ABSTRACT

SWENSEN, C. T. Physiological responses between a Stairmaster Upright and a Stairmaster Semi-Recumbent cycle at a submaximal self-selected pace. MS in Adult Fitness/Cardiac Rehabilitation, December 1999, 32pp. (J. Porcari)

Many people feel that they do not get as good a workout on a semi-recumbent (SR) cycle ergometer compared to a traditional upright (UP) cycle ergometer. This study compared the responses to 30 minutes of exercise on the Stairmaster UP and SR at a self-selected pace. Twenty-four volunteers (12M, 12F), 18 to 28 years old, served as subjects (Ss). Each S was given 3-5 practice sessions on each ergometer prior to testing. They then performed a 30-minute exercise bout on each cycle in random order and on a separate day. VO_2, HR, Kcal, SBP, DBP, and RPE data were averaged for each 30-minute session. Comparisons between modalities were analyzed with a 2-way ANOVA with repeated measures and Tukey's post-hoc tests. There were no differences in responses between males and females, therefore data were pooled.

	VO_2	HR	Kcal/min	RPE	SBP	DBP
UP	22.8 ± 4.52*	137 ± 18.1*	7.8 ± 1.89*	12.6 ± 1.80	153 ± 18.7*	67 ± 9.6
SR	19.9 ± 5.05	124 ± 15.7	6.8 ± 2.12	12.5 ± 1.63	139 ± 17.6	61 ± 11.0

* significantly different than SR ($p < .05$)

Ss worked at significantly higher workloads on SR (101 watts) compared to UP (89.1 watts) even though Ss worked at similar RPE values. VO_2, HR, and Kcal were significantly higher in UP compared to SR cycling. Thus, it would appear that the SR cycle might not provide as good a workout as the UP cycle when subjects self-selected exercise intensity.

PHYSIOLOGICAL RESPONSES BETWEEN A STAIRMASTER UPRIGHT AND A STAIRMASTER SEMI-RECUMBENT CYCLE AT A SUBMAXIMAL SELF-SELECTED PACE

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FACULTY

UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE

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THESIS FINAL ORAL DEFENSE FORM

Candidate: Chad T. Swensen

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.

Thesis Committee Chairperson Signature	5-13-99 Date
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Glenn Brice Thesis Committee Member Signature	5-13-99 Date

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

Garth Tymeson Associate Dean, College of Health, Physical Education, and Recreation	6-23-99 Date
Garth Tymeson Director of University Graduate Studies	6-23-99 Date

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INTRODUCTION

As society becomes more and more exercise conscious, the need to assess the physiological and cardiovascular benefits of new exercise machines becomes important. Many questions arise as to which exercise modality provides the best workout. Recently, there have been questions concerning the intensity of the workout between the upright (UP) and the semi-recumbent (SR) cycle. Recumbent bikes are becoming more and more popular and practical for active, sedentary, and cardiac populations because of the features they offer. These include easy accessibility, a comfortable seat that is lower to the ground, a non-weight bearing design, and workloads that can accommodate lower levels of fitness. The need to establish physiological responses to exercise on these machines in an authentic manner seems appropriate.

It has been reported that submaximal heart rates have been significantly lower in the SR position than the UP position at rest, at various percentages of VO_{2max}, and at absolute workloads. VO_2 has also been found to be lower at absolute workloads in the SR position (6). It is believed that lower HR and VO_2 at set workloads are due to the increase of venous return and increased mechanical efficiency (a decreased gravity affect on the legs) associated with the more supine body position. Differences in submaximal BP between the two positions are unclear (2). Bonzheim et al. (1) reported maximal HR, VO_2, and BP to be the same between the two exercise modalities, but these responses on the SR occurred at a higher workload than the UP.

While the above studies compared physiological responses at certain percentages of VO_2 or at set absolute workloads, to our knowledge no one has compared these two modalities at a self-selected intensity, or self-preferred pace, which more often reflects the exercise habits of society. Allowing subjects to choose their own exercise intensity was an important factor in the present study because most home or fitness center exercisers control their own pace. Working at a self-selected pace will more accurately reflect what these subjects would do in a normal aerobic workout. The objective of this study was not to control the subjects, but to produce results from a natural, self-selected intensity. According to Dishman et al. (3), individuals who have exercise prescriptions according to their preferred intensities may better adhere to an exercise program. Also, knowledge of self-selected intensities (along with specific data) may provide insight to the public when interpreting popular exercise prescription guidelines and enable clinicians and health educators to better convey their message (5).

Accordingly, the purpose of the study was to compare submaximal exercise responses on the Stairmaster UP and SR at a self-selected pace. It has been anecdotally reported that exercise in the SR position is easier than the UP position. This study may help to clarify these issues.

METHODS

Overview

Subjects in the current study were tested on the StairMaster UP and the StairMaster SR cycle ergometers. Following adequate practice, each subject completed a self-selected 30-minute submaximal test on each of the modalities. Oxygen consumption

(VO_2 ml·kg·min and L·min), respiratory exchange ratio (RER), heart rate (HR), rating of perceived exertion (RPE), systolic blood pressure (SBP), diastolic blood pressure (DBP), caloric expenditure, and work levels were compared between modalities.

