COMPARING PHYSIOLOGICAL RESPONSES BETWEEN THE REVOLUTIONARY ROCKET AND A STANDARD BICYCLE

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the Degree Master of Science, Clinical Exercise Physiology

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COMPARING PHYSIOLOGICAL RESPONSES BETWEEN THE
REVOLUTIONARY ROCKET AND A STANDARD BICYCLE

By: Megan A. Storlien

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree Master of Science, Clinical Exercise Physiology.

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ABSTRACT

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This study was designed to examine potential differences in the physiological responses between exercising on the Revolutionary Rocket (Rocket) and a standard bicycle. Sixteen subjects (8 males, 8 females) performed one practice session on each bike. Subjects then completed two, 20-minute steady-state rides, one on the Rocket and one on a standard bicycle in random order. The tests were conducted in four, 5-minute stages. The stages were at 8 mph, 10 mph, 12 mph, and 14 mph. During the testing VO₂ and caloric expenditure were measured continually. Heart rate was monitored each minute using a heart rate monitor. Rating of perceived effort was assessed using the Borg 6-20 scale at end of each stage. Speed was determined using identical bicycle computers that were affixed to each bicycle. Results indicated that the VO₂ and Kcal responses were significantly different between bikes, but only at 12 and 14 mph. The RPE responses were not significantly different between bikes at any of the four speeds. Based upon these results it appears that exercising on the Rocket elicits lower responses than exercising on a standard bicycle in both males and females.
ACKNOWLEDGEMENT

I would like to thank John Porcari, Scott Doberstein, and Manny Felix for guiding me throughout this research process. I would also like to thank my CEP family for giving me continuous support throughout the year. Lastly, I would like to thank my family for instilling me with a hard work ethic and the motivation to make it this far in my education. I will take these qualities and use them every day as I continue to learn and grow.
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INTRODUCTION

Numerous studies have documented the health and fitness benefits associated with regular aerobic exercise. These include increases in maximal oxygen uptake (VO$_{2\text{max}}$), glucose tolerance, capillary density, skeletal muscle blood flow, feelings of well-being, as well as decreases in submaximal heart rate (HR) and blood pressure, body fat, and the incidence of mental disorders (American College of Sports Medicine, 2010). The American College of Sports Medicine (ACSM) currently recommends that apparently healthy adults should engage in a minimum of 30 minutes of moderate intensity aerobic activity 5 days each week or vigorous intensity activity for a minimum of 20 minutes at least 3 days a week (Haskell, Lee, Pate, Powell, Blair, Franklin, Macera, Heath, Thompson, & Bauman, 2007). According to ACSM guidelines, apparently healthy individuals should use an exercise intensity of 50-85% of VO$_{2\text{max}}$, 40/50-85% of oxygen uptake reserve (VO$_{2\text{R}}$) and heart rate reserve (HRR), or 64/70-94% of maximum heart rate (HR$_{\text{max}}$) (ACSM, 2010). Currently, only 15% of adults meet ACSM guidelines for cardiorespiratory fitness (Pollock, Gaesser, Butcher, Sespres, Dishman, Granlin, & Garber, 1998).

Every year new types of exercise equipment come on the market with the promise of revolutionizing the fitness world. One of the most recent pieces of exercise on the market is the Revolutionary Rocket (Revolutionary Bicycles Inc., Wilmington, NC). Invented by Alexander Hunt, the Revolutionary Rocket (Rocket) is a bicycle that combines an upper body rowing motion with the typical leg pedaling motion of cycling in
an attempt to provide the user with a full body workout (Figure 1). The handle bars move back and forth 5.5 inches and are connected by a rod to the gears that are powered by the pedals (Figure 2).

Figure 1. Image of the Revolutionary Rocket

Figure 2. Image of the handlebars on the Revolutionary Rocket
To our knowledge, no studies have been conducted on the Rocket. However, a product called the Rowbike (Rowbike Inc., Agoura Hills, CA) utilizes a motion similar to the Rocket. The Rowbike is a combination of a Concept II rower and a bicycle (See Figure 3); and is propelled with a forward and backward arm motion. The range of motion of the upper body is greater than the Rocket, but the pattern of movement is similar. Manufactures of the Rowbike claim that the Rowbike burns 50% more calories than a regular bicycle.

