
Please let us know if you need a break to use the restroom, if you need water, or a snack.

[SURVEYS INCLUDE (1) SF-36, (2) TRAIT FEELINGS OF ENERGY AND FATIGUE, AND (3) STATE FEELINGS OF ENERGY AND FATIGUE]

We will have you take three surveys. You can either do these surveys on the computer or you can fill them in with pen and paper. Which do you prefer? The instructions for the surveys are on the first page of each of them. If you have any questions, please let us know.
Face Mask Familiarization

Next, we are going to familiarize you with the mask we will be using to collect metabolic data. The mask may feel slightly uncomfortable at first but should not restrict your breathing. Please let me know if you are unable to breathe or if the mask is too uncomfortable.

[HAVE THE PARTICIPANT HOLD THE FRONT OF THE MASK OVER MOUTH/NOSE WITHOUT THE STRAP TO DETERMINE IF THE MASK FITS PROPERLY.]

I would like you to put this mask over your mouth and nose and breathe deeply in while covering the mouth hole to determine if there is a tight seal.

Do you feel like there is a tight seal with no air escaping?

- **If NO:** Okay, we will try a different size. [REPEAT PREVIOUS STEPS.]
- **If YES:** Okay, I am now going to attach the head straps and mouthpiece. Then I will assist you with putting it on properly.

[MAKE SURE THE PONYTAIL HOLE IS ON THE BOTTOM]

[TOP TWO CLIPS AND HONEYCOMB TUBE SHOULD BE IN THE MASK BEFORE PUTTING THE MASK ON AND ADJUST THE STRAPS]

[IDENTIFY THAT THE MASK IS ON PROPERLY/RELATIVELY COMFORTABLE]

[LET THE PARTICIPANT KNOW THAT YOU WILL BE PRESSING ON THE MASK TO MAKE SURE THERE IS SUCTION AND NO AIR IS ESCAPING]

This will be how the mask should feel for every visit. If you feel that you have any difficulty breathing, please stop us and let us know. We will remove the face mask now.

Do you feel comfortable enough with the mask and how we will put it on?

[REMOVE FACEMASK]

Recumbent Familiarization

This is one of the bikes we will be using for our study. This bike is called the recumbent bicycle. We will use this bike twice for our studies. We will adjust the seat position now so that we can properly adjust it for you before each of your
next visits. While you are on the bike, we ask that you rest your hands on the handles by the seat, but do not squeeze them.

[CONFIRM WITH PARTICIPANT THAT THEY ARE COMFORTABLE AND ABLE TO ADEQUATELY BIKE – NOTATE THEIR SEAT POSITION]

We will be collecting heart rate every minute based on the data from the heart rate monitor that you are wearing. Every 5 minutes we will also be taking blood pressure and asking you how you CURRENTLY feel based on two different ratings scales. Every five minutes we will also let you know that you are doing a good job. The first scale is called the rating of perceived exertion and it looks like this…. During exercise we will simply show you this scale and ask you to point to the number that corresponds to your feelings at that current time (6-20).

[SHOW PARTICIPANT RPE SCALE AND EXPLAIN IT]

**RPE Familiarization: (Borg Rating of Perceived Exertion Scale)**

While completing the physical activities today, we want you to rate your perception of exertion. This feeling should reflect how heavy and strenuous the exercise feels to you, combining all sensations and feelings of physical stress and effort. Do not concern yourself with any one factor such as leg pain or shortness of breath but try to focus on your total feeling of exertion. Please look at the rating scale; it ranges from 6 to 20, where 6 means “no exertion at all,” similar to resting, and 20 means “maximal exertion,” as in the hardest that you have ever worked. Choose the number from below that best describes your level of exertion.

Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is. There is no right or wrong answer. Your own feeling of effort and exertion is important, not how it compares to other people.

The other scale we will be using is called The Feelings Scale and that looks like this… Similarly, to the RPE scale we will show you this scale every five minutes and ask you to, again, point to the number that corresponds to your feelings at the current time.

The other scale we will be using is called The Feelings Scale and that looks like this

[SHOW PARTICIPANT FEELINGS SCALE AND EXPLAIN IT]

Similarly, to the RPE scale we will show you this scale every five minutes and ask you to, again, point to the number that corresponds to your feelings at the current time.