Subjects

Subjects for this study were 24 volunteers. The subjects, 12 males and 12 females, ranged in age from 18 to 28 years. Subjects were recruited from the University of Wisconsin-La Crosse and the local community. All subjects were apparently healthy and participated in regular fitness activities at least three times per week. Prior to the study, all subjects completed a Physical Readiness Questionnaire (PAR-Q) (see Appendix A) to screen for orthopedic or cardiovascular problems. The UW-L Institutional Review Board for Human Subjects approved the protocol and each subject read and signed an informed consent (see Appendix B) prior to testing.

Methods and Procedures

All exercise testing was performed at the University of Wisconsin-La Crosse in the Human Performance Laboratory. Each subject was given three to five practice sessions to learn how to operate each ergometer and to become familiar with the other testing equipment to reduce anxiety. During the last practice session, subjects wore the Polar Heart Rate Monitor, headgear, and mouthpiece that they would wear during testing.

All subjects reported to the lab at the same time on two separate occasions. Order of testing was randomized and a maximum of 2 weeks separated each testing trial. Height of the seat was adjusted for each individual on each modality so there was a slight bend in the knee when the leg was maximally extended. Each machine had toe straps for secure footing while pedaling.

The protocol for each of the two tests was to perform a 30-minute submaximal exercise bout at a self-selected intensity. Each 30-minute bout was preceded by a 5-minute warm up and followed by a 5-minute cool down. During each test, consoles of the machines were covered to eliminate feedback to the subject and the researcher adjusted the workloads when requested by the subject. All data collected before, during, and after testing were written down on a data collection sheet (see Appendix C). Before testing, explanation of testing protocol and RPE were reviewed (see Appendix D). Each subject's height, weight, heart rate, and blood pressure were measured before each test.

<u>Measures</u>

During each test oxygen uptake, heart rate, respiratory exchange ratio, systolic and diastolic blood pressures, ratings of perceived exertion, and caloric expenditure were measured. Expired gas was measured continually using the Quinton Q-Plex (Quinton Instrument Company, Seattle, WA). VO_2, RER, and Kcal/min were collected every minute from the Quinton Q-Plex. The Q-Plex was calibrated before the beginning of each test with gas compositions determined by the Micro-Schollander technique. Flow meter volume was calibrated using a 3-L syringe pump at various flow rates. The subjects' ratings of perceived exertion (RPE) were recorded every 5-minutes using Borg's scale of perceived exertion (see Appendix D). Heart rates were taken every minute with the Polar Vantage Heart Rate Monitor (Polar-CIC Inc., Port Washington, NY) which consists of a watch and chest strap. The watch records and displays the data, and the chest strap detects the heartbeats and sends the information to the watch.

Statistical Treatment

For comparison purposes, all data were averaged every 5-minutes during each 30-minute exercise session. Differences between modalities and between males and females were determined using a two-way ANOVA with repeated measures. Tukey's post-hoc tests were used to isolate pairwise differences. Alpha was set at .05 to achieve statistical significance.

RESULTS

The present study was conducted to determine if there were significant differences in responses during submaximal, steady state exercise on the StairMaster SR and the StairMaster UP cycles. Twelve male subjects ranging in age from 20-28 years and 12 female subjects also ranging in age from 20-28 years participated in the study. Their physical characteristics are presented in Table 1.

Table 1. Descriptive physical characteristics of the subjects (N = 24)

Gender (n)	Age (yr) x ± SD (range)	Height (cm) x ± SD (range)	Weight (kg) x ± SD (range)
Males (12)	22.2 ± 2.33 (20-28)	179.7 ± 3.52 (175-185)	79.0 ± 9.76 (63.6-95.5)
Females (12)	22.8 ± 2.30 (20-28)	165.2 ± 6.95 (155-178)	60.0 ±8.71 (47-75)

All subjects completed 30-minutes of submaximal exercise at a self-selected pace, on both ergometers. Comparisons of physiological responses (VO_2, HR, Kcal, RPE, RER, SBP, and DBP) between the SR and UP cycles are presented in Tables 2-8. A comparison of work levels achieved between the SR and UP is presented in Table 9.

Oxygen Consumption

Values for VO_2 are presented in Table 2 and in Figure 1. Overall it was found that VO_2 for UP was significantly greater ($p < .05$) than SR with no significant interaction (responses between the two ergometers paralleled each other, $p > .05$). The average difference between conditions was 2.9 ml/kg/min. When looking at the pattern of VO_2 over the 30-minute exercise bout, it was found that VO_2 increased significantly ($p < .05$) up until approximately minute 10, and then plateaued. A plot of VO_2 over the 30-minute exercise bout is presented in Figure 1.

