ABSTRACT

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Maximal physiological responses on upright (UP) and semi-recumbent (SR) cycles were completed in 12 male and 7 female (19-27 yrs) subjects while performing incremental maximal exercise tests. The subjects were habituated to each modality with 10 practice sessions with each mode prior to testing. Testing order on the bikes was randomized and performed 24-48 hours apart. Data were analyzed using 2X6 MANOVA with repeated measures. Heart rate, SBP, DBP, VO_2, RPE, and Kcals/min were measured at the end of each 2-minute stage and at maximal exercise. At both submaximal and maximal exertion, HR, SBP, DBP, VO_2, RPE, and Kcals/min were not significantly different ($p > 0.05$). This study shows that after habituation, both cycles promote similar physiological responses. Therefore, either cycle may be chosen for maximal exercise testing depending on comfort level and personal preference.

A COMPARISON OF THE MAXIMAL EXERCISE RESPONSES ON UPRIGHT AND SEMI-RECUMBENT CYCLE ERGOMETERS WITH HABITUATION

A MANUSCRIPT STYLE THESIS PRESENTED

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INTRODUCTION

Common exercise equipment found in many rehabilitation and fitness facilities includes treadmills, stair steppers, rowers, and stationary bicycles. In recent years, a new form of cycle ergometer, the semi-recumbent (SR), has gained popularity among the exercising population. Many users prefer SR cycles to upright (UP) cycles because of its greater comfort level.

Previous studies performed on UP and SR bicycles have produced mixed results. At submaximal workloads, heart rate (HR) is lower on the SR possibly due to increased venous return, which results in increased stroke volume (1,2,3). Also, VO_2 is lower at submaximal workloads on the SR possibly due to not having to raise one's legs against gravity (1,4). The seat back also gives greater stability and provides leverage to help with pedaling.

Along with differences found at submaximal workloads, significant differences in physiological responses were found at maximal exertion on UP and SR cycles (5,6). Some studies found no significant differences in physiological responses on the cycles at maximal exertion (1,2,5,7,8). Reasons for lower HR and maximal oxygen consumption on SR cycles have been attributed to position of the hamstring muscles and insufficient habituation to the equipment. Another possible reason for lower HR and VO_2 max may be attributed to the potentially higher end diastolic volume in the SR position (9). High VO_2 max measurements are typically associated with the use of large-mass muscle groups. The SR position is thought to limit the use of upper torso and gluteal muscles, which may result in lower VO_2 max values (9,10). The SR position, however, with the added back support may provide subjects greater leverage to pedal against (5). Westcott (3) concluded that the SR position facilitates venous return thereby alleviating stress on the heart and resulting in lower systolic blood pressure (SBP). Peripheral resistance was shown by Hermansen et al. (10) not to be affected by the position of the body. In short, there is a serious lack of consistency in studies of UP vs. SR cycling.

A primary weakness in previous research, which examined differences between UP and SR bicycles, may have been the absence of habituation. Therefore, the purpose of this study was to compare the maximal physiological responses of male and female, college-age (19-27 yrs), moderately active students on the UP and SR bicycles following habituation.

METHODS

Subject Selection

Subjects included 12 male and 7 female college-age (19-27 years) moderately active volunteers. Moderately active as defined for this study were those individuals who exercise 3-5 times per week for 30-60 min per session. Subjects were included based on activity levels and cross-modal experience. All subjects were apparently healthy with no known cardiovascular disease or musculoskeletal limitations (11). Subjects filled out a Par-Q form (see Appendix A) and signed an informed consent prior to joining the study (see Appendix B). Use of human subjects in this study was approved by the Institutional Review Board at the University of Wisconsin-La Crosse. Subjects were asked not to eat for a minimum of 3 hrs before testing and practice sessions and not to perform any rigorous exercise within 24 hrs of testing sessions.