**Feeling Scale**
This scale is designed to assess how you feel in the moment. The exercise may feel pleasant or unpleasant. Additionally, how you feel may fluctuate throughout the exercise. Think of the middle of the scale as ‘neutral,’ which would indicate that at the moment the exercise does not feel pleasant or unpleasant. Think of the right side of the scale as ‘pleasure,’ indicating that at the moment the exercise feels pleasant, which can be anything from ‘fairly good’ to ‘very good.’ Think of the left side of the scale as ‘displeasure,’ indicating that at the moment the exercise feels unpleasant, which can be anything from ‘fairly bad’ to ‘very bad.’

The feeling scale is designed to assess how you feel in the moment and you will be asked to rate how they feel right now on a scale which ranges from -5 to +5.

Do you understand what we will be doing when using this bike and how to answer the two scales that you were shown?

Do you feel that you could sustain exercise at a slightly higher intensity for 25 minutes with the mask on and indicate your feelings based on the scales shown to you when prompted?
- If NO: explain the protocol again and refamiliarize scales and ask if they have any questions
- If YES: Now that you are familiar with what will be done on the experimental days, we will briefly familiarize you with the Theracycle. The other bike that we will be using for testing.

Theracycle Familiarization

This is the other bike we will be using for our study. This bike is called the Theracycle. We will use this bike twice for our studies. We will adjust the seat position now so that we can properly adjust it for you before each of your next visits. While you are on the bike, we ask that you rest your hands on the handles by the seat, but do not squeeze them.

[CONFIRM WITH PARTICIPANT THAT THEY ARE COMFORTABLE AND ABLE TO ADEQUATELY BIKE – NOTATE THEIR SEAT POSITION]

We will now have you pedal at a comfortable pace so that you are able to get a feel for how this bike works along with what it feels like to exercise with the mask on. Please stop us and let us know if you are uncomfortable and/or are unable to breathe with the mask on. Similarly, to the recumbent bicycle we will be collecting heart rate every minute based on the data from the heart rate monitor that you are wearing. Every 5 minutes we will also be taking blood pressure and asking you how you CURRENTLY feel based on two different ratings scales. Every five minutes we will also let you know that you are doing a good job. Would you like us to go over the two ratings scales again or do you feel comfortable with them?

The Theracycle is different from many other bikes because it can automatically pedal. First, please sit and feel like you are not even using your legs. Do you feel how the bike is doing all the work and that you have little control over your legs? Now we want you to feel that you have control over your legs and pedal WITH the bike. Again, we want you to feel like you have control over
your legs, so that the bike is not simply doing all the work, but not to the point where you feel that you are doing all the work. You should feel that you are working WITH the bike equally. We do NOT want you to overpower the bike.

If NO: let the participants briefly exercise at a comfortable pace until familiar with Theracycle

[AFTER A COUPLE OF MINUTES BRIEFLY EXERCISING WITH THERACYCLE]

Do you feel that you could exercise on the Theracycle for 25 minutes at a slightly higher intensity with the mask on and indicate your feelings based on the scales shown to you when prompted?

Do you want the two scales re-explained?

- If YES: go over the scales again
- If NO: [HAVE THEM USE THE SCALES] What would you say your rate of perceived exertion is at this time? How are you feeling?

**Following Visit Description**

The following visits will be different from this visit. This visit will take approximately 3 hours while the remaining four visits will take approximately an hour and a half each. The next four visits will include:

- Pre-exercise mental and physical energy and fatigue at that moment survey
- Resting heart rate and blood pressure
- Pre-exercise 10-meter walk
- 5-minute warm-up on that visits bike
- 15-minute trial – collection of heart rate, blood pressure, RPE, Feeling Scale, expired gasses
- 5-minute cool down
- 20-minute break including
  - Post-exercise mental and physical energy and fatigue at the moment survey
  - Physical Activity Enjoyment Scale
  - Post-exercise 10-meter walk
- EEG measurement

**Schedule Next Visits (IF NOT ALREADY DONE)**

**Take Home Folder Familiarization**

Within your take home folder, you will find a copy of your body composition form and an interpretation sheet. We can go over your data with you if you wish. Also, within your folder you will find an accelerometer instructions sheet which we will go over with you shortly. There are also a few forms and surveys within this folder that we ask that you fill out and bring back with you on
your next visit. If you would rather take these on the computer, we will be sending you an email confirming your next visit with us, later today.

The forms and surveys include:

- Health History Questionnaire
  - This questionnaire will ask for your health history.