Table 2. Comparison of VO_2 (ml/kg/min) during semi-recumbent versus upright cycling

Time (minutes)	SR X ± SD	UP X ± SD	Combined X ± SD
1-5	16.2 ± 3.42	19.0 ± 2.10	17.6 ± 3.15
6-10	18.5 ± 3.96	21.7 ± 3.01	20.1 ± 3.82
11-15	20.3 ± 5.00	23.6 ± 4.28	21.9 ± 4.90#
16-20	21.2 ± 5.29	24.2 ± 4.90	22.7 ± 5.27#
21-25	21.5 ± 5.08	24.3 ± 5.18	22.9 ± 5.26#
26-30	21.7 ± 5.31	23.9 ± 4.65	22.8 ± 5.06#
	19.9 ± 5.05	22.8 ± 4.52*	

* significantly different than SR ($p < .05$)
# significantly different than 0-5 minute value ($p < .05$)

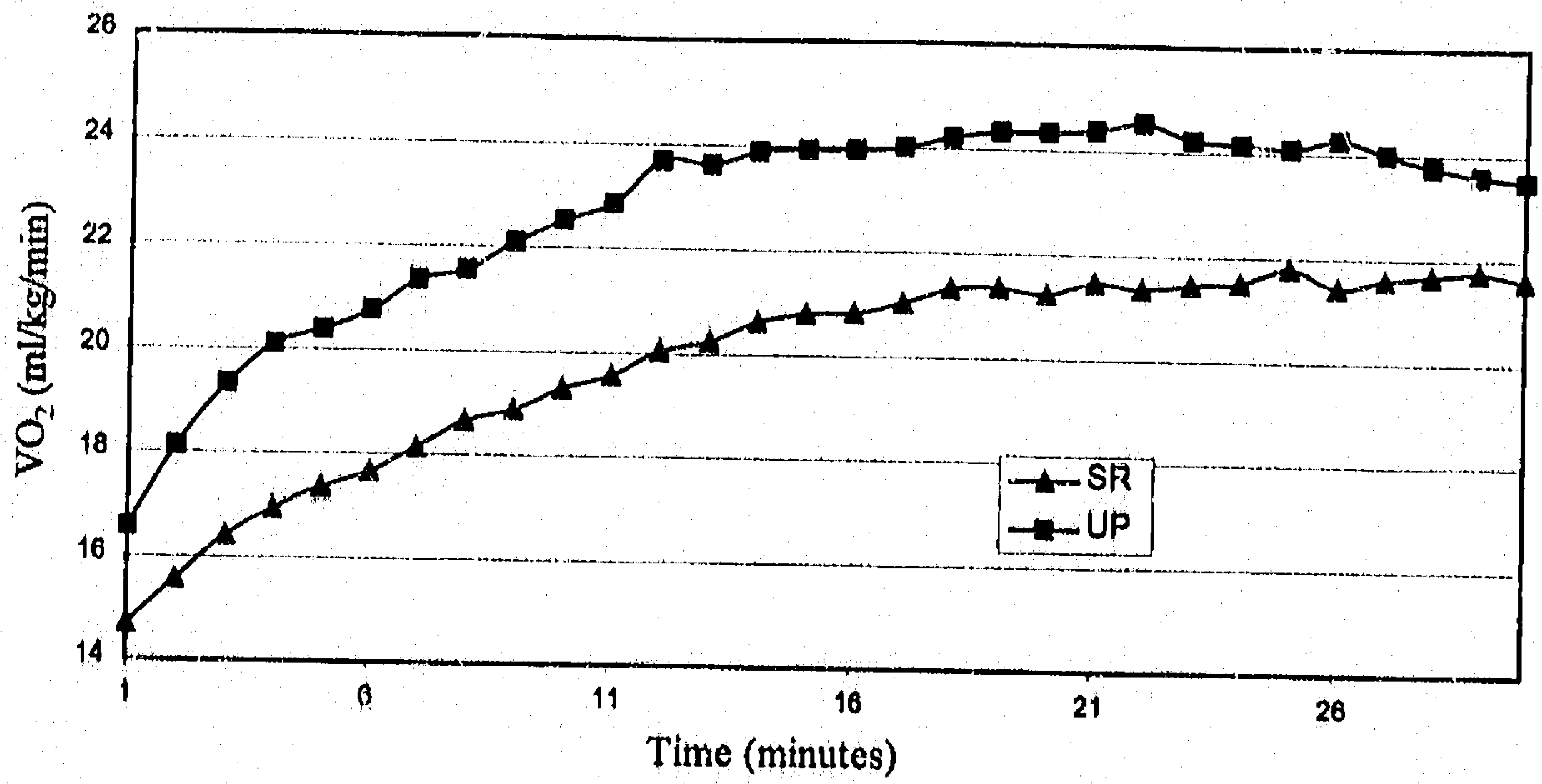

Figure 1. Comparison of VO_2 (ml/kg/min) during semi-recumbent versus upright cycling

Heart Rate

Values for heart rate are presented in Table 3 and Figure 2. Heart rate during UP exercise was significantly greater ($p < .05$) than during SR exercise with no significant interaction ($p > .05$). The average difference between conditions was 12.5 bpm. When looking at the pattern of heart rates over the 30-minute exercise bout, it was found that heart rates increased significantly ($p < .05$) up until approximately minute 10, and then plateaued. A graph of HR values for each 30-minute exercise bout is presented in Figure 2.