Figure 3. Image of the Rowbike

A major advantage of combined upper and lower body exercise is that the workload can be shared between more muscle mass. Previous studies have shown that distributing the workload over more muscle mass results in lower HR responses and lower perceived effort (Gutin, Ang, & Torrey, 1988; Mier & Fieto, 2006). Further, when exercising at the same perceived exertion, they burned more calories since they were able to work at a higher workload.
Since there have not been any studies performed using the Rocket, there are many unanswered questions. The purpose of the study was twofold: First was to determine if exercising on the Rocket meets ACSM guidelines for improving cardiorespiratory fitness. Second was to determine how exercising on the Rocket compares to riding a conventional bicycle at similar speeds.
METHODS

Subject Selection

Subjects for this study were 16 apparently healthy adults (eight males and eight females) from the La Crosse, WI community. Subjects were between 18-40 years of age and had prior experience riding a bicycle. At a minimum, all subjects were recreationally active (must be currently performing aerobic activity for at least 3 days per week for 30 minutes per day). Each subject completed a health history questionnaire developed by the ACSM and the American Heart Association (AHA) prior to participating in laboratory testing (Appendix A). Approval from the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects was obtained and each participant provided written informed consent before beginning the study.

Procedures

Subjects performed a 20-minute practice session on the Rocket and each subject was deemed proficient by the lead researcher before being allowed to continue with further testing procedures. Subjects then completed two, 20-minute steady-state rides, one on the Rocket and one on a standard bicycle. The standard bicycle was identical to the Rocket, except the handlebars were fixed. The order of the Rocket and the conventional bicycle tests were randomized.
All testing took place in the UW-La Crosse Human Performance Lab. The tests were conducted in four, 5-minute stages at 8 mph, 10 mph, 12 mph, and 14 mph. During the testing, VO₂ and caloric expenditure (kcal) were measured continually with a Moxus Metabolic System (AEI Technology, Naperville, IL). HR was monitored each minute using a Polar heart rate monitor (Polar Electro Inc., Lake Success, NY). Rating of perceived exertion (RPE) was assessed using the Borg 6-20 scale at end of each stage (Borg, 1973). Speed was determined using identical Bell bicycle computers that were affixed to each bicycle.
STATISTICAL ANALYSIS

For all variables, differences between the Rocket and the standard bicycle were determined using a two-way ANOVA with repeated measures. When there was a significant F-ratio, pairwise comparisons were made using Tukey’s post-hoc procedures. Alpha was set at p<0.05 to achieve statistical significance for all analyses. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS, Version 19; SPSS Inc., Chicago, IL.)
RESULTS

Descriptive characteristics of the subject population, subdivided by gender, are presented in Table 1.

Table 1. Descriptive characteristics of the subject population (n=16). Values represent mean ± standard deviation.

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>22.3 ± 1.16</td>
<td>24.8 ± 4.37</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163.6 ± 4.66</td>
<td>181.3 ± 8.41</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>62.6 ± 5.82</td>
<td>85.8 ± 10.16</td>
</tr>
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</table>

Exercise responses to both the Rocket and the standard bicycle testing sessions at 8, 10, 12, and 14 mph are summarized in Table 2. Data for HR, VO₂, Kcal and RPE are also presented graphically in Figures 4-7, respectfully. These results indicate that for all variables, exercising on the Rocket elicited lower responses in both males and females than exercising on the standard bicycle. However, only the HR responses were significantly different across all four speeds. The VO₂ and Kcal responses were significantly different between bikes, but only at 12 and 14 mph. The RPE responses were not significantly different between bikes at any of the four speeds.
Table 2. Responses to exercise using the Rocket and the standard bicycle at 8, 10, 12 and 14 mph.

