## ABSTRACT

HAGEN, H. L. A physiological comparison of chair aerobics and cycle ergometry in older females. MS in adult Fitness/Cardiac Rehabilitation, December 1999, 45pp. (C. Foster).

Chair aerobics (CA), a form of low-impact aerobics performed seated on a straight back chair, has been well received as an exercise modality for older populations. Few studies have assessed its effectiveness in cardiovascular (CV) fitness training. We tested 14 (5 with known cardiac disease, 9 without disease) older, physically active women (50-72 years, mean 62.3). Each volunteer completed one varying intensity submaximal arm-leg cycling (ALC) test on a Schwinn Airdyne cycle and one taped CA (e.g., "Fit over Fifty") session while heart rate (HR) and oxygen consumption ($VO_2$) were measured. During CA, subjects exercised at a mean of 9.7 $ml \cdot kg^{-1} \cdot min^{-1}$ (2.8 METs) and 99.5 bpm (58% and 42% of predicted $VO_{2max}$ and $HR_{max}$). Subjects reached a peak of 16.8 $ml \cdot kg^{-1} \cdot min^{-1}$ (4.8 METs) and 123.9 bpm (72% and 73% of predicted $VO_{2max}$ and $HR_{max}$). Linear regression was used to compare the HR-$VO_2$ relationship for ALC and CA. There was no significant difference ($p > .05$) between the slopes for the modalities (ALC = 61, CA = 66 $bpm \cdot l^{-1} \cdot min^{-1}$). There was a small yet significant difference ($p < .05$) between the y-intercepts (ALC = 64, CA = 60 bpm). The results of this study support the conclusion that CA is a moderate intensity exercise and may provide a sufficient stimulus to increase CV fitness in older women.

# A PHYSIOLOGICAL COMPARISON OF CHAIR AEROBICS AND CYCLE ERGOMETRY IN OLDER FEMALES

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FALCULTY

UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE

MASTER OF SCIENCE DEGREE

BY

HEATHER L. HAGEN

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COLLEGE OF HEALTH, PHYSICAL EDUCATION, AND RECREATION

UNIVERSITY OF WISCONSIN-LA CROSSE

THESIS FINAL ORAL DEFENSE FORM

Candidate: Heather Hagen

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

Master of Science in Adult Fitness / Cardiac Rehabilitation

The candidate has successfully completed the thesis final oral defense.

Thesis Committee Chairperson Signature — Date: 6/2/99

Thesis Committee Member Signature — Date: 6/2/99

Thesis Committee Member Signature — Date: 6/12/99

Thesis Committee Member Signature — Date: 6/2/99

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

Associate Dean, College of Health, Physical Education, and Recreation — Date: 7-7-99

Director of University Graduate Studies — Date: 7-7-99

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## INTRODUCTION

Older adults represent the fastest growing segment of the population, with approximately 20% of the population expected to be over the age of 65 by the year 2020 (1). As a large part of the American population ages, physical inactivity is a likely contributor to health problems. In fact, Powell and Blair (2) suggested that physical inactivity accounts for 30% of all deaths due to heart disease, colon cancer, and diabetes. Blair and Connelly (3) identified a need for moderate activity levels in the most sedentary portion of the population. In order to reduce mortality and improve the health of America's fastest growing population, it is clear that older people must lead active lifestyles.

Several studies have demonstrated that low to moderate-intensity exercise at 40-60% of maximal oxygen consumption ($VO_{2max}$) is sufficient to improve the fitness levels of older adults (4,5). Because many older adults are in poor physical condition, even this comparatively low-intensity exercise may be sufficient to achieve an appreciable training effect. Therefore, the older and sedentary segments of the population and especially those people with orthopedic and cardiovascular limitations, may benefit from low-intensity and/or low-impact forms of exercise which might not be as beneficial to younger or more active people. These types of exercise could help promote an active lifestyle without provoking injury or being overly taxing.