- Exercise Self Efficacy Questionnaires
  - These questionnaires will ask you “how confident are you right now that you could exercise three times per week for 20 minutes if”: example you had to exercise alone and will ask you “how confident are you that you can be physically active…”: example “even if you need a long time to develop the necessary routines.”

- Activities Balance Confidence Scale
  - This survey will ask you to “indicate your level of confidence in doing certain activities without losing your balance or becoming unsteady.”

- Self-Reported Physical Activity Questionnaire
  - This survey will ask you to self-report your regular physical activity level.

- Yale Physical Activity Questionnaires
  - “This questionnaire will ask you about some common types of physical activities. Please indicate if you did them during a typical week in the last month.” The second part will “ask about certain types of activities that you have done during the past month.”

It is very important that you answer these questions honestly, to ensure that the data we obtain from the study is valid. Remember that all information is put into the surveys in your participant ID number. We will put your participant number in the email with the surveys in case you forget your participant number.

**Accelerometer Familiarization**

We will now go over the familiarization of the accelerometer. There is a sheet inside your take home folder that describes everything that we will be going over in case you need a reference.

An accelerometer records general movement and will allow us to get a better idea of your overall activity level. This device will measure the physical activity you perform by detecting the movements that are made as well as the acceleration of those movements but will not be able to tell us exactly what activity you are doing. It is easy to use and is worn on your wrist, just like a watch. It may feel slightly awkward at first, but after a few hours you will barely know it is there. They are also quite pricey, so please be careful!
We are giving you this accelerometer by your assigned participant number. Please do NOT switch accelerometers with anyone!
Please wear the accelerometer on your wrist using the wrist band you have been given. Please do not wear this device in any other way. This accelerometer can get wet so you can wear it bathing, showering, or swimming.
If you take off the accelerometer for any reason, please write that on your tracking log. We ask that you keep track of the time the accelerometer was worn using the accelerometer form. You only have to fill out the log for the days that you wear the activity monitor.
We ask that you wear it for the rest of the day and be worn all day, but it can be removed when you are sleeping. We ask that you wear this accelerometer for 7 days.
This accelerometer and band must be returned at your next visit. If for any reason, you decide not to participate in the study, we please ask that you either return this to the department in-person or mail it to the Kinesiology department.

**Concluding Comments**
Do you have any questions or concerns at this time?
- If YES – [ANSWER THEIR QUESTIONS. IF YOU DO NOT KNOW THE ANSWER, TELL THEM YOU WILL FIND OUT AND EMAIL OR CALL THEM.]
- If NO – [CONTINUE]

We will send you reminder emails of your next schedule visit. If you think of any questions or concerns after you leave today, please do not hesitate to email, or call us. Here is your $25.00 Amazon gift card that you get for participating in this visit. Please sign this receipt to show that you received the gift card, and I will give you a copy for your records. Thank you for your time, patience, and participation in this visit, we look forward to seeing you next week on [DAY, DATE, AND TIME.] Have a great rest of your week!
Appendix 3: Data Collection Sheet for Baseline

Participant No. ________ Date ________
Form Filled Out By: ________ Data Entered By: ________

1. Informed Consent Signed
   - Complete ________

2. Date of Birth
   MM DD YYYY

3. Resting Measures
   HR (bpm) ________
   BP (mmHg) ________ / ________

4. Objective Measures
   Height 1 ________ cm ________ inches
   Height 2 ________ cm ________ inches
   Ht. 3 if necessary ________ cm ________ inches
   Height Average ________ cm ________ inches

   Body Mass from InBody ________ kg ________ lbs.

   BMI (kg/m\(^2\)) ________ [criteria: 18 kg/m\(^2\) to 40 kg/m\(^2\)]

4. InBody 770 – attach print out
   *CONFIRM WITH PARTICIPANT: Do you have a pacemaker or other electronic medical device implanted?  Yes  No
   If YES – SKIP InBody assessment
   - Complete ________

5. BioSway – attach print out
   - Stable Surface ________
   - Unstable Surface ________
6. **Cognitive Screening with EEG**
   - Complete   ______

7. **10 Meter Walk Test**
   **Trial 1: Normal Pace**
   - Time 0 m to 2 m (s) ______
   - Time 2 m to 8 m (s) ______
   - Time 0 m to 8 m (s) ______
   - Time 8 m to 10 m (s) ______
   - Time 0 m to 10 m (s) ______
   **Trial 2: Normal Pace**
   - Time 0 m to 2 m (s) ______
   - Time 2 m to 8 m (s) ______
   - Time 0 m to 8 m (s) ______
   - Time 8 m to 10 m (s) ______
   - Time 0 m to 10 m (s) ______
   **1 Minute Rest**