Kcal/Min

Values for caloric expenditure are presented in Table 4. Overall it was found that Kcal for UP was significantly greater ($p < .05$) than SR with no significant interaction

Table 3. Comparison of heart rates during semi-recumbent versus upright cycling

Time (minutes)	SR X ± SD	UP X ± SD	Combined X ± SD
1-5	112.4 ± 13.21	121.6 ± 15.86	117.0 ± 15.17
6-10	119.8 ± 13.91	131.8 ± 16.26	125.8 ± 16.17
11-15	124.6 ± 15.51	138.7 ± 17.31	131.6 ± 17.70#
16-20	128.5 ± 14.75	141.4 ± 17.10	135.0 ± 17.08#
21-25	129.6 ± 14.88	143.6 ± 16.65	136.6 ± 17.14#
26-30	130.2 ± 15.44	142.8 ± 16.61	136.5 ± 17.10#
	124.2 ± 15.74	136.7 ± 18.11*	

* significantly different than SR ($p < .05$)
# significantly different than 0-5 minute value ($p < .05$)

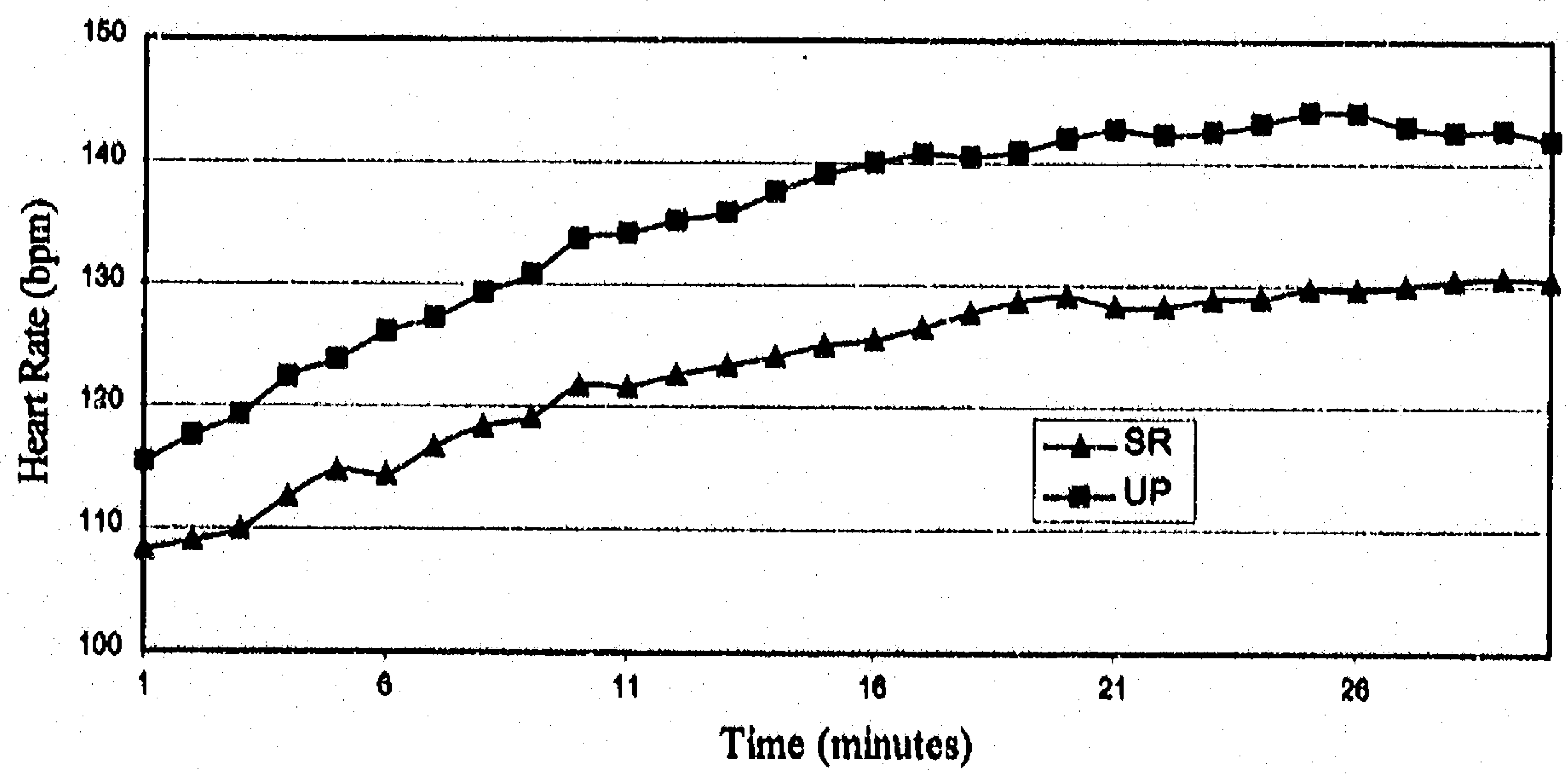

Figure 2. Comparison of heart rates during semi-recumbent versus upright cycling

(p > .05). The average difference between conditions was 1.0 Kcal/min. When looking at the pattern of Kcal over the 30-minute exercise bout, it was determined that caloric expenditure increased significantly (p < .05) up until approximately minute 10, and then plateaued.

