ABSTRACT

JOHNSON, C. C. A comparison of the submaximal and maximal responses to upright versus semi-recumbent cycling in males. MS in Adult Fitness/Cardiac Rehabilitation, December 1999, 34pp. (J. Porcari)

The purpose of this study was to compare the submaximal and maximal physiological responses of males using a StairMaster upright (UP) and a StairMaster semi-recumbent (SR) cycle. Fifteen male students (mean age = 22 ± 2.4 yrs) served as Ss. All Ss completed maximal tests on each modality during which the following physiological responses were evaluated: HR, VO_2, BP, RER, RPE, and caloric expenditure (Kcal). The maximal physiological responses from the UP and SR tests were compared using paired t-tests. There were no significant ($p > 0.05$) differences in maximal SBP, DBP, and RER. There were significant ($p < 0.05$) differences in VO_2, HR, RPE, and Kcal between the cycles. Submaximal evaluation revealed no significant ($p > 0.05$) difference in SBP or DBP. There were significant ($p < 0.05$) differences in submaximal VO_2, HR, RER, Kcal, and RPE. Any significance found at either maximal or submaximal testing was a result of higher values on the UP compared to the SR cycle. Despite the higher physiological responses on the UP, Ss were able to exercise longer (15.3 vs 13.2 minutes) and Ss watts were higher (269 vs 240) on the SR cycle. The results of this study indicate that when developing an exercise prescription, the workloads prescribed on the SR cycle would need to be higher than on an UP cycle in order to achieve the same intensity.

A COMPARISON OF THE SUBMAXIMAL AND MAXIMAL RESPONSES TO UPRIGHT VERSUS SEMI-RECUMBENT CYCLING IN MALES

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FACULTY

UNIVERSITY OF WISCONSIN-LA CROSSE

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BY

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THESIS FINAL ORAL DEFENSE FORM

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We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

Master of Science: Adult Fitness/Cardiac Rehabilitation

The candidate has successfully completed the thesis final oral defense.

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This thesis is approved by the College of Health, Physical Education, and Recreation.

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INTRODUCTION

As more and more individuals and health and fitness clubs purchase semi-recumbent cycles, users often question whether they get the same workout when using a semi-recumbent compared to a traditional upright cycle. Many people have the

perception that exercising on a semi-recumbent cycle is easier and they do not get as good a workout. One of the many benefits of cycle ergometers is that they can be a beneficial type of exercise for individuals who cannot tolerate the stress of running. These include the obese, the elderly, and those who may have an overuse injury. These individuals are faced with the decision of what type of cycle ergometer to use.

There are several types of cycle ergometers. The traditional upright ergometer is the most widely used, however, recently the use of the semi-recumbent cycle ergometer has increased. The semi-recumbent bicycle is designed so that the subject pedals with both legs extended horizontally while in the sitting position. It has been suggested that increased venous return associated with supine body position can produce significantly lower heart rate (HR) responses when compared with the upright position (3,7). There are only a few studies which have evaluated physiological differences between users of upright and semi-recumbent cycle ergometers (2). Among the studies that looked at physiological responses, most report no difference in HRs and oxygen consumption (VO_2) between users of upright and recumbent cycles at maximal workloads (4,5). However, Bonzheim, Franklin, Dewitt, and Marks (2) and Walsh-Riddle and Blumenthal (7) reported significantly lower submaximal HR and VO_2 values in the recumbent position compared to the upright position. Studies investigating the blood pressure responses to semi-recumbent cycling are inconclusive. Some studies report blood pressures to be similar for cycling in the two positions (6,8) whereas some reported systolic and diastolic blood pressure to be higher in the recumbent position (3,5). The study by Bonzheim and coworkers (2) contradicted these studies by reporting significantly lower systolic and diastolic blood pressures during submaximal work of subjects in the recumbent compared with the upright position. These differences were not seen during maximal exertion. The studies do agree that there is a similar HR vs VO_2 relationship between the two positions, thus making exercise prescription easy to calculate.

The discrepancies among studies reveal the need for further research, especially with regards to the physiological responses during use of the upright versus the semi-recumbent ergometer. The purpose of this study was to compare the submaximal and maximal responses to exercise between the StairMaster upright and StairMaster semi-recumbent cycles in males.