Habituation

Each subject was habituated to the UP and SR cycles by performing 10 practice sessions on each bicycle over a 4-week period. Subjects practiced at fitness facilities in the city of La Crosse, WI and on the University of Wisconsin-La Crosse campus. Each practice session lasted 30 min and alternated between the UP and SR cycles. Subjects were asked to work at an intensity of 13 to 15 (somewhat hard to hard) on the Borg Rate of Perceived Exertion (RPE) scale (see Appendix C) for each of the practice sessions (12). Subjects followed practice guidelines and filled out a practice session worksheet for each session (see Appendix D). Additionally, subjects performed the last 3 sessions on each cycle in the human performance laboratory to become familiar with the testing equipment used for VO_2 max (including headgear with a mouthpiece and nose clip), and heart rate (including chest strap and a watch). Laboratory habituation occurred in the human performance laboratory at the University of Wisconsin-La Crosse.

Testing

Subjects' height and weight were measured on a standard physician's scale in the human performance laboratory (Hilton Medical Supply, La Crosse, WI). Testing began with a 5-min warm-up followed by 2-min stages of increasing intensity on the StairMaster Stratus UP and SR bicycles (models 3900 RC and 3300 CE, StairMaster, Kirkland, WA). Measurements of SBP, diastolic blood pressure (DBP), HR, and RPE were taken following each 2-min stage and at maximal exertion. A calibrated mercury sphygmomanometer and stethoscope were used to measure SBP and DBP. Heart rates were recorded using a Polar Vantage XL Heart Rate Monitor (Polar-CIC Inc., Port

Washington, NY). A Quinton Metabolic Cart (QMC) (Quinton Instrument Company, Seattle, WA) was used for VO_2 max testing and was calibrated prior to each test.

Testing was conducted in the human performance laboratory at the University of Wisconsin-La Crosse. Barometric pressure, temperature, and humidity were recorded prior to each test. Tests were conducted on 2 separate days at a similar time of day with a 24-48 hr rest between tests. Cycle test order was assigned randomly for all subjects. Testing was terminated at volitional exhaustion or when subjects failed to maintain 60 rpms for more than 10 sec.

Statistical Analysis

Standard descriptive statistics were used to characterize the subjects. Heart rate, SBP, DBP, VO_2, RPE, and watts were collected and analyzed using a 2X6 MANOVA with repeated measures. Alpha was set at .05.

RESULTS

The descriptive characteristics of the subjects are presented in Table 1.

Table 1

Descriptive Characteristics of the Subject Population (N=19)

Gender	Age (yrs)	Height (cm)	Weight (kg)
Males (n=12)	23 ± 2	182 ± 8	88 ± 23
Females (n=7)	22 ± 3	169 ± 7	63 ± 11

Tables 2 and 3 summarize the submaximal data of males and females during incremental testing on the UP and SR cycles. There were no significant differences ($p > 0.05$) between the cycles at stages I-IV.

Table 2

Submaximal Responses of Males on the UP and SR Cycles (MEAN ± SD)

		Watts	HR (bpm)	SBP (mmHg)	DBP (mmHg)	RPE	VO_2 (ml/kg/min)
I	UP	50	104 ± 13	128 ± 11	74 ± 14	7 ± 1	11.2 ± 3.7
	SR	50	104 ± 16	124 ± 11	67 ± 13	7 ± 1	9.8 ± 1.8
	Df		0	4	7	0	1.4
II	UP	84	117 ± 11	138 ± 12	73 ± 16	8 ± 2	13.9 ± 1.7
	SR	84	112 ± 8	135 ± 13	72 ± 10	9 ± 2	12.7 ± 1.7
	Df		5	3	1	1	1.2
III	UP	118	136 ± 20	146 ± 15	78 ± 17	10 ± 2	18.5 ± 2.5
	SR	118	124 ± 11	144 ± 14	67 ± 11	10 ± 2	16.7 ± 2.6
	Df		12	2	11	0	1.8
IV	UP	152	146 ± 20	147 ± 5	71 ± 16	12 ± 2	22.6 ± 3.9
	SR	152	135 ± 13	153 ± 14	68 ± 14	12 ± 2	20.1 ± 3.5
	Df		11	6	3	0	2.5

Note. No significant differences were found between variables on each cycle ($p > 0.05$). Df=Difference between values on the UP and SR cycles.