<table>
<thead>
<tr>
<th>Speed</th>
<th>Variable</th>
<th>Revolutionary Rocket</th>
<th>Standard Bicycle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>X ± SD</td>
<td>X ± SD</td>
</tr>
<tr>
<td>8 mph.</td>
<td>HR (bpm)</td>
<td>90 ± 9.9*</td>
<td>95 ± 13.8</td>
</tr>
<tr>
<td></td>
<td>%HRmax</td>
<td>46 ± 4.9*</td>
<td>48 ± 7.1</td>
</tr>
<tr>
<td></td>
<td>VO2 (ml/kg/min)</td>
<td>10.6 ± 1.38</td>
<td>11.1 ± 2.06</td>
</tr>
<tr>
<td></td>
<td>Kcal/min</td>
<td>3.9 ± .50</td>
<td>4.0 ± .54</td>
</tr>
<tr>
<td></td>
<td>RPE</td>
<td>7.4 ± .96</td>
<td>7.7 ± 1.01</td>
</tr>
<tr>
<td>10 mph.</td>
<td>HR (bpm)</td>
<td>98 ± 12.1*</td>
<td>104 ± 16.3</td>
</tr>
<tr>
<td></td>
<td>%HRmax</td>
<td>50 ± 6.0*</td>
<td>53 ± 8.2</td>
</tr>
<tr>
<td></td>
<td>VO2 (ml/kg/min)</td>
<td>12.9 ± 1.90</td>
<td>11.1 ± 2.06</td>
</tr>
<tr>
<td></td>
<td>Kcal/min</td>
<td>4.7 ± .47</td>
<td>4.0 ± .54</td>
</tr>
<tr>
<td></td>
<td>RPE</td>
<td>8.0 ± 1.16</td>
<td>8.1 ± 1.26</td>
</tr>
<tr>
<td>12 mph.</td>
<td>HR (bpm)</td>
<td>115 ± 19.9*</td>
<td>118 ± 20.9</td>
</tr>
<tr>
<td></td>
<td>%HRmax</td>
<td>58 ± 9.8*</td>
<td>60 ± 10.5</td>
</tr>
<tr>
<td></td>
<td>VO2 (ml/kg/min)</td>
<td>16.1 ± 2.51*</td>
<td>17.4 ± 3.02</td>
</tr>
<tr>
<td></td>
<td>Kcal/min</td>
<td>5.8 ± .56*</td>
<td>6.3 ± .72</td>
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<tr>
<td></td>
<td>RPE</td>
<td>9.3 ± 1.40</td>
<td>9.8 ± 1.38</td>
</tr>
<tr>
<td>14 mph.</td>
<td>HR (bpm)</td>
<td>139 ± 28.1*</td>
<td>146 ± 28.2</td>
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<tr>
<td></td>
<td>%HRmax</td>
<td>70 ± 13.9*</td>
<td>74 ± 14.0</td>
</tr>
<tr>
<td></td>
<td>VO2 (ml/kg/min)</td>
<td>24.2 ± 4.27*</td>
<td>26.2 ± 5.84</td>
</tr>
<tr>
<td></td>
<td>Kcal/min</td>
<td>8.7 ± .67*</td>
<td>9.4 ± .68</td>
</tr>
<tr>
<td></td>
<td>RPE</td>
<td>11.0 ± 1.55</td>
<td>11.7 ± 2.15</td>
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*Significantly different than standard bicycle (p<.05)
Figure 4. Average HR responses of subjects at 8, 10, 12, and 14 mph using the Rocket and the standard bicycle.
*Significant difference between bikes. (p<.05).

Figure 5. Average oxygen consumption (ml/kg/min) of subjects at 8, 10, 12 and 14 mph using the Rocket and the standard bicycle.
*Significant difference between bikes (p<.05).
Figure 6. Average caloric expenditure (Kcal) of subjects at 8, 10, 12 and 14 mph using the Rocket and the standard bicycle.
*Significant difference between bikes (p<.05)

Figure 7. Average RPE responses of subjects at 8, 10, 12 and 14 mph using the Rocket and the standard bicycle.
DISCUSSION

The purpose of the study was to first determine if exercising on the Rocket meets ACSM guidelines for improving cardiopulmonary fitness. Second was to determine how exercising on the Rocket compares to riding a conventional bicycle at similar speeds. According to ACSM guidelines, apparently healthy individuals should exercise between 64-94% of HRmax (ACSM, 2010) in order to achieve a cardiopulmonary training benefit. The results of this study found that out of the four different speeds, subjects exercising on the Rocket exceeded the minimal threshold of 64% of HRmax only at 14 mph. Thus, exercise on the Rocket needs to be done at a higher speed in order to provide a cardiopulmonary training benefit.

When comparing responses between bikes, exercise responses were generally higher on the regular bicycle compared to the Rocket. Additionally, subjects perceived riding the regular bike to be more difficult; however this difference was not statistically significant. These findings suggest that spreading the workload out over greater muscle mass on the Rocket results in less cardiopulmonary and perceptual effort. A study done on walking poles supports this finding since when walking with poles, the perception of effort was lower compared to walking at the same speed without poles (Bracko, 2009).