Low-impact aerobics may be an appropriate exercise mode for older adults since this type of exercise allows participants to increase their fitness levels without placing ballistic impact stress on the lower body (6-10). A recently developed variant of low-impact aerobics is chair aerobics (CA) which allows participants to do most or all of an exercise session while seated in or supported by a chair. Only a few investigators have studied various physical responses to CA. Chair aerobics has been shown to improve grip strength, spinal flexion, chair-to-stand time, and the ability to perform activities of daily living in nursing home residents (11). Also, by examining 24-hour heart rate responses in healthy older women and male cardiac patients, CA was found to be a moderate-intensity exercise using the ACSM (12) classification.

The aerobic requirements of CA has not been determined. Clearly, this type of exercise mode needs to be evaluated to determine whether the intensity is both sufficient enough to evoke cardiovascular and health benefits and low enough to avoid the risk of untoward events. Combined arm-leg cycling (ALC) on a Schwinn Airdyne cycle is a similar activity to CA in that both modalities utilize arm and leg movements in a seated position to raise heart rate and oxygen consumption. Comparing these two modalities will help to determine whether heart rate and oxygen consumption during CA respond in a similar manner to ALC. Thus, the purpose of this study was to: 1) document the aerobic and hemodynamic responses during CA and 2) compare the HR-$VO_2$ response during CA and ALC ergometry.

## METHODS

Fourteen (5 with and 9 without known cardiac disease) physically active female subjects over the age of 50 volunteered as subjects for this study. The physical characteristics of the subjects are presented in Table 1.

Table 1. Physical Characteristics of 14 older women

| | Mean | Standard Deviation | Range |
|---|---|---|---|
| Age (years) | 62.6 | ±6.9 | 57 – 73 |
| Height (cm) | 163.6 | ± 5.7 | 155 – 178 |
| Weight (kg) | 66.7 | ± 6.8 | 56.7 – 77.1 |
| CA HR peak (bpm) | 123.9 | ± 25 | 90 – 172 |
| CA $VO_2$ peak ($ml \bullet kg^{-1} \bullet min^{-1}$) | 16.79 | ± 2.5 | 13.2 – 19.7 |

Subjects were required to have attended at least 3 CA sessions prior to beginning the study to assure that they were familiar with the routine and able to follow the instructor throughout the testing session. Subjects provided informed consent (see Appendix A) and completed the medical/health history questionnaire (see Appendix B) prior to performing any testing. The study had been approved by the University Insititutional Review Board prior to any contact with the subjects.

Metabolic data were measured and recorded each minute using open-circuit spirometry (QMC, Quinton Instrument Co, Seattle, WA). Heart rate (HR) was measured using radio telemetry (Polar Vantage XL, Finland). The HR monitor was preset at a 15-second recording interval.

Subjects wore the HR monitor and the face mask with the breathing valve throughout both the ALC ergometry test and the CA routine. Participants were habituated to the equipment before testing. Each subject completed the cycling test prior to CA in order to make the participant more comfortable with the equipment during the 45-minute CA routine. Both tests were performed within 1 week of each other. Subjects taking medications known to alter the HR response to exercise were tested at the same time of day.

Prior to each test, the metabolic cart was calibrated using known gases previously determined through the micro-Scholander technique. The pneumotach was calibrated using a syringe of known volume. Borg's 6-20 Rating of Perceived Exertion (RPE) Scale (see Appendix C) was explained to the participants. The face mask was fitted to the subject and tightened to ensure that all expired air was directed to the metabolic cart. The HR monitor was positioned snugly around the chest. The subject's resting HR and $VO_2$ were recorded for 3 minutes before exercise began in each testing situation.

Participants performed ALC at several power outputs according to an intermittent varying intensity protocol designed to mimic CA. Chair aerobics increases and decreases in intensity; thus, a protocol was designed to reflect these intensities. Using a metronome for audio support, subjects completed a 3-minute warm-up pedaling with both arms and legs at 35 revolutions per minute (rpm) (25 watts). Subjects then cycled at 40 rpm (50 watts) and 45 rpm (75 watts) for 1 minute each. This work period was followed by 1 minute of pedaling at 35 rpm (25 watts). The test continued to increase by 5 rpm (25 watts) each minute for 2 minutes with a 1-minute recovery stage (25 watts). The rating of perceived exertion was recorded during the last 30 seconds of each stage. The test was terminated when the subjects reported a rating of 15 (e.g., hard) for perceived exertion. A schematic of the power outputs is presented in Figure 1.