Table 4. Comparison of kcal/min during semi-recumbent versus upright cycling

Time (minutes)	SR X ± SD	UP X ± SD	Combined X ± SD
1-5	5.6 ± 1.71	6.6 ± 1.20	6.1 ± 1.54
6-10	6.3 ± 1.87	7.1 ± 1.85	6.9 ± 1.84
11-15	7.0 ± 2.01	8.1 ± 1.91	7.6 ± 2.02#
16-20	7.3 ± 2.10	8.4 ± 1.98	7.8 ± 2.09#
21-25	7.4 ± 2.14	8.4 ± 2.08	7.9 ± 2.14#
26-30	7.5 ± 2.37	8.2 ± 1.93	7.9 ± 2.18#
	6.8 ± 2.12	7.8 ± 1.89*	

* significantly different than SR (p < .05)
# significantly different than 0-5 minute value (p < .05)

Rating of Perceived Exertion

Values for RPE are presented in Table 5. It was reported that there was no significant difference (p > .05) in RPE between cycles and no significant interaction (p > .05) between stages. The average difference between cycles was 0.1 RPE unit. When looking at the pattern of RPE over the 30-minute exercise bout, it was determined that RPE increased significantly (p < .05) up until approximately minute 10, and then plateaued.

Table 5. Comparison of RPE during semi-recumbent versus upright cycling

Time (minutes)	SR X ± SD	UP X ± SD	Combined X ± SD
1-5	10.7 ± 1.12	10.8 ± 1.55	10.8 ± 1.34
6-10	12.1 ± 1.32	12.0 ± 1.37	12.0 ± 1.33
11-15	12.6 ± 1.38	12.8 ± 1.67	12.7 ± 1.52#
16-20	13.1 ± 1.39	13.4 ± 1.74	13.3 ± 1.56#
21-25	12.8 ± 2.95	13.4 ± 1.41	13.3 ± 1.46#
26-30	13.2 ± 1.50	13.4 ± 1.59	13.3 ± 1.53#
	12.5 ± 1.63	12.6 ± 1.80	

significantly different than 0-5 minute value ($p < .05$)

Respiratory Exchange Ratio

Values for RER are presented in Table 6. It was determined that there was no significant difference ($p > .05$) in RER between modalities and no significant interaction ($p > .05$). The average difference between conditions was an RER of 0.01.

Table 6. Comparison of RER during semi-recumbent versus upright cycling

Time (minutes)	SR X ± SD	UP X ± SD	Combined X ± SD
1-5	0.95 ± .044	0.97 ±.047	0.96 ± .047
6-10	0.96 ± .053	1.02 ±.215	0.97 ± .054
11-15	0.97 ± .046	0.98 ±.068	0.97 ± .058
16-20	0.97 ± .041	0.98 ±.052	0.97 ± .047
21-25	0.96 ± .042	0.97 ±.048	0.96 ± .045
26-30	0.96 ± .047	0.95 ±.044	0.95 ± .045
	0.96 ± .045	0.97 ± .053	

Systolic Blood Pressure

Values for SBP are presented in Table 7. Overall it was found that SBP for UP was significantly greater ($p < .05$) than SR with no significant interaction ($p > .05$). The average difference between conditions was 13.7 mmHg. When looking at the pattern of SBP over the 30-minute exercise bout, it was found that SBP peaked between minute 15-20 for both conditions.

Table 7. Comparison of systolic blood pressure during semi-recumbent versus upright cycling

Time (minutes)	SR X ± SD	UP X ± SD	Combined X ± SD
1-5	134.4 ± 19.83	149.3 ± 18.96	141.9 ± 20.62
6-10	138.7 ± 18.12	152.8 ± 18.25	145.8 ± 19.36
11-15	140.3 ± 11.91	153.8 ± 17.70	146.8 ± 17.91
16-20	142.3 ± 16.28	154.7 ± 19.17	149.1 ± 18.67#
21-25	139.0 ± 16.75	154.3 ± 20.30	146.3 ± 19.29
26-30	140.0 ± 19.72	150.8 ± 20.48	145.4 ± 20.62
	139.0 ± 17.63	152.7 ± 18.70*	

* significantly different than SR ($p < .05$)
# significantly different than 0-5 minute value ($p < .05$)

Diastolic Blood Pressure

Values for DBP are presented in Table 8. There was no significant difference ($p > .05$) in DBP between modalities and no significant interaction ($p > .05$). There was a tendency for DBP to decrease across the 30-minute exercise period, but there was no significant difference ($p > .05$) among time periods. The average difference between conditions was 6.4 mmHg.

Table 8. Comparison of diastolic blood pressure during semi-recumbent versus upright cycling

Time (minutes)	SR X ± SD	UP X ± SD	Combined X ± SD
1-5	63.2 ± 11.68	66.9 ± 17.26	66.5 ± 11.67
6-10	62.5 ± 12.30	69.0 ± 8.85	65.8 ± 11.10
11-15	62.0 ± 10.65	68.0 ± 9.14	65.0 ± 10.28
16-20	60.6 ± 10.61	66.8 ± 9.06	63.7 ± 10.24
21-25	59.1 ± 10.63	64.6 ± 9.16	61.8 ± 10.21
26-30	58.4 ± 10.43	65.9 ± 10.16	62.2 ± 10.87
	61.0 ± 11.02	67.4 ± 9.58	

<u>Work Levels</u>

Values for work levels (power output) are presented in Table 9. It was found that work levels on the SR were significantly greater ($p < .05$) than the UP. The mean work level on the SR was 101 watts and 89.1 watts on the UP. When looking at the pattern of power output over the 30-minute exercise bout, it was determined that watts increased significantly ($p < .05$) up until approximately minute 10, and then plateaued.