Table 3

Submaximal Responses of Females on the UP and SR Cycles (MEAN ± SD)

		Watts	HR (bpm)	SBP (mmHg)	DBP (mmHg)	RPE	VO_2 (ml/kg/min)
I	UP	50	121 ± 10	125 ± 10	59 ± 4	9 ± 2	15.3 ± 5.9
	SR	50	113 ± 11	119 ± 12	60 ± 16	8 ± 2	12.1 ± 2.4
	Df		8	6	1	1	3.2
II	UP	84	141 ± 14	133 ± 15	63 ± 9	11 ± 2	16.1 ± 3.9
	SR	84	130 ± 13	124 ± 14	60 ± 9	11 ± 1	12.8 ± 2.1
	Df		11	9	3	0	3.2
III	UP	118	158 ± 15	137 ± 10	59 ± 11	13 ± 1	23.2 ± 3.9
	SR	118	148 ± 16	134 ± 22	54 ± 15	13 ± 1	18.2 ± 3.9
	Df		10	3	5	0	5.0
IV	UP	152	171 ± 17	146 ± 10	67 ± 9	15 ± 2	29.3 ± 4.6
	SR	152	162 ± 17	142 ±22	59 ± 13	14 ± 1	24.2 ± 5.2
	Df		9	4	8	1	5.1

Note. No significant differences were found between variables on each bicycle ($p > 0.05$).
Df=Difference between values on the UP and SR cycles.

Tables 4 and 5 summarize the physiological responses to maximal exercise for each cycle and each gender. No physiological differences were found between cycle types in subjects at maximal exertion, however, subjects did attain higher workloads (watts) on the SR cycle. Figure 1 summarizes the values obtained during maximal exercise including both gender and modality.

Table 4

Physiological Responses of Males to Maximal Exercise

	UP X ± SD	SR X ± SD	Difference
HR (bpm)	183 ± 3	179 ± 3	4
SBP (mm Hg)	165 ± 4	175 ± 4	10
DBP (mm Hg)	66 ± 5	65 ± 4	1
RPE	18 ± 1	18 ± 1	0
VO_2 (ml/kg/min)	37.9 ± 1.9	38.4 ± 2.0	0.5
Kcals/min	17.4 ± 2.7	16.9 ± 1.8	0.5
Watts	258 ± 11	297 ± 11	39*

*indicates statistical significance ($p < 0.05$)

Table 5

Physiological Responses of Females to Maximal Exercise

	UP X ± SD	SR X ± SD	Difference
HR (bpm)	184 ± 4	188 ± 4	4
SBP (mm Hg)	152 ± 5	147 ± 6	5
DBP (mm Hg)	63 ± 7	66 ± 6	3
RPE	17 ± 1	18 ± 1	1
VO_2 (ml/kg/min)	38.7 ± 2.4	36.6 ± 2.7	2.1
Kcals/min	12.9 ± 3.1	12.2 ± 2.2	0.7
Watts	203 ± 14	232 ± 14	28*

*indicates statistical significance ($p < 0.05$)