   **Trial 1: Fast, Safe Pace**
   - Time 0 m to 2 m (s) ______
   - Time 2 m to 8 m (s) ______
   - Time 0 m to 8 m (s) ______
   - Time 8 m to 10 m (s) ______
   - Time 0 m to 10 m (s) ______
   **Trial 2: Fast, Safe Pace**
   - Time 0 m to 2 m (s) ______
   - Time 2 m to 8 m (s) ______
   - Time 0 m to 8 m (s) ______
   - Time 8 m to 10 m (s) ______
   - Time 0 m to 10 m (s) ______
   **1 Minute Rest**

8. **In-Lab Surveys**
   - SF-36 ______
   - State Feelings of Energy and Fatigue _____
   - Trait Feelings of Energy and Fatigue _____

9. **Face Mask Familiarization**
   - Face Mask Size: XS S M
   - Head Strap Size S M

10. **65-70% HR MAX calculation and familiarization**
    Age ______ years
    Max HR = 208 – (0.7 x Age) = 208 – (0.7 * _________) = _________ bpm
    65% - 70 % range = (HRmax *.65) – (HRmax*.70)
    **Range (bpm)**

11. **Recumbent Practice**
    Seat Settings: # visible

12. **Theracycle Practice**
13. **RPE Familiarization:** (Borg Rating of Perceived Exertion scale)

While completing the physical activities today, we want you to rate your perception of exertion. This feeling should reflect how heavy and strenuous the exercise feels to you, combining all sensations and feelings of physical stress and effort. Do not concern yourself with any one factor such as leg pain or shortness of breath but try to focus on your total feeling of exertion. Please look at the rating scale; it ranges from 6 to 20, where 6 means "no exertion at all," similar to resting, and 20 means "maximal exertion," as in the hardest that you have ever worked. Choose the number from below that best describes your level of exertion. Try to appraise your feeling of exertion as honestly as possible, without thinking about what the actual physical load is.

**There is no right or wrong answer. Your own feeling of effort and exertion is important, not how it compares to other people.**

Did the participant understand RPE?

Yes  No
14. **Feeling Scale Familiarization:**
This scale is designed to assess how you feel in the moment. The exercise may feel pleasant or unpleasant. Additionally, how you feel may fluctuate throughout the exercise. Think of the middle of the scale as ‘neutral,’ which would indicate that at the moment the exercise does not feel pleasant or unpleasant. Think of the right side of the scale as ‘pleasure,’ indicating that at the moment the exercise feels pleasant, which can be anything from ‘fairly good’ to ‘very good.’ Think of the left side of the scale as
‘displeasure,’ indicating that at the moment the exercise feels unpleasant, which can be anything from ‘fairly bad’ to ‘very bad.’

The feeling scale is designed to assess how you feel in the moment and participants will be asked to rate how they feel right now on a scale which ranges from –5 to +5.

Did the participant understand the Feeling Scale?

Yes           No

---

**How Do You Feel NOW?**

<table>
<thead>
<tr>
<th></th>
<th>-5</th>
<th>-4</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>+1</th>
<th>+2</th>
<th>+3</th>
<th>+4</th>
<th>+5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very bad</td>
<td>Bad</td>
<td>Fairly bad</td>
<td>Neutral</td>
<td>Fairly good</td>
<td>Good</td>
<td>Very good</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---
Appendix 4: Trial Randomizer

Research Randomizer
Results:
15 Sets of 4 Yes Numbers Per
Set
Range: From 1 to 4 -- No