DISCUSSION

This study evaluated the physiological responses of young, healthy subjects to 30-minutes of exercise on SR and UP cycle ergometers at a self-selected pace. The self-selection of exercise pace in this study made it distinct from previous studies which

Table 9. Comparison of work levels (power output) during semi-recumbent versus upright cycling

Time (minutes)	SR X ± SD (watts)	UP X ± SD (watts)	Combined X ± SD (watts)
1-5	2.9 ± 1.50 (82)	2.5 ± 1.04 (76)	2.7 ± 1.29 (79)
6-10	3.7 ± 1.76 (96)	3.0 ± 1.12 (84)	3.4 ± 1.50 (91)
11-15	4.0 ± 1.81 (101)	3.6 ± 1.36 (94)	3.8 ± 1.60 (98)#
16-20	4.2 ± 1.85 (104)	3.6 ± 1.45 (94)	3.9 ± 1.68 (99)#
21-25	4.4 ± 1.98 (108)	3.5 ± 1.44 (93)	4.0 ± 1.78 (101)#
26-30	4.4 ± 2.17 (108)	3.4 ± 1.45 (91)	3.9 ± 1.89 (99)#
	4.0 ± 1.90 (101)*	3.3 ± 1.35 (89)	

* significantly different than UP ($p < .05$)
# significantly different than 0-5 minute value ($p < .05$)

required subjects to exercise at a given absolute workload or percentage of VO_2 and HR. The intention in the current study was to mimic an average workout that an individual would do in a fitness center setting. Asking the individuals to exercise at a specific intensity would interfere with the self-selection process and could not reflect an average workout of the individual. It was found that subjects worked at significantly higher workloads on SR (101 watts) compared to UP (89.1 watts) even though subjects worked at similar RPE values.

Despite working at the same RPE, there were significant differences in relative VO_2 and caloric expenditure in the UP compared to the SR position. When comparing averages of VO_2 and Kcal/min over the 30-minute period, the UP yielded a 13% (2.9 ml/kg/min, 1.0 kcal/min) higher VO_2 and kcal/min than the SR. These responses to submaximal exercise reflect a greater physiologic cost during UP exercise compared to

SR. The lower VO_2 during SR cycling may be due to the fact that the legs did not have to be raised against gravity thus reducing the external workload. Increased muscular efficiency may also be a factor in lowering physiological responses and is attributed to the more efficient push against the higher seat back on the SR ergometer. Walsh-Riddle and Blumenthal (6) also found that individuals had higher VO_2 and caloric expenditure values on the UP cycle in which they attributed to the use of more muscle mass in the UP position. No differences in RPE values between the ergometers may have been caused by localized hamstring fatigue in the SR position, which may have increased RPE relative to VO_2.

Exercise heart rates were 13 bpm (9%) lower in the SR versus the UP modality. The semi-recumbent position allows a more horizontal leg position that may increase venous return and lower HR during submaximal exercise (2). Reduced external workload and increased internal muscular efficiency again may have had an impact in the lower HR responses during SR cycling compared to UP.

The UP position also led to significant differences in SBP when compared to the SR position. Over the 30-minute period, SBP was 14 mmHg higher (9%) compared to the SR. These changes were consistent with the increased cardiovascular demands (significantly higher VO_2 and HR) when exercising in the UP position. This finding is in agreement with the study of Bonzheim et al. (1) and contrasts with Curie et al. (2) who reported SBP to be lower in the UP position compared to the SR position.

When comparing work levels between the two modalities, the SR was found to be significantly higher than the UP ergometer. Work level for the 30-minute period averaged 12 watts (17%) higher during SR compared to UP. It is hypothesized that the high seat back allows a greater push during SR compared to UP resulting in greater muscular efficiency.

The self-selected intensities utilized in the present study elicited similar RPE responses for both the UP and SR. The subjects perceived the exercise intensity between the two modalities as being relatively equal, even though th^ UP resulted in more oxygen being consumed, elicited higher HRs, and resulted in more calories being expended. Our RPE data are in agreement with the results of Quinn et al. (4) and is in contrast with Bonzheim et al. (1) and Walsh-Riddle and Blumenthal (6) who found submaximal RPEs to be significantly higher in the UP position compared to the SR. However, both of those studies were conducted at absolute workloads.

RER and DBP were not significant between the UP and SR modalities in the current study. The RER results are in agreement with Quinn et al. (4) in which they also found no significant difference when comparing the supine (SUP), SR, and UP ergometers. There is no other related literature to compare these findings to since they did not compare all physiological responses between the two cycles.

In conclusion, VO_2, HR, Kcal/min, and SBP responses were all lower during submaximal exercise on the SR cycle when compared with the UP despite similar RPE values and higher workloads during SR exercise. Thus, it would appear that the SR cycle might not give as good a workout as the UP cycle when subjects self-select exercise intensity.