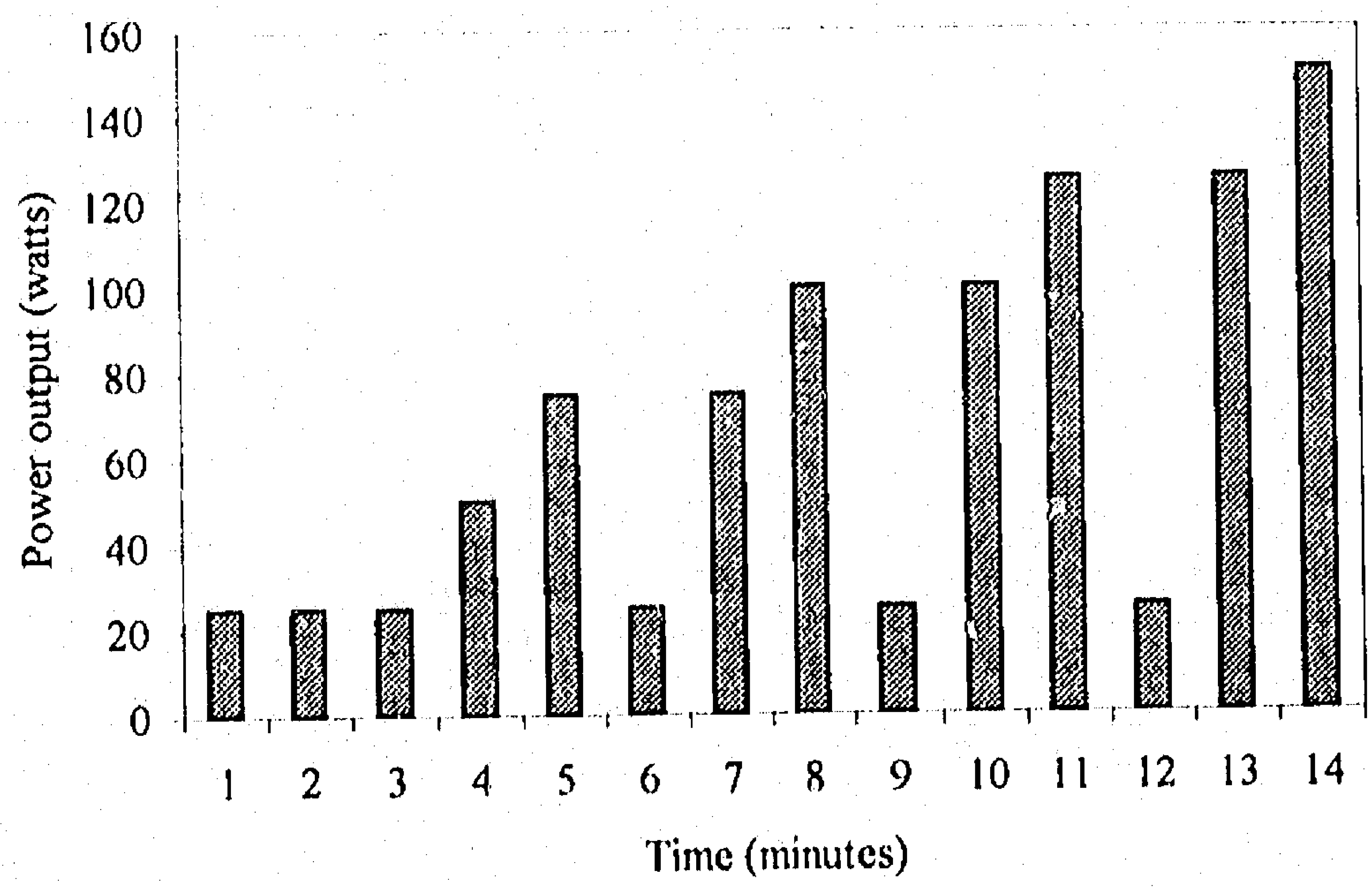


Figure 1. Arm-leg cycling protocol. An intermittent protocol was designed to mimic chair aerobics by increasing and decreasing in intensity.