METHODS

Subject selection. Fifteen male volunteers between the ages of 20 and 28 served as subjects for this study. Subjects were recruited from the University of

Wisconsin-La Crosse and the surrounding community. All subjects completed an informed consent document (see Appendix A) and health history questionnaire (Par-Q) (see Appendix B) prior to participation in the study. Use of human subjects in this study was approved by the Institutional Review Board at the University of Wisconsin-La Crosse.

Overview of testing protocol. Each subject completed two to three practice sessions on both the StairMaster upright (UP) and StairMaster semi-recumbent (SR) ergometers. After the practice sessions, the subjects performed one incremental VO_{2max} test on each modality. Subjects were randomly assigned the order for the UP and SR tests. The second test was done within one week of the first test. During each test VO_2 was measured as well as blood pressure (BP), HR, respiratory exchange ratio (RER), caloric expenditure (Kcal), and rating of perceived exertion (RPE).

Practice session. During the practice sessions instructions were given regarding the proper technique for using the equipment safely. Proper body positioning and appropriate pedal speed were also discussed. The researcher explained and read specific instructions on the proper use of the heart rate monitors, head gear, nose clip, mouthpiece, and rating of perceived exertion scale (RPE) (see Appendix C). During the final practice session, subjects practiced on the UP and the SR while wearing the mouthpiece and headgear used to measure oxygen consumption. This was done to help reduce anxiety and to allow the subjects to become familiar with the testing procedures. In accordance with the American College of Sports Medicine (ACSM) guidelines for exercise testing (1) subjects were told that no food, caffeine, or alcohol were to be consumed for at least 3 hours prior to testing.

Testing sessions. Prior to each test the subject's height was measured without shoes to the nearest 1cm and weight to the nearest .1 kg. These data were then entered into the Quinton (Q-Plex 1, Quinton Instrument Company, Seattle, WA) metabolic cart. Exercise testing was performed on the StairMaster upright (UP) and the StairMaster semi-recumbent (SR) cycles. The UP cycle had its seat and pedal placement in the traditional upright position. The SR had its seat position at a measured 45-degree angle to allow for added back support for the subjects. The foot pedals of the SR were level with the seat allowing subjects to pedal parallel to the ground. The seat heights of both cycles were adjusted individually to allow a slight bend in the knee while the leg was at full extension. The pedal rate was 75 revolutions per minute (RPM) for both cycles. This cadence was chosen since most subjects were able to maintain it easily. Each subject exercised at two-minute incremental stages until volitional exhaustion.

Measurements and Instrumentation. During all tests the subjects were required to wear a Polar Vantage Heart Rate Monitor (Polar-CIC Inc., Port Washington, NY). These monitors consist of a heart rate watch and a chest strap. The chest strap contained electrodes which detect the heart rate, and the watch displayed the measured heart rate. Blood pressure was measured while the subjects continued to pedal using a mercury sphygmomanometer. Expired gas during the tests was measured using the QMC Metabolic Analyzer (Bothell, WA). The Q-Plex, an automated metabolic cart, was used to assess the subjects' expired air for the determination of absolute and relative VO_2, caloric expenditure, and respiratory exchange ratio (RER). The Quinton metabolic cart was calibrated prior to the testing of each subject. The gas analyzers were calibrated using known gas concentrations verified by the micro-Scholander technique. The pneumotach was calibrated using a 3.0L syringe pump at various flow rates.

Statistical analyses. Data analyses was performed using SPSS statistical software (Lawrence Erlbaum Associates, Publishers, Hillsdale, U.S.), and Microsoft Excel '97 statistical software. Maximal values between cycle tests were analyzed using paired t-tests, while the submaximal values were analyzed using a two-way ANOVA with repeated measures. Paired differences were assessed using the paired t-test and Bonferonni adjustment. Alpha was set at 0.05 for all analyses.

RESULTS

Fifteen male subjects completed an incremental maximal test on both the UP and SR cycles. The descriptive characteristics of the subjects are presented in Table 1.