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APPENDIX A

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE*

PAR-Q

For most people physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Common sense is your best guide in answering these few questions. Please read them carefully and check (√) the YES or NO opposite the question if it applies to you.

YES NO

1. Has your doctor ever said you have heart trouble?
2. Do you frequently have pains in your heart and chest?
3. Do you often feel faint or have spells of severe dizziness?
4. Has your doctor ever said your blood pressure is too high?
5. Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?
6. Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?

Age: ________
Height: ________
Weight: ________

Signature: ________________________

*Developed by the British Columbia Ministry of Health. Conceptualized and critiqued by the Multidisciplinary Advisory Board on Exercise (MABE)
Reference PAR-Q Validation Report, British Columbia Ministry of Health, 1978.
Produced by the British Columbia Ministry of Health and the Department of National Health & Welfare.

APPENDIX B

INFORMED CONSENT

INFORMED CONSENT

A COMPARISON OF THE SUBMAXIMAL RESPONSES TO UPRIGHT VERSUS SEMI-RECUMBENT CYCLING

I, ______________________, would like to volunteer in a study to compare the submaximal responses to exercise between a StairMaster upright and a StairMaster semi-recumbent cycle. 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 these variables I am aware I will be wearing a mouthpiece and headgear along with a Polar heart rate monitor.

Prior to testing, I will be allowed three to five practice sessions on each modality to allow for familiarity. I am aware that the study requires me to bike at a self-selected pace for 30 minutes.

I am aware that there may be certain risks involved while participating in this study. These risks may include abnormal heart rates and blood pressure reading 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 be 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 cycle is "easier" and they do not produce 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 results are 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 am strongly encouraged to ask any questions that I may have whether it be prior to testing or during testing. If I have any questions or concerns, I can call Chad Swensen at 783-7554, or John Porcari, research advisor, at 785-8684.

After reading this consent form and having all my questions at this time 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.

Participant______________________ Date____________

Witness ______________________ Date____________

APPENDIX C

DATA COLLECTION SHEET

DATA COLLECTION SHEET

NAME: ______________________ DATE: __________ 19________

TELE#: ______________________

MODE: SEMI-RECUMBENT UPRIGHT

BLOOD PRESSURE DATA SHEET

TIME	WKLD/LEVEL	WATTS	TIME	SBP	DBP	Resting HR
			Begin			
			5			
			10			
			15			
			20			
			25			
			30			
			End			

APPENDIX D

RATINGS OF PERCEIVED EXERTION (RPE)

Fifteen-Point Borg Perceived Exertion Scale*

Ratings of Perceived Exertion	Level of Exertion
6	
7	Very, very light
8	
8	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
16	Very hard
18	
19	Very, very hard
20	

* Borg, G. A. Psychological bases of perceived exertion. *Med. Sci. Sports.* 14:377-381, 1983.

Explanation of Testing Protocol and RPE to Subjects

"During this test, you will exercise for a total of 30 minutes. This is a self-selected intensity test, at any time if you feel the need to increase or decrease the exercise level on the cycle ergometer, please ask by signaling up or down. You are asked to work out at a pace that you would normally work out on this bike in an average workout situation. Pretend that you have this cycle in your basement, and you want to exercise at your normal exercise intensity. Blood pressure, HR, and RPE data will be collected throughout the test.

RPE is your rating of perceived exertion. This indicates an overall feeling of effort and fatigue you are feeling over your entire body. The scale ranges from 6 and 20, 6 being the lowest effort you could possibly feel and 20 being the maximum amount of effort and fatigue you could achieve. At various times during the test, I will hold up an RPE scale and you can point to what number corresponds with the overall fatigue and effort you feel at that particular point in time. There is no wrong answer for this scale, but try and answer honestly with a number that accurately reflects you exertion level. Are there any questions you would like to ask before the test will begin?"

APPENDIX E

REVIEW OF LITERATURE

REVIEW OF RELATED LITERATURE

In recent years the use of semi-recumbent (SR) cycles has grown tremendously. More and more health clubs and fitness centers are purchasing these cycles for use by their members. As such, health club members want to know the relative benefits to using such an exercise modality. They wonder whether they are getting as good of a workout as they would with the traditional upright (UP) cycle. Also, more and more clinical facilities are purchasing SR cycles because of the added benefits of the machines. Individuals with limited range of motion and other health-related problems are finding it easier to exercise on SR cycles compared to traditional UP cycles. SR bikes are low to the ground and provide a padded, high-backed seat, which tends to be more comfortable than a traditional bicycle seat. As the usage of these bikes increases, the need for studies to determine how physiological responses differ between the cycles becomes important.

Submaximal Responses

A study by Bonzheim et al. (1) compared the submaximal physiological responses to exercise on UP and SR cycle ergometers. They found that VO_2, HR, BP, and RPE all were significantly higher during UP exercise compared to the SR at a workload of 100 watts.

Walsh-Riddle and Blumenthal (4) also compared the submaximal responses between the UP and SR. The results were generally comparable to those of Bonzheim (1) in that they found significantly lower HR, VO_2, and RPE on the SR at rest and at 75% and 90% of VO_{2peak}.