While no studies have examined combined arm and leg exercise with respect to ACSM guidelines, studies have been conducted to investigate the effectiveness of combined arm and leg exercise during steady-state exercise. Mier & Fieto, (2006) compared leg-only exercise on an elliptical trainer to combined arm-leg exercise. Results
of the study indicated that VO₂ was higher during combined arm-leg exercise on the elliptical, but HR and RPE were lower. The authors suggest that combining arm and leg exercise can result in greater total energy expenditure when compared to leg-only exercise. Similarly, Gutin et al. (1988) examined arm ergometry when combined with leg exercise. Results indicated that VO₂ during combined arm and leg work was much higher, but RPE and HR were similar, therefore allowing for a much longer exercise bout at a greater intensity. These findings suggest that incorporating more muscle mass allows a greater metabolic load to be tolerated. During this study, our findings were similar when looking at HR and RPE, however the VO₂ and Kcal values were lower on the Rocket when compared to the standard bicycle.

Future research should investigate the responses to exercising on the Rocket at speeds greater than 14 mph. This could further aid fitness professionals in evaluating the relative effectiveness of the Rocket when prescribing exercise to patients and clients. Since many subjects also regulate exercise intensity using RPE, another way to conduct the study would be to compare responses between the Rocket and the standard bike at matched levels of RPE. Testing the Rocket in an outdoor environment would be a beneficial study as well. The increased resistance from the ground and use of different muscles for balance may increase the effectiveness of the Rocket as a form of exercise.

In summary, it was found that exercise using the Rocket meets ACSM guidelines for increasing cardiorespiratory fitness at speeds of 14 mph or greater. Also, exercise using the Rocket elicited a lower HR, VO₂, Kcal, and RPE when compared to exercise on a standard bicycle, probably due to the sharing of the workload amongst a greater muscle mass.
REFERENCES


AHA/ACSM Health/Fitness Facility Preparticipation Screening Questionnaire

Assess your health status by marking all true statements.

History
You have had:
___ a heart attack
___ heart surgery
___ cardiac catheterization
___ coronary angioplasty (PTCA)
___ pacemaker/implantable cardiac
___ defibrillator/rhythm disturbance
___ heart valve disease
___ heart failure
___ heart transplantation
___ congenital heart disease

Symptoms
___ You experience chest discomfort with exertion.
___ You experience unreasonable breathlessness.
___ You experience dizziness, fainting, or blackouts.
___ You take heart medications.

Other health issues
___ You have diabetes.
___ You have asthma or other lung disease.
___ You have burning or cramping sensation in your lower legs when walking short distances.
___ You have musculoskeletal problems that limit your physical activity.
___ You have concerns about the safety of exercise.
___ You take prescription medication(s).
___ You are pregnant.

Cardiovascular risk factors
___ You are a man older than 45 years.
___ You are a woman older than 55 years.
___ you had a hysterectomy, or are postmenopausal.
___ You smoke, or quit smoking within the previous 6 months.
___ Your blood pressure is >140/90 mm Hg.
___ You do not know your blood pressure.
___ You take blood pressure medication.
___ Your blood cholesterol level is >200 mg/dL.
___ You do not know your cholesterol level.
___ You have a close blood relative who had a heart attack or heart surgery before age 55 (father or brother) or age 65 (mother or sister).
___ You are physically inactive (i.e., you get <30 minutes of physical activity on at least 3 days per week).
___ You are > 20 pounds overweight.

___ None of the above

If you marked any of these statements in this section, consult your physician or other appropriate health care provider before engaging in exercise. You may need to use a facility with a medically qualified staff.

If you marked two or more of the statements in this section you should consult your physician or other appropriate health care provider before engaging in exercise. You might benefit from using a facility with a professionally qualified exercise staff to guide your exercise program.

You should be able to exercise safely without consulting your physician or other appropriate health care provider in a self-guided program or almost any facility that meets your exercise program needs.
APPENDIX B

INFORMED CONSENT
INFORMED CONSENT FOR “Comparing Physiological Responses during Exercise on the Revolutionary Rocket and a Conventional Bicycle”

1. I, __________________________, give my informed consent to participate in this study designed to compare physiological responses between the Revolutionary Rocket and a conventional bicycle. I have been informed that the study is under the direction of John Porcari, Ph.D. who is the program director of the Clinical Exercise Physiology program at the University of Wisconsin-La Crosse. I consent to the presentation, publication and other release of summary data from the study which is not identifiable with myself.