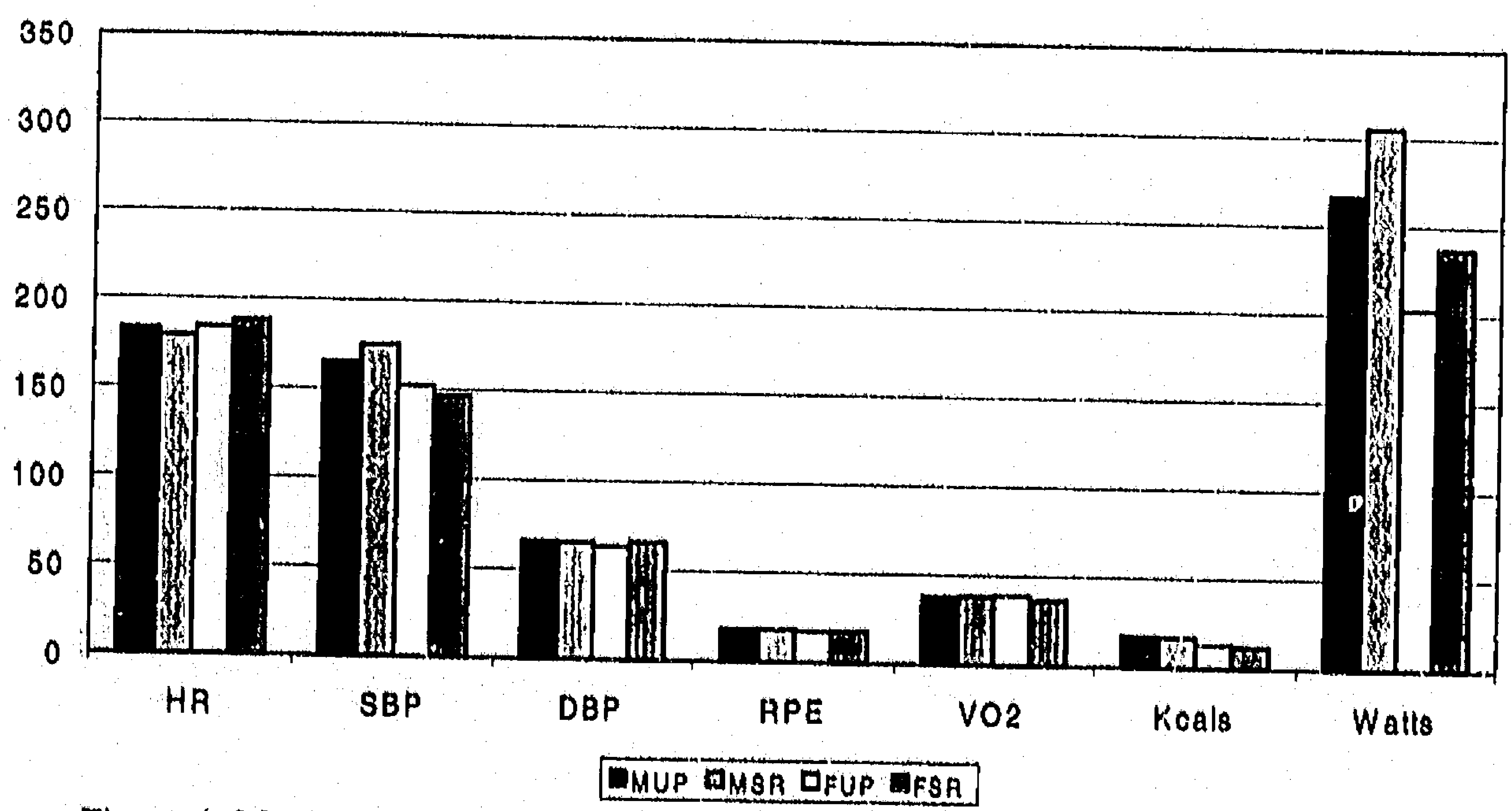

Figure 1. Maximal values of males and females on the UP and SR cycles.

DISCUSSION

This study examined the physiological responses of men and women to maximal exercise on UP and SR stationary cycles. This study also compared the submaximal responses of stages prior to maximal exertion. All physiological variables were similar between UP and SR cycles during submaximal exercise in the current study. These results differ from those found by other researchers. Pauly (2) and Johnson (5) found HR, SBP, and VO_2 to be significantly higher during submaximal exertion on an UP vs. SR cycles. The primary differences in methodology between the present study and those published by Pauly (2) and Johnson (5) is that subjects in the present study were habituated prior to testing. The biomechanics used for the UP cycle more closely resemble activities of daily living. Therefore, the SR cycle may require more practice, or habituation. After habituation, the bicycles appear to illicit the same physiological responses at submaximal exertion.