Table 1. Descriptive characteristics of the subject population (N = 15)

Gender	Age (years) $X \pm SD$ (range)	Height (cm) $X \pm SD$ (range)	Weight (kg) $X \pm SD$ (range)
Males (15)	22.2 ± 2.37 (20-28)	177.6 ± 5.4 (170-185)	80.4 ± 15.5 (61.2-113.4)

Values are presented as mean ± SD

Table 2 summarizes the physiological responses to maximal exercise for each condition. It was found that exercise on the UP cycle elicited a significantly higher ($p < 0.05$) VO_2, HR, RPE, and caloric expenditure than maximal exercise on the SR cycle. However, no significant differences ($p < 0.05$) were found for RER, SBP, and DBP between conditions.

Tables 3-9 summarize the physiological responses to submaximal exercise. Five stages were analyzed since all subjects completed at least this number of stages.

Submaximal values for VO_2 are presented in Table 3. Values during use of the UP were significantly ($p < 0.05$) greater than SR across all five stages. There was also a significant interaction ($p < 0.05$) which indicates that differences between UP and SR generally got larger as each stage increased.

Table 2. Physiological responses to maximal exercise on the UP and SR cycles

Variable	UP $\bar{X} \pm SD$	SR $\bar{X} \pm SD$	Difference
VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	41.5 ± 7.7	38.5 ± 5.4*	3.0
HR (bpm)	184 ± 8.3	177 ± 10.8*	7.0
Kcal	17.1 ± 2.4	15.8 ± 1.7*	1.3
RER	1.19 ± .113	1.15 ± .072	0.04
RPE	18.9 ± 1.0	18.1 ± 1.7*	0.8
SBP (mm Hg)	183 ± 13.9	187.6 ± 12.9	4.6
DBP (mm Hg)	71 ± 6.9	71 ± 7.4	0
WATTS	240 ± 22.6	269 ± 21.8*	29
TIME (min)	13.2 ± 2.0	15.3 ± 2.1*	2.1

* Significantly different ($p < 0.05$) than UP

Submaximal values for heart rates are presented in Table 4. Values during use of the UP were significantly ($p < 0.05$) greater than SR for the last three stages. There was also a significant interaction ($p < 0.05$) indicating that the differences between UP and SR were not consistent across the stages.

Table 3. VO_2 Responses to submaximal exercise on the UP and SR cycles ($ml\,kg^{-1}\,min^{-1}$)

Stage	UP X ± SD	SR X ± SD	Difference
I	15.1 ± 2.5	13.5 ± 2.1*	1.6
II	18.0 ± 2.7	15.8 ± 2.4*	2.2
III	23.9 ± 3.9	20.1 ± 3.1*	3.8
IV	29.5 ± 4.9	23.9 ± 3.7*	5.6
V	33.9 ± 6.2	28.6 ± 4.7*	5.3

* Significantly different ($p < 0.05$) than UP

Table 4. Heart rate responses to submaximal exercise on the UP and SR cycles (bpm)

Stage	UP X ± SD	SR X ± SD	Difference
I	107 ± 15.6	98 ± 9.1	9
II	117 ± 15.5	107 ± 9.4	10
III	136 ± 16.6	120 ± 11.2*	26
IV	152 ± 16.9	134 ± 14.1*	18
V	165 ± 15.6	149 ± 14.3*	16

* Significantly different ($p < 0.05$) than UP

Submaximal values for caloric expenditure are presented in Table 5. Values for UP were significantly ($p < 0.05$) greater than SR across all five stages. There was also a significant interaction ($p < 0.05$), which indicates that differences between UP and SR increased at each successive stage.

Table 5. Caloric expenditure responses to submaximal exercise on the UP and SR cycles

Stage	UP X ± SD	SR X ± SD	Difference
I	5.9 ± 0.4	5.3 ± 0.5*	0.6
II	7.1 ± 0.7	6.2 ± 0.6*	0.9
III	9.5 ± 0.7	7.9 ± 0.6*	1.6
IV	11.8 ± 0.4	9.5 ± 0.6*	2.3
V	13.7 ± 0.9	11.5 ± 0.6*	2.2

* Significantly different ($p < 0.05$) than UP

Submaximal values for rating of perceived exertion are presented in Table 6. Values for UP were significantly ($p < 0.05$) greater than SR for the last two stages. There was also a significant interaction ($p < 0.05$) indicating that differences between the UP and SR got larger with each successive stage.