<table>
<thead>
<tr>
<th>Set</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Set No.</th>
<th>Assigned Trial (A-D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1001/0001</td>
<td>D A B C</td>
</tr>
<tr>
<td>1002/0002</td>
<td>C D A B</td>
</tr>
<tr>
<td>1003/0003</td>
<td>D A B C</td>
</tr>
<tr>
<td>1004/0004</td>
<td>A B C D</td>
</tr>
<tr>
<td>1005/0005</td>
<td>B A C D</td>
</tr>
<tr>
<td>1006/0006</td>
<td>B A D C</td>
</tr>
<tr>
<td>1007/0007</td>
<td>D B A C</td>
</tr>
<tr>
<td>1008/0008</td>
<td>D B C A</td>
</tr>
<tr>
<td>1009/0009</td>
<td>A B D C</td>
</tr>
<tr>
<td>1010/0010</td>
<td>B D C A</td>
</tr>
<tr>
<td>1011/0011</td>
<td>C D A B</td>
</tr>
<tr>
<td>1012/0012</td>
<td>B D C A</td>
</tr>
<tr>
<td>1013/0013</td>
<td>C D B A</td>
</tr>
<tr>
<td>1014/0014</td>
<td>C B A D</td>
</tr>
<tr>
<td>1015/0015</td>
<td>C D B A</td>
</tr>
</tbody>
</table>

Appendix 5: Data Collection Sheet for Trials

Participant No. _______ Date _______
Form Filled Out By: _________ Data Entered By: _______

Assigned Trial (A-D): *circle one*
Visit A: Active-assisted cycling completed at 70% HRmax
Visit B: Active-assisted cycling completed at a self-selected pace*
Visit C: Recumbent cycling completed at 70% HRmax
Visit D: Recumbent cycling completed at a self-selected pace

Visit Checklist
€ PRE - Mental and Physical Energy and Fatigue – State
€ Resting HR and BP
€ PRE - 10-meter walk
€ Warm Up
€ Trial – collection HR, BP, RPE, Feeling Scale, Expired Gases
€ Cool Down
€ 10-minute break
  o POST - Mental and Physical Energy and Fatigue – State
  o Physical Activity Enjoyment Scale
  o LAST VISIT – Decision Utility Survey
  o POST - 10-meter walk
€ EEG measurement and Behavioral Cognitive Assessment

Seat Settings: Check Bike Settings and Sizes for Mask and EEG Document in Data Collection Sheets – FIXED Folder on Drive

FOR TRIALS A AND C: Calculate 65-70% HRmax using the Tanaka Method. Utilize 65-70HRMaxAges50-85 Sheet in Checklists – Coordinators and Visit(s) Folder on Drive.

<table>
<thead>
<tr>
<th>Recumbent</th>
<th>Theracycle Vertical</th>
<th>Theracycle Horizontal</th>
</tr>
</thead>
</table>

Range (bpm) 65% - 70 % range =

PRE- Mental and Physical Energy and Fatigue – STATE
  - Complete _____

Resting Heart Rate and Blood Pressure
**HR**

| mmHg | bpm | Blood Pressure | / |  |

## 10 METER WALK – Typical Walking SPEED

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time in seconds</td>
<td>Time in seconds</td>
</tr>
<tr>
<td>Sequence 1: 0-2 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence 2: 2-8 (6m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total time: 0-8 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence 3: 8-10 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total time: 0-10 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Minute Rest in Chair</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## 10 METER WALK – Fast Walking SPEED

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time in seconds</td>
<td>Time in seconds</td>
</tr>
<tr>
<td>Sequence 1: 0-2 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence 2: 2-8 (6m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total time: 0-8 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence 3: 8-10 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total time: 0-10 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Minute Rest in Chair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Workload</td>
<td>HR (bpm)</td>
</tr>
<tr>
<td>--------------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>RESTING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warm Up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:00 – 4:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:01 - 5:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00:00 – 1:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:01 – 2:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:01 – 3:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:01 – 4:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:01 – 5:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:01 – 6:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:01 – 7:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:01 – 8:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:01 – 9:01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:01 – 10:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:01 – 11:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:01 – 12:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:01 – 13:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13:01 – 14:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14:01 – 15:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cool Down</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:00 – 4:00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:01 - 5:00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES:
**STANDARD 20 MINUTES BEFORE EEG RECOVERY -- EEG and Behavioral Cognitive Tasks**

<table>
<thead>
<tr>
<th>HR (bpm)</th>
<th>00:00 – 1:00</th>
<th>1:01 – 2:00</th>
<th>2:01 – 3:00</th>
<th>3:01 – 4:00</th>
<th>4:01 – 5:00</th>
<th>5:01 – 6:00</th>
<th>6:01 – 7:00</th>
<th>7:01 – 8:00</th>
<th>8:01 – 9:01</th>
<th>9:01 – 10:00</th>
<th>10:01 – 11:00</th>
<th>11:01 – 12:00</th>
<th>12:01 – 13:00</th>
<th>13:01 – 14:00</th>
<th>14:01 – 15:00</th>
<th>15:01 – 16:00</th>
<th>16:01 – 17:00</th>
<th>17:01 – 18:00</th>
<th>18:01 – 19:00</th>
<th>19:01 – 20:00</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continue to questionnaires and the POST- 10 meter walk test while collecting HR data.