In addition to equality of the submaximal variables, the current study found the maximal variables to be similar between cycles. In the previous studies by Johnson (5) and Pauly (2), HR, SBP, and VO_2 were found to be significantly higher on the UP cycle during maximal exertion. These findings were attributed to weak hamstring and quadriceps muscles as well as not habituating to the equipment. Current findings suggest that 4 weeks of habituation provided an adequate training effect, which allowed subjects to obtain equivalent values on each cycle.

Maximal HR and VO_2 values for both men and women were found to be equal between the two cycles. These findings agree with Taylor et al. (13), Bonzheim et al. (1), Currie et al. (7), Pauly (2), Quinn et al. (8). These studies suggest that there are no fundamental differences between the UP and SR cycles. However, results from the present study do not agree with those from Walsh-Riddle and Blumenthal (6) and Johnson (5) who found maximum HR and oxygen consumption to be higher on the UP vs. the SR. Walsh-Riddle and Blumenthal (6) used untrained hypertensive subjects, which may have affected results. In the present study, subjects were apparently healthy, moderately active and were also habituated to the cycles for 4 weeks.

In the current study, maximal SBP and DBP responses were not significantly different between cycles. This agrees with studies by Currie et al. (7), Johnson (5), Pauly (2), and Quinn et al. (8). Further, Walsh-Riddle and Blumenthal (6) and Bonzheim et al. (1) found no differences in RPE at maximal exertion on the cycles, which also agrees with the current study's results.

Maximal workloads (watts) were found to be significantly higher on the SR cycle in the present study. Reasons for the difference in workload may be due to the fact that the body is not battling gravity as much on the SR vs. UP cycles. Furthermore, SR cycles have a seatback, which may be used for leverage thus aiding subjects in attaining higher workloads. Research suggests that the more comfortable a person is, the lower their HR and BP responses will be to a given workload (14). Subjects may have been more comfortable on the SR cycle and, therefore, reached max HR, SBP, and DBP at higher workloads.

In conclusion, despite achieving higher workloads on the SR cycle, both males and females achieved similar physiological responses with maximum exercise between cycles. These results suggest that once a subject is habituated, either cycle may be used for clinical or field assessments of maximal physiological responses to exercise.

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APPENDIX A

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Name________________________

PHYSICAL ACTIVITY
READINESS QUESTIONNAIRE (PAR-Q)*

The PAR-Q is a standard form used to determine your initial health and activity level.

The test identifies those individuals who may be at risk if they engage in this study.

Answer the following questions to the best of your ability by checking yes or no as the questions pertain to you.

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

*American College of Sports Medicine: Guidelines for Exercise Testing and Prescription, (5th ed.). Baltimore, MD: Williams and Wilkins, 1995.

APPENDIX B

INFORMED CONSENT

INFORMED CONSENT FOR THE COMPARISON OF THE MAXIMAL EXERCISE RESPONSES ON THE UPRIGHT AND SEMI-RECUMBENT CYCLES FOLLOWING FOUR WEEKS OF PRACTICE/TRAINING ON THE CYCLES

I____________________________volunteer to participate in this study of maximal testing on upright and semi-recumbent cycles. I have been informed that I will be required to perform 8 practice sessions on each of the bicycles within a four-week period. I have been informed that during the practice sessions I will be required to record information about the workouts and will be contacted periodically by the researchers regarding the progress of the workouts. I have been informed of the rate of perceived exertion (RPE) scale. I have been informed that I will work between a 13 and 15 ("somewhat hard" to "hard") on the RPE scale for each of the practice sessions.

Four practice sessions (two on each cycle) will be conducted in the Human Performance Research Laboratory on the University of Wisconsin-LaCrosse campus to become familiar with the actual testing equipment which will include wearing a mouthpiece, nose clip, and heart rate monitor.

I have been informed that following the six weeks of practice, I will be required to perform a VO_2 max test on each of the cycles with a 24 to 48 hour rest period in between tests. I am aware that I will complete each test in a randomly assigned order.

I consent to presentation and publication or other dissemination of study results so long as the information is anonymous and disguised so no identification can be made. I have been informed that although a record will be kept of my having participated in the experiment, all experimental data collected from my participation will be identified by number only.