Table 6. Rating of perceived exertion responses to submaximal exercise on the UP and SR cycles

Stage	UP X ± SD	SR X ± SD	Difference
I	7.9 ± 1.1	7.9 ± 0.92	0
II	9.5 ± 1.3	9.5 ± 1.6	0
III	11.7 ± 1.8	11.4 ± 1.5	0.3
IV	14.1 ± 2.2	12.8 ± 2.1*	1.3
V	16.1 ± 2.0	14.3 ± 1.9*	1.8

* Significantly different ($p < 0.05$) than UP

Values for submaximal respiratory exchange ratio responses are presented in Table 7. Values for UP were significantly ($p < 0.05$) greater than SR for stages three and four. There was also a significant interaction ($p < 0.05$), which indicates that the differences between the UP and SR got larger with each successive stage.

Submaximal values for systolic blood pressure and diastolic blood pressure responses are presented in Tables 8 and 9. There was no significant difference between modalities or among stages for either SBP or DBP. It can be seen that values for SBP increased significantly ($p < 0.05$) across the stages for both modalities, where as DBP values remained constant.

Table 7. Respiratory exchange ratio responses to submaximal exercise on the UP and SR cycles

Stage	UP X ± SD	SR X ± SD	Difference
I	0.94 ± 0.07	0.93 ± 0.06	0.01
II	0.95 ± 0.07	0.94 ± 0.05	0.01
III	1.02 ± 0.08	0.97 ± 0.05*	0.05
IV	1.08 ± 0.09	1.03 ± 0.06*	0.05
V	1.12 ± 0.10	1.08 ± 0.06	0.04

* Significantly different ($p < 0.05$) than UP

Table 8. Systolic blood pressure responses to submaximal exercise on the UP and SR cycles (mm Hg)

Stage	UP X ± SD	SR X ± SD	Difference
I	123 ± 9.2	122 ± 9.6	1
II	134 ± 15.4	130 ± 11.2	4
III	149 ± 17.5	145 ± 14.4	4
IV	162 ± 16.9	159 ± 11.9	3
V	168 ± 16.3	171 ± 13.6	3

Table 9. Diastolic blood pressure responses to submaximal exercise on the UP and SR cycles (mm Hg)

Stage	UP $\bar{X} \pm SD$	SR $\bar{X} \pm SD$	Difference
I	70 ± 4.3	71 ± 5.7	1
II	72 ± 5.1	71 ± 5.5	1
III	71 ± 5.1	70 ± 5.8	1
IV	72 ± 5.5	71 ± 5.5	1
V	71 ± 6.3	70 ± 5.1	1

DISCUSSION

This study investigated the physiological responses to exercise with UP and SR stationary cycles. It was found that maximal exercise on the UP cycle resulted in a significantly higher oxygen consumption, heart rate response, rating of perceived exertion, and caloric expenditure than on the SR cycle. Higher HR and VO_2 values on the UP cycle are consistent with the findings of Currie, Kelly, and Pitt (3) and Walsh-Riddle and Blumenthal (7), but in contrast to those of Quinn, Smith, Vromen, Kertzer, and Olney (6) and Bonzheim and coworkers (2) who found no differences between modalities. There are several possible explanations as to why the UP cycle elicited higher physiological responses compared to the SR cycle. The chair-like style of the SR provides subjects with added back support, which offers more stability while providing the subjects with greater leverage to pedal against. This concept may also explain why the subjects were able to exercise longer and achieve higher workloads (watts) on the SR versus the UP cycle. Despite the subjects increased time on the SR cycle, their maximal HR and VO_2 values were lower than with the UP cycle. Many subjects were not familiar with exercising on the SR cycle and complained of localized muscular fatigue. Therefore it was hypothesized that subjects had to stop before achieving their maximal cardiovascular responses.

Very little data are available regarding rating of perceived exertion and caloric expenditure at maximal levels. A higher RPE on the UP contrasts findings by Bonzheim and coworkers (2) who found no significant differences between the modalities. Maximal blood pressure responses were nonsignificantly different between modalities and are in agreement with studies by Currie et al. (3) and Quinn and coworkers (6).