**POST- Mental and Physical Energy and Fatigue – STATE**
- Complete _____

**Physical Activity Enjoyment Scale**
- Complete _____

**LAST VISIT ONLY – Decision Utility Survey**
- Complete _____

**10 METER WALK – Typical Walking SPEED**

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time in seconds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence 1: 0-2 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence 2: 2-8 (6m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total time: 0-8 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence 3: 8-10 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total time: 0-10 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Minute Rest in Chair</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**10 METER WALK – Fast Walking SPEED**

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time in seconds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence 1: 0-2 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence 2: 2-8 (6m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total time: 0-8 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence 3: 8-10 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total time: 0-10 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Minute Rest in Chair</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EEG Measurement**  Completed _____
Appendix 6: Health History Questionnaire
Theracycle HHQ

Start of Block: Health History Questionnaire

Participant Info

- Participant ID # ________________________________
- Date of Birth (mm/dd/yyyy) ________________________________

Gender

- Male
- Female
- Non-binary / third gender
- Prefer not to answer

Have you ever been diagnosed (by a doctor) with PERIPHERAL VASCULAR DISEASE (PVD)?

- Yes
- No

Have you ever been diagnosed (by a doctor) with CHRONIC OBSTRUCTIVE PULMONARY DISEASE [COPD] (i.e., emphysema, chronic bronchitis)?

- Yes
- No

Have you ever been diagnosed (by a doctor) with ASTHMA?

- Yes
- No

Have you ever been diagnosed (by a doctor) with ARTHRITIS (i.e., osteoarthritis, degenerative joint disease, rheumatoid arthritis)?

- Yes
- No
Have you ever been diagnosed (by a doctor) with UPPER GASTROINTESTINAL DISEASE [i.e., ulcer, hiatal hernia gastroesophageal reflux disease (GERD)]?

- Yes
- No

Have you ever been diagnosed (by a doctor) with CHRONIC LIVER DISEASE (i.e., chronic, or persistent hepatitis, cirrhosis)?

- Yes
- No

Have you ever been diagnosed (by a doctor) with HIGH BLOOD PRESSURE (i.e., hypertension)?

- Yes
- No

Have you ever been diagnosed (by a doctor) with HIGH CHOLESTEROL?

- Yes
- No

Have you ever been diagnosed (by a doctor) with CARDIOVASCULAR DISEASE [i.e., myocardial infarction (heart attack), congestive heart failure (CHF), heart rhythm disorders (arrhythmias), heart murmur, chronic angina (chest pain)]?

- Yes
- No

Have you been diagnosed (by a doctor) with CEREBROVASCULAR DISEASE [i.e., stroke, transient ischemic attack (TIA)]?

- Yes
- No

Have you ever been diagnosed (by a doctor) with DEGENERATIVE DISC DISORDER?

- Yes
- No

Have you ever been diagnosed (by a doctor) with DEPRESSION?

- Yes
- No
Have you ever been diagnosed (by a doctor) with ANXIETY?

- Yes
- No

Have you ever been diagnosed (by a doctor) with VISUAL IMPAIRMENTS (i.e., cataracts, glaucoma, macular degeneration)?

- Yes
- No

Have you ever been diagnosed (by a doctor) with HEARING IMPAIRMENTS?

- Yes
- No

Have you ever been diagnosed (by a doctor) with FIBROMYALGIA?

- Yes
- No

Have you ever been diagnosed (by a doctor) with CHRONIC FATIGUE SYNDROME?

- Yes
- No

Have you ever been diagnosed (by a doctor) with ANEMIA?

- Yes
- No

Have you ever been diagnosed (by a doctor) with HASHIMOTO'S DISEASE (autoimmune thyroidism)?

- Yes
- No

Have you ever been diagnosed (by a doctor) with EPILEPSY?

- Yes
- No
Have you ever been diagnosed (by a doctor) with having CHRONIC MODERATE OR SEVERE BACK PAIN?
  
  ○ Yes
  ○ No

Have you ever been diagnosed (by a doctor) with having FREQUENT AND/OR SEVERE HEADACHES (i.e., migraines)?
  