2. I have been informed that my participation in this study will require me to complete three different trials on three different days. Day one will include a practice trial where I will be riding the Revolutionary Rocket to get accustomed to the bicycle. Day two and three will include either a trial on the Revolutionary Rocket or the conventional bicycle while wearing a portable VO_2 analyzer and heart rate monitor. During each trial I will ride for a total of 20 minutes. The 20 minutes will be broken up into four, 5-minute stages at four increasing speeds. I will also give a rating of perceived exertion during each stage.

3. I have been informed that there are no risks associated with this study other than the fatigue and muscle soreness that is normally associated with exercise.

4. I have been informed that there are no primary benefits to myself other than knowledge about my energy expenditure, heart rate and perceived exertion. Based on the results of this study, we may be able to start a trend in the fitness world by learning about a new type of exercise. This in turn could possibly help adults achieve their fitness goals and maintain a healthy lifestyle.

5. I have been informed that the investigator will answer questions regarding the procedures throughout the course of the study.

6. I have been informed that I am free to decline to participate or to withdraw from the study at any time without penalty.

7. Concerns about any aspects of this study may be referred to Dr. Porcari at 608 785 8684. Questions about the protection of human subjects may be addressed to the Chair of the UW-L Institutional Review Board 608 785 6892.

Investigator: __________________________

Subject (print name): __________________________  Subject Signature: __________________________

Date: __________________________
I have observed the informed consent process for this subject and am writing my name below to signify that I believe that the subject understands the nature of the study and the risks that they are being asked to assume.

Witness: ____________________________
APPENDIX C

REVIEW OF LITERATURE
REVIEW OF LITERATURE

It is known that participating in regular aerobic exercise and physical activity is beneficial for overall well-being and long-term health. Every year new types of exercise equipment are designed with every intention of changing the fitness world. One of the latest pieces of exercise equipment on the market is a product called the Revolutionary Rocket (Revolutionary Bicycles Inc., Wilmington, NC). The Revolutionary Rocket (Rocket) was invented by Alexander Hunt and combines the motions of rowing with the upper body and cycling with the lower body.

The purpose of this review of literature is to examine current guidelines regarding training for cardiorespiratory fitness as well as previous research regarding combined arm and leg exercise. In addition, this review will examine the protocols and procedures necessary for reliable data collection during steady-state exercise testing.

Guidelines for Improving Cardiorespiratory Fitness

There is currently a large body of laboratory and population-based evidence documenting the numerous health and fitness benefits associated with physical activity and endurance training (ACSM, 2010). The American College of Sports Medicine (ACSM) currently recommends that healthy adults engage in a minimum of 30 minutes of moderate intensity aerobic activity on 5 days each week or vigorous intensity activity for a minimum of 20 minutes at least 3 days per week (Haskell et al., 2007). Only 15% of adults meet ACSM guidelines for cardiorespiratory fitness (Pollock et al., 1998).
According to the ACSM, apparently healthy individuals should use an exercise intensity of 50-85% of maximal oxygen consumption (VO$_{2\text{max}}$), 40/50-85% of oxygen uptake reserve (VO$_{2\text{R}}$) and heart rate reserve (HRR), or 64/70-94% of maximum heart rate (HR$_{\text{max}}$) (ACSM, 2010). There are a large variety of modalities that can be used to achieve these recommendations, including a combination of arm and leg exercise.

**Physiological Responses to Combined Arm and Leg Exercise**

Previous studies have examined arm and leg exercise in various combinations to determine which mode is the most beneficial. Mier & Fieto, (2006) compared leg-only exercise on an elliptical trainer to combined arm-leg exercise. Twenty-six subjects participated in the study and performed six, 5-minute stages while steady state oxygen uptake (VO$_2$), minute ventilation (VE), heart rate (HR), and rating of perceived exertion (RPE) were measured. Results of the study indicated that VO$_2$ and VE were higher during combined arm-leg exercise on the elliptical, but HR and RPE were lower. The authors suggest that combining arm and leg exercise can result in greater total energy expenditure when compared to leg-only exercise.