During submaximal exercise in this study VO_2 responses were significantly lower in the SR versus the UP cycle at all absolute workloads. This is in agreement with Bonzheim et al. (2) but contrasts studies by Quinn et al. (6) and Proctor et al. (5). Quinn et al. and Proctor and coworkers also found lower VO_2 responses using the recumbent cycle, but these values were not significant. Heart rates were also lower at each submaximal stage on the SR versus UP cycle, which is in agreement with studies by Bonzheim et al. (2), Westcott (8), and Walsh-Riddle and Blumenthal (7). The results of the present study are in contrast to those of Quinn and coworkers (1995) who found no significant differences between the modalities. The findings of Quinn and coworkers (6) although not significant, revealed a slightly lower HR response on the recumbent compared to the upright cycle.

Several theories may be offered to explain the differences in physiological responses to submaximal exercise between the UP and SR cycles. Westcott (8) states that heart rates are lower on the SR cycle due to increased venous return. The elevated leg position during SR cycling, which is similar to supine cycling, may facilitate blood returning to the heart, thereby increasing stroke volume and reflexively decreasing heart rate. This finding is in agreement with others who studied these cycling modalities (3,4).

It has been hypothesized that the reduced VO_2 and caloric expenditure seen during submaximal work for SR was most likely caused by the fact that the weight of the legs did not have to be raised against gravity, and therefore external work was reduced. Additionally, the high seat back on the SR cycle, as mentioned earlier, provides a stable platform to push against, thus the legs can push more efficiently. The increased efficiency would result in a lower VO_2 and caloric expenditure.

The submaximal RPE data is similar to studies by Bonzheim et al. (2) and Walsh-Riddle and Blumenthal (7) who also found higher values on the UP compared to the recumbent cycle. In this study, RPE was significantly higher only during the last two stages of submaximal work. One possible explanation for this is that in order to follow the same protocol as used by the women in a companion study, a lower initial workload was chosen so both men and women could perform the test without undue fatigue. In theory, this low workload in the first few stages may have been too easy for the men and they possibly could not relate their effort to a number on the Borg scale. However, as the test continued and the workloads increased, the subjects were better able to relate their effort to a number on the scale. This may explain why there is a significant difference in RPE after stage three and at the maximal level as mentioned earlier.

Blood pressures in this study were not significantly different between modalities for either systolic blood pressure (SBP) or diastolic blood pressure (DBP). These findings are in agreement with those of Quinn and coworkers (6) and Currie and colleagues (3), but contrast the results of studies by Proctor et al. (5) and Westcott (8) who found significantly higher SBP with use of the recumbent compared to the UP cycle. This study did show SBP to be higher on the SR versus the UP cycle, but the differences were not significant. Bonzheim et al. (2) found the significantly lower SBP on the recumbent compared to the UP cycle.

Based on the results of this study it is concluded that individuals can attain a higher peak VO_2, HR, and caloric expenditure on the UP versus SR cycle.

At submaximal workloads, this study found that subjects attained a higher VO_2, HR, Kcals, RER, and RPE in the UP position compared to the SR position at each given workload. Thus, when developing an exercise prescription, the workloads prescribed on a recumbent cycle would need to be higher than on an upright cycle in order to achieve the same intensity.

REFERENCES

1. American College of Sports Medicine. Guidelines for Exercise Testing and Prescription, 5th Ed. Philadelphia: Williams & Wilkins, 1995, p. 47.

2. Bonzheim, S. C., B. Franklin, C. Dewitt, C. Marks, B. Goslin, R. Jarski, R. and S. Dann. Physiological responses to recumbent versus upright cycle ergometry, and implications for exercise prescription in patients with coronary artery disease. *Am. J. Cardiol.* 69:40-44, 1992.

3. Currie, P. J., M. J. Kelly, and A. Pitt. Comparison of supine and erect bicycle exercise electrocardiography in coronary heart disease: accentuation of exercise-induced ischemic st depression by supine posture. *Am. J. Cardiol.* 52:1167-1173, 1983.

4. Manyari, D. E. and W. J. Kostuk. Left and right ventricular function at rest and during bicycle exercise in the supine and sitting positions in normal subjects and patients with coronary artery disease. *Am. J. Cardiol.* 51:36-42,1983.