  ○ Yes
  ○ No

Have you ever been diagnosed (by a doctor) with CANCER?
  
  ○ Yes, please specify which type of cancer ________________________________
  ○ No

Have you ever been diagnosed (by a doctor) with THYROID DYSFUNCTION (i.e., hyperthyroidism, hypothyroidism)?
  
  ○ Yes, please specify which type of thyroid dysfunction ___________________________
  ○ No

Do you have a history of an injury/injuries to your upper or lower extremities (i.e., arms or legs)?
  
  ○ Yes
  ○ No

Display This Question:
  If Do you have a history of an injury/injuries to your upper or lower extremities (i.e., arms or legs)? = Yes

What type of injury/injuries occurred to your upper or lower extremities? How was/is it treated?
  
  __________________________________________________________________________
  __________________________________________________________________________

Have you had any SURGERIES as an adult (over the age of 18)?
  
  ○ Yes
  ○ No

Display This Question:
  If Have you had any SURGERIES as an adult (over the age of 18)? = Yes

What type(s) of surgery/surgeries have you undergone?
  
  __________________________________________________________________________
  __________________________________________________________________________
Please list any OTHER HEALTH CONDITIONS/DISEASES (i.e., motor speech disorder, voice disorder, swelling disorder, etc.) you have, that were not mentioned in the previous questions. Indicate the STATUS OF THE CONDITION: recently diagnosed, no longer have, or how many years you have had this health condition/disease.

___________________________________________________________________________

If you have selected yes to having any of diseases/conditions or written any diseases/conditions in the previous question, please explain how you are CURRENTLY MANAGING (i.e., speech therapy, physical therapy, etc.) these health conditions/diseases (only explain for the diseases/conditions you currently have).

___________________________________________________________________________

Do you take any prescription (Rx) medications, over the counter (OTC) medications (including pain medication, allergy medication, etc.), or supplements (S) (including vitamins, etc.)?

If yes, please list these in the space below, and indicate the name of the medication-supplement, what you take the medication-supplement to treat (if applicable), the dose (amount) you take, and the frequency with which you take this medication.

<table>
<thead>
<tr>
<th>Medication Name</th>
<th>Rx, OTC, or S</th>
<th>What condition does this treat</th>
<th>Dosage (amount)</th>
<th>Frequency (Days per wk/times per day), please specify</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
If you drink ALCOHOL, on average how many alcoholic beverages do you drink (i.e., wine, beer, hard seltzer, and hard liquor)?

- None (I do not drink alcohol)
- Less than once a week
- 1-3 drinks per week
- 4-6 drinks per week
- 1 drink daily
- 2 drinks daily
- 3 drinks daily
- More than 3 drinks daily

If you drink CAFFEINATED beverages, on average how many caffeinated beverages do you drink (i.e., coffee, caffeinated tea, soda, energy drinks, etc.)?

- None
- Less than once a week
- 1-3 drinks per week
- 4-6 drinks per week
- 1 drink daily
- 2 drinks daily
- 3 drinks daily
- More than 3 drinks daily

On average how many MEALS do you consume per DAY? [A meal is considered any of the regular occasions in a day when a reasonably large amount of food is eaten, such as breakfast, lunch, or dinner.]
Do you currently follow a SPECIFIC DIET?

- Vegan
- Vegetarian
- Keto (High Protein)
- Low Fat
- Low Sodium
- Other, please specify ________________________________
- I do not follow a specific diet.

How many servings of DAIRY do you consume each day? For example: the USDA states that 1 serving of dairy is the equivalent to 1 cup of milk, 1 cup of yogurt, 2 slices of cheese, or 1 cup of cottage cheese.

- 0
- 1-2
- 2-3
- 3-4
- 5 or more
How many servings of FRUIT do you consume each day? [i.e., 1 serving of fruit is the equivalent of one medium size fruit (banana, apples, peach, etc.) or 1/4 cup of berries or smaller fruits.]

- 0
- 1-2
- 2-3
- 3-4
- 5 or more

How many servings of VEGETABLES do you consume each day? [i.e., 1 serving of vegetables is the equivalent of 1/2 cup of vegetable, 1 cup of raw greens, or 1/2 cup of dried beans, canned beans, peas, or lentils.]