Curie et al. (2) compared the submaximal responses between an UP and a supine (SUP) cycle ergometer. Submaximal exercise was done at 100-300 kpm/min on each modality and HR response was found to be significantly lower in the SUP position. SBP results were significantly higher in the SUP position compared to the UP position. It was hypothesized that there was an increase in venous return in the SUP position, augmenting stroke volume, which would explain the higher SBP response and lower HR response in that position.

In the only study that utilized all three ergometers, UP, SR, and supine (SUP), Quinn et al. (3) compared the physiological responses to submaximal exercise. When comparing the UP to the SR cycle, they found no substantial differences in the cardiovascular responses between the two modalities. However, the study did find that there were significant differences between the SUP cycle compared to both the UP and the SR ergometers. Blood pressure responses between the three were similar and there was no difference in RPE, but VO_2 and HR results were significantly lower in the SUP position compared to UP and SR. Results such as these indicate that because of the SUP position (upper body supine and legs 33cm above the hip joint) there is an augmented venous return that elicits a lower heart rate than either the UP or SR. Lower VO_2 values in the SUP position are thought to be a result of external work being reduced because the legs did not have to be raised against gravity as in the SR and UP positions. The SUP position also optimizes the muscular efficiency of cycle riding compared to the UP and SR cycles.

Maximal Responses

Bonzheim et al. (1) found that during maximal exercise, the physiological responses (VO_2, HR, RPE, and BP) were not significantly different between the UP and SR cycles. However, peak-power output (watts) and exercise time (minutes) were both significantly greater on the SR ergometer compared to the UP cycle.

Walsh-Riddle and Blumenthal (4) reported that at maximal exercise the UP cycle elicited a significantly higher VO_{2peak} and maximal HR compared to the SR, probably because of more muscle involvement in the UP position. In the UP position, the rider can shift their weight more, thus maximizing muscle mass.

Currie et al. (2) also compared maximal responses between the UP and SR cycle ergometers. They found that maximal workload was significantly higher and exercise time was significantly longer on the UP compared to the SR. When comparing physiological responses, the UP elicited a higher maximal HR and a lower SBP than the SR.

Quinn et al. (3) compared the maximal responses among UP, SR, and SUP cycling. They found that there were no significant physiological differences among all three modalities in terms of maximal VO_2, HR, BP, and RPE. Additionally, the HR and VO_2 regressions were similar throughout the three modalities.

Influences on Body Position

Body position has been reported to have the greatest influence on the physiological differences when comparing the responses of the SR versus the UP cycle ergometers. Bonzheim et al. (1) claimed that during SR cycling there is reduced external work due to the weight of the legs not having to be raised against gravity as much as during UP cycling. There is also an increase in internal muscle efficiency during SR cycling. The higher seat back position on the SR enables individuals to achieve a better push while peddling. Both of these factors would result in a lower VO_2 at any given workload during SR exercise. There also is an increase in maximal power output and exercise duration on the SR cycle because of the more stable base to push against.

An increase in venous return due to the horizontal leg position probably explains the lower HR responses in the SR position. An increased venous return augments stroke volume, thus a given cardiac output can be achieved with a lower heart rate.

Exercise Prescription

Bonzheim et al. (1) found that the maximal HR and VO_2 differences between the SR and UP were not significant and the exercise regressions of % VO_2max on % HRmax were nearly identical. Since regressions were similar, a given percentage of HRmax during SR cycling results in a percentage of SR VO_2max comparable to that of UP cycling. Thus, the clinician may prescribe upright exercise using peak HR and VO_2 values obtained during SR cycling; however, submaximal responses at any given workload during SR cycling are lower. Consequently, an individual would have to work at a higher workload on the SR to achieve the same physiological benefits.

Additional studies by Walsh-Riddle and Blumenthal (4) and Curie et al. (2) also found lower HRs on the SR compared to the UP cycle during submaximal exercise. Thus, for exercise prescription purposes, their study also supports that a power output given for UP exercise should be increased for SR training.

Quinn et al. (3) suggest that data from SUP or SR testing can be used to prescribe UP ergometry exercise with some confidence. Because regressions of VO_2 on HR for SUP, SR, and UP modalities were similar, a given HR for SUP cycling results in a given SUP VO_2 that is comparable to either UP or SR cycling. Peak data from SUP or SR exercise testing were comparable to UP cycling and allow a similar exercise prescription for the UP ergometer.

Summary

There is limited research comparing the physiological responses of SR to UP cycles. The data that are available provide conflicting findings regarding the submaximal and maximal cardiovascular responses to exercise. A general perception is that exercising on the SR provides an "easier" workout compared to the UP. We have not found additional studies which compared the physiological responses on the SR and UP modalities when subjects exercised at a self-selected pace. Conflicting evidence of the cardiovascular responses to exercise on the two modalities makes exercise prescription difficult, but as more studies are done, exercise prescription will become more precise. As the use of SR exercise cycles grows, so does the need for all to understand the benefits of SR ergometry. There was a need for this study to help understand the physiological responses to self-selected cycle exercise and to explore contrasting data.

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