5. Proctor, D., W. Sinning, T. Quinn, J. Roemmich, V. Ehrich, and B. Goodpaster. Submaximal responses to upright, recumbent and supine bicycle ergometer exercise. *Med. Sci. Sports Exerc.* 22:S12, 69, 1990.

6. Quinn, T. J., S. W. Smith, N. B. Vroman, R. Kertzer, and W. B. Olney. Physiologic responses of cardiac patients to supine, recumbent and upright cycle ergometry. *Arch. Phys. Med. Rehab.* 76:257-261, 1995.

7. Walsh-Riddle, M., and J. A. Blumenthal. Cardiovascular responses during upright and semi-recumbent cycle ergometry testing. *Med. Sci. Sports Exerc.* 21:581-585, 1989.

8. Westcott, W. L. Recumbent cycling keeps exertion levels high but cardiac effort low. *Perspective.* 2:34-35, 1991.

APPENDIX A

INFORMED CONSENT FORM

INFORMED CONSENT
A COMPARISON OF THE SUBMAXIMAL AND MAXIMAL RESPONSES TO UPRIGHT VERSUS SEMI-RECUMBENT CYCLING IN MALES

I, ______________________________ volunteer to participate in a study to compare the submaximal and maximal responses to exercise between a StairMaster upright and a StairMaster semi-recumbent cycle. I understand that during each maximal test I will exercise until I feel as though I can no longer continue. The submaximal responses will be evaluated during each maximal test. Participation in this study requires me to have my oxygen consumption, caloric expenditure, heart rate, RPE, RER, and blood pressure measured throughout each test. In order to test the above variables I am aware I will be wearing a mouthpiece, headgear and nose clip along with a heart rate monitor.

Prior to testing, I will be allowed two to three practice sessions on each modality to allow for familiarity. I will be completing two separate maximal tests, one on each cycle. The maximal test will be completed during separate sessions lasting approximately 30 minutes each session. I am aware that the study involves cycling at incremental stages increasing the workload every two minutes until I can no longer continue.

I am aware there may be certain risks involved while participating in this study. These risks may include abnormal heart rates and blood pressure readings and, in rare instances death. I consider myself to be in good health and to my knowledge I have no known pre-existing cardiac problems, however, if at any time during the test I experience any lightheadedness or dizziness I will make the investigator aware immediately. Discomforts that may arise from testing may include sore legs and general fatigue.

From the results of this study, I will be able to see whether there is an advantage of one cycle over the other. From the standpoint of the general public, the perception is that the semi-recumbent bike is "easier" and they do not get as good of a workout. The results will allow the general public and myself to see the relationship between the two modalities.

I agree to presentation and publication of the results of the study as long as the individual's identity is kept confidential. I understand although I will be kept on record as participating in this study, there will be no names listed in reports, abstracts, or journals. The data obtained will be used only as a group collection and not on an individual basis.

I have been encouraged to ask any questions that I may have whether it be prior to testing or during testing. If I have questions or concerns, I can call Chuck Johnson at 779-4852, Marsha Pauly at 782-1978, or Dr. John Porcari, research advisor, at 785-8684.

After reading this consent form and having all my questions answered to my satisfaction, I voluntarily consent to be a subject in this study. I am fully aware that participation is voluntary and that if I refuse to participate in this study or if I choose to withdraw from this study I may do so at any time with no penalty. Contact Garth Tymeson, Chair of UWL Institutional Review Board, if you have any questions about the protection of human subjects, (608-785-8155).

Participant ______________________ Date ______________

Witness ______________________ Date ______________

APPENDIX B

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

(PAR-Q)

Physical Activity Readiness Questionnaire*

Name: ______________________ Date _____ 19 _____

Phone: Home: ______________________ Age _______

Work: ______________________ Height _______

Weight _______

YES NO 1. Has your doctor ever said you have heart trouble?

YES NO 2. Do you frequently have pains in your heart and chest?

YES NO 3. Do you often feel faint or have spells of severe dizziness?

YES NO 4. Has a doctor ever said your blood pressure was too high?

YES NO 5. Do you have a bone or joint problem such as arthritis that may be aggravated by exercise or even made worse with exercise?

YES NO 6. Do you know of any reason not mentioned above why you should not participate in maximal exercise testing?