- 0
- 1-2
- 2-3
- 3-4
- 5 or more

How many servings of PROTEIN do you consume each week? [i.e., 1 serving size of protein is equivalent to 3 ounces (roughly the size of a deck of cards) of cooked chicken, beef, fish, or pork; 1 large egg; 1/2 cup tofu; or 1/4 cup mixed nuts.]

- 0
- 1-2
- 2-3
- 3-4
- 5 or more

Do you smoke CIGARETTES?

- Yes
- No

Skip To: If Do you smoke CIGARETTES? = No

On average, how many CIGARETTES do you smoke per DAY?
I prefer not to answer. (11)

I do not smoke cigarettes daily, I smoke them weekly.

Display This Question:

If On average, how many CIGARETTES do you smoke per DAY? = I do not smoke cigarettes daily, I smoke them weekly.

On average, how many CIGARETTES do you smoke per WEEK?

1-3
4-6
7-9
10-13
14-16
17-19
20 or more
I prefer not to answer. (11)

Do you currently smoke CIGARS?
Yes
No

Skip To: If Do you currently smoke CIGARS? = No

On average, how many CIGARS do you smoke per DAY?
If On average, how many CIGARS do you smoke per DAY? = I do not smoke cigars daily, I smoke them weekly.

On average, how many CIGARS do you smoke per WEEK?

- 1-2
- 3-4
- 5 or more
- I prefer not to answer.
- I do not smoke cigars daily, I smoke them weekly.

Do you smoke any OTHER TOBACCO products?

- Yes
- No

Skip To: If Do you smoke any OTHER TOBACCO products? = No

What OTHER TOBACCO products do you smoke?______________________________________

How many times per DAY do you smoke these OTHER TOBACCO products?

- 1-3
- 4-6
- 7-9
- 10-13
- 14 or more
- I prefer not to answer.
- I do smoke these daily, I smoke them weekly.
If How many times per DAY do you smoke these OTHER TOBACCO products? = I do smoke these daily, I smoke them weekly.

On average, how many times per WEEK do you smoke these OTHER TOBACCO products?

- 1-3
- 4-6
- 7-9
- 10-13
- 14-16
- 17-19
- 20 or more
- I prefer not to answer. (11)

How would you describe your current employment?

- Full time – working at least 35 hours/week
- Part time – working less than 35 hours/week
- Laid-off or unemployed, but looking for work
- Laid-off or unemployed, but not looking for work
- Retired, not working at all
- Retired, working part-time
- Disabled
- I prefer not to answer

What is your highest level of education (last grade completed or degree(s) received):

- Less than a high school diploma
- High school diploma or equivalent
- Some college
- Graduated from college
- Graduate or professional degree
- I prefer not to answer
Do you live independently? Independent living is defined as living with no assistance in your care and completion of activities of daily living.

- Yes
- No

Have you ever been married or lived with a partner?

- Yes
- No
- I prefer not to answer

Do you currently live with a partner or spouse?

- Yes
- No
- I prefer not to answer

How many total people live in your household - including you?

- 1
- 2 (11)
- 3 (12)
- 4 (13)
- 5 (14)
- 6 (15)
- more than 6 (16)

What is your total yearly household income (includes income from total people living in your household)?
Are there any current major stressors, or life changes that have occurred recently?

- Yes
- No

Display This Question:
If Are there any current major stressors, or life changes that have occurred recently? = Yes

Please provide an explanation of these stressors.

__________________________________________________________
__________________________________________________________

Have there been any major changes in your health during the past year?

- Yes
- No

Display This Question:
If Have there been any major changes in your health during the past year? = Yes

Please list and provide an explanation of these changes.

__________________________________________________________
__________________________________________________________

End of Block: Health History Questionnaire
Appendix 7: Borg RPE (6-20) Scale

<table>
<thead>
<tr>
<th>Rating</th>
<th>Perceived Exertion</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>No exertion</td>
</tr>
<tr>
<td>7</td>
<td>Extremely light</td>
</tr>
<tr>
<td>8</td>
<td>Very light</td>
</tr>
<tr>
<td>9</td>
<td>Light</td>
</tr>
<tr>
<td>10</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>11</td>
<td>Hard</td>
</tr>
<tr>
<td>12</td>
<td>Very hard</td>
</tr>
<tr>
<td>13</td>
<td>Extremely hard</td>
</tr>
<tr>
<td>14</td>
<td>Maximal exertion</td>
</tr>
<tr>
<td>15</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>