I have been informed that there may be some discomfort involved in performing the maximal testing procedure, and dizziness, faintness, injury, fatigue, and in some rare instances death may occur. However, the probability of death occurring is very small and has never occurred on the University of Wisconsin-LaCrosse campus. The principal researcher, who is certified in ACLS, CPR, and First Aid, will collect all data. All precautions will be taken to ensure a safe testing environment.

I have been informed that the principal researcher will terminate the maximal test due to inability of the subject to maintain pedaling speed of 60 rpms or if any heart rate or blood pressure inconsistencies occur. I am aware that I may stop the test at any time due to fatigue or inability to continue.

I have been informed that the investigator will answer questions regarding the procedures of this study at any time. I have been informed that I may withdraw from this study at any time without penalty.

Concerns about any aspects of this study or project may be referred to the principal researcher (Charlotte Goebel (608) 796-9340) and thesis advisor (Dr. Richard Mikat (608) 785-8182).

Questions regarding the protection of human subjects may be addressed to Dr. Garth Tymeson, Chair, University of Wisconsin-LaCrosse, Institutional Review Board for the Protection of Human Subjects (608) 785-8155.

____
Researcher

Date______________________

____
Participant

Date______________________

APPENDIX C

RATE OF PERCEIVED EXERTION (RPE) SCALE

RATE OF PERCEIVED EXERTION SCALE*

6	
7	VERY, VERY LIGHT
8	
9	VERY LIGHT
10	
11	FAIRLY LIGHT
12	
13	SOMEWHAT HARD
14	
15	HARD
16	
17	VERY HARD
18	
19	VERY, VERY HARD
20	

*American College of Sports Medicine: Guidelines for Exercise Testing and Prescription, (5th ed.). Baltimore, MD: Williams and Wilkins, 1995.

APPENDIX D

PRACTICE INSTRUCTIONS

AND

DATA FORM

PRACTICE/TESTING INSTRUCTIONS

As a subject in this study, you will be completing 10 practice sessions on the upright bicycle and 10 practice sessions on the semi-recumbent bicycle. Each of these sessions will last 30 minutes and all practice sessions will be completed by December 4, 1999.

For each practice session, you will fill out the evaluation form provided by the researcher. Please randomly select the exercise mode for each practice session (do not do 10 sessions in a row on the upright and then 10 sessions on the semi-recumbent). Four of these 16 sessions (two on the upright and two on the semi-recumbent bicycle) will be conducted in the human performance laboratory (225 Mitchell Hall). The researchers will take appointments according to subject availability. During the final practice session in the human performance laboratory, you will be able to use the headgear, mouthpiece, nose clip, and heart rate monitor to help reduce anxiety and become comfortable with the testing equipment.

Following the practice session period, the researcher will take appointments for maximal exertion testing. You will need to schedule two tests (one for the upright and one for the semi-recumbent bicycle). Testing should take place during the same time of day with a 24-hour rest period between tests. Please allow 45 minutes to one hour for each test. The testing sessions will take place in the human performance laboratory (225 Mitchell Hall).

Prior to testing sessions, please follow these guidelines:

1. Please wear comfortable clothing and proper athletic shoes for exercising.
2. Please avoid food, tobacco, alcohol, and caffeine for three hours before testing.
3. Please arrive at the testing site well-rested and please refrain from heavy physical activity for at least 3 hours prior to testing.

PRACTICE SESSION DATA SHEET

NAME____________________________

DATE____________________________

PRACTICE LOCATION____

PRACTICE SESSION NUMBER____________

TIME OF DAY_________________ LENGTH OF SESSION______minutes

TYPE OF BICYCLE USED______UPRIGHT ______SEMI-RECUMBENT

PEAK HEART RATE (HR)________ RPE________

SPEED (WATTS)_______ TOTAL KCAL_______

==

APPENDIX E

LITERATURE REVIEW

LITERATURE REVIEW

Introduction

The primary purpose of the present study is to compare the physiological variables of maximal exercise testing of male and female college-age volunteers on both the UP and SR bicycles. According to Taylor, Buskirk, and Henschela (1) maximum values for individuals should remain consistent as long as the individual maintains similar physical activity. Maximal oxygen intake measures cardiorespiratory performance. Therefore, individuals should attain similar VO_2 max on the UP and SR as long as all other variables remain the same. Little research has been conducted comparing the UP and SR cycles either during submaximal or maximal exertion. Previous studies have been conducted on subjects with cardiovascular disease, hypertension, and healthy populations.