The above questions have been answered truthfully and to the best of my knowledge. I am not withholding any information that would place me at an increased risk of injury by participating in maximal exercise testing.

Signature: ______________________ Date: _____ 19 _____

* Modified version from fifth edition ACSM's Guidelines for Exercise Testing and Prescription. P.14, 1995.

APPENDIX C

RATING OF PERCIEVED EXERTION

Rating of Perceived Exertion Description*

At various times throughout your cycling I will hold up this scale and ask you to select the number that best represents how hard you feel the work is for you at this time. As you can see this scale ranges from a low of 6 to a high of 20. The higher the number the harder you feel the effort is for you. The highest number (20) should represent the maximal effort and fatigue level you have ever felt while cycling. There is no wrong or right answer. Just try to estimate your total feeling of exertion and effort as honestly and accurately as you possibly can.

* Butts, N. K. Physiological profiles of high school female runners. *Research Quarterly for Exercise and Sport.* 53:(1), 1982.

RATING OF PERCEIVED EXERTION SCALE (RPE)*

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	

* Borg, G. A. Perceived exertion: A note on "history" and methods. *Med. Sci. Sports.* 5:90-93, 1973.

APPENDIX D

STAGE TO WORKLOAD COMPARISON

STAGE	TIME (min)	WORKLOAD (Watts)
1	0-2	50
2	2-4	84
3	4-6	118
4	6-8	152
5	8-10	180
6	10-12	220
7	12-14	254
8	14-16	288

* These values are the same for both the upright and semi-recumbent cycle.

APPENDIX E

REVIEW OF LITERATURE

REVIEW OF RELATED LITERATURE

Introduction

As more and more individuals continue to search for the perfect exercise modality, companies continue to offer many varieties to choose from. The most common forms of exercise include walking, running, and cycling. However, not everyone can do these activities on a regular basis for a variety of reasons. The obese, elderly, those with over-use injuries, or those just looking for a change in their exercise routine are left to search for a type of exercise that is more comfortable to use, yet still provides a good workout.

Benefits of Semi-Recumbent Ergometers

The semi-recumbent (SR) bicycle is designed so that the subject pedals with both legs extended horizontally while in the sitting position. The seat of the SR ergometer is horizontal, while the backrest is inclined at approximately a 45 degree angle to help support the upper body. It has been suggested that increased venous return associated with supine body position can produce significantly lower heart rate (HR) responses when compared with the upright (UP) position (3,8). The horizontal leg position used with the SR cycle may increase venous return and thereby help to explain the lower resting and submaximal exercise HR's in the SR position. The lower submaximal HRs found while exercising in the SR position may be beneficial for some patients, such as the elderly.

Submaximal Responses to Cycling in Different Positions

Bonzheim et al. (2) compared the physiological responses between UP and recumbent cycle ergometry. At a level of 100 watts, relative VO_2 was 15% lower in the recumbent than in the UP position. Oxygen uptake values at submaximal exertion were also studied by Quinn et al. (6). They found the supine VO_2 was significantly lower at submaximal work ($300 kgm \cdot min^{-1}$) compared with both the recumbent and UP positions, however, they found no differences between SR and UP. This is in agreement with the findings of Proctor et al. (5). According to Quinn et al. (6) the reduced VO_2 seen in the supine position during submaximal work was most likely caused by the fact that the weight of the legs did not have to be raised against gravity, and therefore the external work may be reduced.

The HR values reported in the various studies comparing cycling modalities are contrasting as well. One study reported no difference in HR between upright and recumbent ergometry (5), while studies by Bonzheim et al. (2) and Walsh-Riddle and Blumenthal (8) reported significantly lower HRs in the recumbent compared with UP position at absolute submaximal workloads. Quinn and coworkers (6) and Proctor et al. (5) found that supine exercise was conducted at a lower HR than recumbent exercise. It is thought in these cases that an increased venous return augments stroke volume, resulting in the lower heart rates.

The blood pressure responses to exercise using the various modalities are variable as well. At submaximal levels, most investigators found no significant differences between supine and upright ergometers (3,4,6). However, studies by Bonzheim et al. (2) and Proctor and coworkers (5) contrast these findings. The study by Bonzheim reported significantly lower systolic (SBP) and diastolic (DBP) blood pressure during submaximal work in the recumbent position compared with the upright position at a workload of 100 watts. Currie, Kelly, and Pitt (3), and Proctor et al. (5) found SBP to be significantly higher in the recumbent compared to either the supine or upright position. Differences between modalities probably relate to the varying amounts of isometric hand gripping allowed by the subjects.