Similarly, Gutin, Ang, & Torrey, (1988) examined arm ergometry when combined with leg exercise. Subjects included 10 nonsmoking men with a mean age of 31 years. Each subject performed two incremental tests using the legs and/or arms. Ventilatory breakpoint (VB), VO$_2$, HR, and RPE were measured. Results indicated that VB and VO$_2$ during combined arm and leg work were much higher than arm or leg work alone. In addition, RPE and HR were similar during the leg and/or arm tests. These findings suggest that spreading the work over more muscle mass allows a greater metabolic load to be tolerated.
Hagan, Gettman, Upton, Duncan, & Cummings, (1983) conducted a study in which they compared incremental-load treadmill exercise (T), to arm (A), leg (L), and combined arm and leg work (A+L) on the Schwinn Air-Dyne. The subjects for this study were 15 men and 15 women and each subject performed a VO$_2$max test on the treadmill while oxygen uptake was measured, and three incremental-load work bouts to exhaustion on the ergometer. Results indicated that VO$_2$ and HR were similar on T and A+L, but were significantly greater than A or L alone. Similar results were found by Nagle, Richie, & Giese, (1984) and Mostardi, Gandee & Norris, (1981). Thus, it appears that incorporating the muscle mass of the arms to that of the legs during exercise results in an overall better aerobic workout, without feeling the discomfort that is so often associated with exercise.

Bracko (2009) conducted a study on walking poles to determine if the poles had an influence on physiological responses. The subjects included 14 male recreational hikers and each subject hiked a total of 2 times with and without the use of poles. Subjects hiked on a trail that included sections that were either flat, steep uphill, gradual uphill or gradual downhill. Data collected included VO$_2$, VE, HR and RPE. Results indicated an increase in VO$_2$, VE, and HR with the use of the walking poles. However, RPE did not change when the poles were added. This finding suggests that individuals can get a more intense workout when using walking poles, without an increase in effort.

**Evaluation of RPE**

RPE is another measurement used to assess exercise intensity. While HR and VO$_2$ give a good indication of how a subject’s body is responding to exercise, they alone do not complete the picture of how the exercise is affecting the subject. RPE is the
subjective evaluation of the intensity of exercise and how this intensity is making the
subject feel throughout the workout. According to ACSM guidelines, “moderate”
intensity corresponds to 40-59% of VO2 reserve and HRR (Kaufman, Berg, Noble, &
Thomas, 2006). However, this terminology might not be beneficial in prescribing
exercise to the general population. Instead, explaining what the RPE scale is and how it
works is easier to understand for those not exercise science literate. Then exercise can be
prescribed to individuals with a target RPE. For example, the intensity described above
would correlate to a 12-13 on the Borg 6-20 RPE rating scale (ACSM, 2010).

Rating of perceived exertion has evolved over the years and there are new
variations of the scale. Robertson et al. (2004) studied the validation of the adult OMNI
scale of perceived exertion for cycle ergometer exercise. The study included 40 healthy
men and women who were all physically active. Each subject participated in one
orientation and one estimation trial. During the orientation trial, subjects were
familiarized with cycle ergometer exercise testing and the OMNI-Cycle Scale of
Perceived Exertion. The cycle familiarization procedures consisted of three, 3-min
incremental power output (PO) stages presented continuously. Power outputs were 50,
75, and 100 W for women and 50, 100, and 150 W for men. The estimation trial was
performed on a Monark cycle ergometer. The initial PO was 50 W for women and 75 W
for men. Power outputs were incremented in continuous 3-minute test stages by 25 W
and 50 W, respectively, for women and men. Heart rate was measured from 45 to 60
seconds during each minute of the estimation trial and VO2 was measured from 0 to 60
seconds of the final minute of each power output stage. The test was terminated when the
subject stopped exercise due to fatigue or the investigator determined that the subject
could not maintain the designated pedal rate for 10 consecutive seconds. Results indicated that RPE scores correlated significantly with HR and $V_0^2$ measures.

**Summary**

There are currently many ways in which to engage in physical activity and improve cardiorespiratory fitness. Previous research comparing separate arm and leg exercise to combined arm and leg exercise had revealed that the combination puts less stress on the body while producing higher $V_0^2$ responses. The information obtained from this review will be used in part to determine the effectiveness of the Rocket at meeting ACSM guidelines for cardiorespiratory fitness when compared to a conventional bicycle.
REFERENCES