Heart Rate (HR) Response to Exercise

During exercise or at rest, the HR is a good indicator of how hard the heart is working. Normally the HR increases linearly with increased activity levels (2,3). Differences in how much the heart rate increases are a result of type of exercise (aerobic or anaerobic) how intense the workload, and how well trained the person. More trained individuals will have a lower HR at any given submaximal workload than untrained persons (3). At maximal exertion, however, similar HR will be attained regardless of training status (3). The reason for HR increasing during exercise is to expel more blood per minute to feed the working tissues and sustain exercise (2,3). Following exercise, the HR remains elevated for a while before slowly returning to the resting rate. The body is helping to flush metabolic waste from the working tissues after exercise. Maximum HR decreases with increasing age (~1 bpm/year)(4).

Systolic and Diastolic Blood Pressure (SBP & DBP) Responses to Exercise

Systolic blood pressure increases proportionately to increased exercise intensity (3). The increased SBP facilitates the delivery of blood to the working tissues. Diastolic blood pressure changes little if any during exercise regardless of intensity (3). Diastolic blood pressure represents the pressure in the arteries when the heart is at rest, so there is no reason for it to vary. Blood pressure reaches steady state during submaximal exercise (2,3). As intensity increases, so does SBP. If steady state exercise is prolonged, SBP may decrease gradually (3). This is a very normal response and happens due to increased arteriolar dilation in the active muscles, which decreases total peripheral resistance (TPR) (3). One indication that a person has reached maximal exercise is when SBP decreases with an increase in workload (4).

VO_2 Response to Exercise

The capacity of the cardiovascular system to deliver oxygen to the working muscles is represented by VO_2 (5). The highest rate of oxygen consumption attainable during maximal exercise is VO_2 max (2,3). Oxygen consumption increases linearly with increasing intensity until maximum exercise. If intensity is increased beyond this point, oxygen consumption may either plateau or decrease slightly (3). This means the body can't deliver oxygen as quickly as needed to meet the demands of the muscles. Continuing to exercise beyond this point will bring the anaerobic reserves into action, however, these supplies are also limited. Maximum oxygen consumption values are generally lower in women than men of the same age and decline with age and cardiovascular disease (5).

Factors Affecting HR, BP, and VO_2

Many factors can affect HR, SBP, DBP, and VO_2 including environmental conditions, nicotine, caffeine, and stress. Subjects were instructed not to consume caffeine or nicotine minimum of 3 hours before the test. Environmental conditions within the laboratory were strictly controlled with barometric pressure, temperature, and humidity recorded prior to each test. Stress on the subject may be increased if comfort level is low (3). If a person has little or no prior experience on a piece of equipment, they may feel awkward the first few times. As a result, more energy is expended causing increased physiological responses (3). Once comfortable with the equipment less energy is used.

Rating of Perceived Exertion (RPE) Response to Exercise

The RPE scale was developed by Borg (6) to quantify the subjective symptoms of subjects as related to objective measurements (6). The scale was intended to be a general indicator of physical strain. It integrates signals from the working muscles and joints, the central cardiovascular system and the central nervous system (7). Borg developed this scale based on the HR/intensity linear relationship and correlates to HR's which can be estimated from 60 bpm at rest to 200 bpm at maximal intensity (7). The physical stress of an activity causes a certain strain for each individual depending upon the intensity perceived by the systems of the body. Neither a single RPE value nor a HR measure may be used alone as an accurate indicator of strain on the body (7). They compliment each other. Individuals vary on RPE responses according to their understanding of the scale.

It has been adopted by the ACSM as a good indicator of perceived exertion during exercise testing as well as for exercise prescriptions. One indicator of attainment of maximal exertion is an RPE rating of 19 or higher (4).