The subjects rating of perceived exertion (RPE) while exercising at submaximal levels are contrasting as well. Walsh-Riddle and Blumenthal (8) and Bonzheim and coworkers (2) both reported submaximal exercise RPEs to be significantly lower in the recumbent position compared with the upright position at similar workloads. Studies by Proctor et al. (5) and Quinn et al. (6) found no significant difference in RPEs among the upright, supine, and recumbent positions.

Maximal Responses to Exercising at Different Positions

The discrepancies in physiological responses to various cycling modalities seen at the submaximal level are not found at the maximal level. Unlike submaximal VO_2, maximal VO_2 values were not significantly affected by positional change (2,5,6), and heart rates were also found to be similar among upright, supine, recumbent, and semi-recumbent maximal exercise (2,5,6). The same holds true for blood pressure responses with use of the various modalities at the maximal level. In the studies that evaluated maximal blood pressure responses, there were no significant differences found among the different body positions (2,3,6,7,8).

Exercise Prescription

When it comes down to choosing which cycle ergometer to use for exercise prescription, individuals are faced with a variety of options. As stated by Quinn et al. (6) exercise prescriptions may be made with some confidence when one has data from a supine or recumbent exercise test and wants to prescribe upright (or vise versa) ergometry. Since the linear relationship of VO_2 versus HR for supine, recumbent, and upright are nearly identical, a given HR during supine ergometry results in a given supine oxygen uptake that is comparable with either recumbent or upright cycles (6). The absolute workload may be lower during upright cycling (2), but the percentage of maximal functional capacity would be similar.

Summary

With an increase in the number of individuals and health clubs purchasing semi-recumbent cycles, the need for further physiological evaluation is apparent. While maximal HR and VO_2 responses appear to be equal at maximal workloads, submaximal responses of SR compared to UP are conflicting. These discrepancies among cycling modalities at different workloads need to be clarified before exercise prescription can be done with any confidence.

REFERENCES

1. American College of Sports Medicine. Guidelines for Exercise Testing and Prescription, 5th Ed. Philadelphia: Williams & Wilkins, 1995.

2. Bonzheim, S. C., B. Franklin, C. Dewitt, C. Marks, B. Goslin, R. Jarski, and S. Dann. Physiologic responses to recumbent versus upright cycle ergometry, and implications for exercise prescription in patients with coronary artery disease. *Am. J. Cardiol.* 69:40-44, 1992.

3. Currie, P. J., M. J. Kelly, and A. Pitt. Comparison of supine and erect bicycle exercise electrocardiography in coronary heart disease: accentuation of exercise-induced ischemic st depression by supine posture. *Am. J. Cardiol.* 52:1167-1173, 1983.

4. Kramer, B., B. Massie, and N. Tupic. Hemodynamic differences between supine and upright exercise in patients with congestive heart failure. *Circulation.* 66:820-825, 1982.

5. Proctor D., W. Sinning, T. Quinn, J. Roemmich, V. Ehrich, and B. Goodpaster. Submaximal responses to upright, recumbent and supine bicycle ergometer exercise. *Med. Sci. Sports Exerc.* 22:S12, 69, 1990.

6. Quinn, T.J., S. W. Smith, N. B. Vroman, R. Kertzer, and W. B. Olney. Physiologic responses of cardiac patients to supine, recumbent, and upright cycle ergometry. *Arch. Phys. Med. Rehab.* 76:257-261,1995.

7. Steingart, R. M., J. Wexler, S. Slagle, and J. Scheuer. Radionuclide ventriculographic responses to graded supine and upright exercise: critical role of the Frank-Starling mechanism at submaximal exercise. *Am. J. Cardiol.* 53:1671-1677, 1984.

8. Walsh-Riddle, M., and J. A. Blumenthal. Cardiovascular responses during upright and semi-recumbent cycle ergometry testing. *Med. Sci. Sports Exerc.* 21:581-585, 1989.