Maximal VO_2 Testing on the UP and SR Bicycles

Studies regarding maximal VO_2 testing on the UP and SR have shown conflicting results. Of the various physiological variables measured, heart rate (HR) and maximal oxygen consumption were found to be similar on the UP and SR cycles even though higher workloads were at[illegible]ned on the SR cycle (8,9,10,11). However, Walsh-Riddle and Blumenthal (12) and Johnson (13) found VO_2 max and HR to be significantly higher on the UP as compared to the SR bicycle. Johnson (13) and Pauly (10) found no significant differences in SBP and DBP on the UP and SR during maximal exercise. At maximal exertion, RPE's were found to be similar on the UP and SR (12).

Submaximal Exercise Testing on UP and SR Bicycles

Previous studies differ regarding the physiological responses to submaximal testing on the SR and UP bicycles. A few studies supported the concept that at similar submaximal power output, HR, RPE, and systolic blood pressure (SBP) were greater on the UP than on the SR (8,10,14). Two studies found no significant differences in HR at the submaximal levels on the SR and UP bicycles (11,15). Smith et al. (15) also found that RPE remained unaffected by seat angle. Pauly (10), however, reported that RPE was significantly higher on the SR cycle during submaximal testing. Two studies reported that VO_2 was lower on the SR than on the UP during submaximal testing, possibly due to more localized muscle fatigue of the quadriceps and the hamstrings (8,15). Westcott (14) found that after extensive training and habituation (i.e. 8 weeks), at submaximal exertion, subjects revealed higher HR, RPE, and SBP on the UP even though subjects worked at a higher intensity (e.g. power output) on the SR. Subjects were able to work at a higher intensity on the SR than on the UP while still maintaining lower HR, RPE, and SBP.

Reasons for Differences in Physiological Variables on the SR and UP

It has been hypothesized that greater overall body involvement and less localized muscle fatigue in the UP position may explain why subjects were able to attain higher exertion levels. A greater VO_2 max is associated with using larger muscle masses. The more localized muscles (i.e. hamstrings and quadriceps) in the SR position limit use of the upper torso in aiding the subject to attain a higher VO_2 (16,17). The SR position with the added back support may provide subjects greater leverage to pedal against (13). Westcott (14) concluded that the SR position facilitates venous return thereby alleviating stress on the heart and resulting in lower SBP. Peripheral resistance was shown by Hermansen et al. (18) not to be affected by the position of the body. Another reason for higher physiological responses on the UP cycle could be that this cycle simulates activities of daily living more closely than the SR cycle. Therefore the body needs more time to adjust to the different positioning of the SR cycle.

Pedal Speed for Maximal Exercise Testing

Hermansen and Saltin (16) tested various pedal speeds to determine the optimal pedal frequency to use during stationary bicycle testing to obtain the best results. The authors found that pedal speeds of 60 to 70 rpm elicited greater VO_2 max values than speeds of 50 or 80 rpms (16).

Exercise Prescription

When considering exercise prescription on the UP and SR bicycles, the workloads are not interchangeable. The SR uses lower workloads, meaning that exercise should be prescribed at a higher intensity for the SR. Smith et al. (15) found that muscular efficiency was higher on the SR as compared to the UP. Use of the SR bicycle can improve muscular efficiency without affecting RPE and HR. The SR does allow a person to achieve max HR but at much higher work loads (8).

Bonzheim et al. (8) also administered an enjoyment scale to the study participants. Findings revealed that patients perceived the SR to be significantly easier than the UP at submaximal levels. At peak exercise, perceptual responses were not significantly different (8). It is important to emphasize that although physiological responses to UP and SR are similar, perceptual and cardiovascular responses are much lower on the SR for any given intensity.

Summary

Previous research on the comparisons of physiological responses to maximal exercise on the UP and SR bicycle has been very limited and contradictory. Suggestions regarding the habituation or training of subjects led the researcher to the present study using extensive habituation before testing to determine the validity of previous research.

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