Subjects performed the CA routine by watching a videotape of the "Fit Over Fifty" CA class led by an experienced instructor. Previous experience with the same routine made the videotape easy to follow and allowed the subjects to exercise at their accustomed intensity. The CA session consisted of 10 minutes of full range of motion activities, 20 minutes of seated actions and movements performed for cardiovascular and muscular endurance, a 10-minute low-impact standing aerobics portion (partially supported by the chair), and a 5-minute cool down in a seated position. All participants used the same straight back chair during all data collection. A RPE was recorded after the routine was completed.

During testing, the breathing valve was oriented in a vertical position with the expiratory side pointed toward the floor. The hose continued down to the abdomen and was then turned to go over the shoulder. To prevent the gas collection apparatus from hindering the subject, the hose was taped and held in place with an elastic bandage. Two hoses were joined to allow increased freedom of movement during the standing portions of the session (see Appendix D). During some portions of the CA routine, it was necessary for the researcher to help move the hose so the equipment did not interfere with the CA movements.

The HR-$VO_2$ regression lines were calculated for both CA and ALC for each subject. The highest HR obtained during CA was used as an end-point for the ALC ergometry data. The slopes of the regression lines during comparable levels of exercise formed the primary outcome measure and were compared using a paried t-test. A probability of less than 0.05 was considered statistically significant. As a secondary outcome measure, the peak and mean $VO_2$ during the CA session was normalized to the percent of the predicted $VO_2$ peak (based on extrapolation of the HR-$VO_2$ relationship to the age predicted maximum heart rate, using the ALC ergometry regression line). Lastly, the pattern of $VO_2$ and HR over the 45-minutes CA session was calculated by averaging every subject's values each minute.

# RESULTS

All subjects completed both testing modalities without complication. The ALC test was terminated when subjects reported an RPE of 15. The mean RPE for CA was 13.9 ± 1.73. Four subjects obtained a higher HR during CA; however, these subjects reported a lower RPE for CA.

There was no significant difference ($p > .05$) between the slopes of the regression lines for ALC and CA (ALC = 61, CA = 66 bpm•$l^{-1}$•$min^{-1}$). There was a small yet significant difference ($p < .05$) between y-intercepts for each modalitity (ALC = 64, CA = 60 bpm). The coefficients of determination for CA and ALC were $r^2 = .9142$ and $r^2 = .9676$, respectively. The mean regression lines for each modality are presented in Figure 2. All HR data obtained from the CA session were averaged across time and are presented in Figure 3. All $VO_2$ data obtained from the CA session were averaged across time and are presented in Figure 4.

Subjects exercised at a mean HR of 99.5 ± 9.9 bpm and a mean $VO_2$ of 9.7 ml•$kg^{-1}$•$min^{-1}$ ± 3.3 (2.8 METs) during the CA session. Peak HR and $VO_2$ were defined as the highest HR and $VO_2$ attained during CA. A mean peak HR of 123.9 ± 25 and a mean peak $VO_2$ of 16.79 ± 2.5 ml•$kg^{-1}$•$min^{-1}$ (4.8 METs) was achieved during CA. Mean peak respiratory quotient during CA was 1.065 ± .05

Maximal oxygen uptake was predicted by extrapolating the ALC HR-$VO_2$ regression to the age-predicted maximum HR for the 8 subjects who were not taking HR-lowering medications and did not exceed their age-predicted maximum HR. The mean intensity of CA for these subjects was 72.7% ± 12.2 of age predicted maximum HR and 72.1% ± 8.7 of predicted maximum $VO_2$.

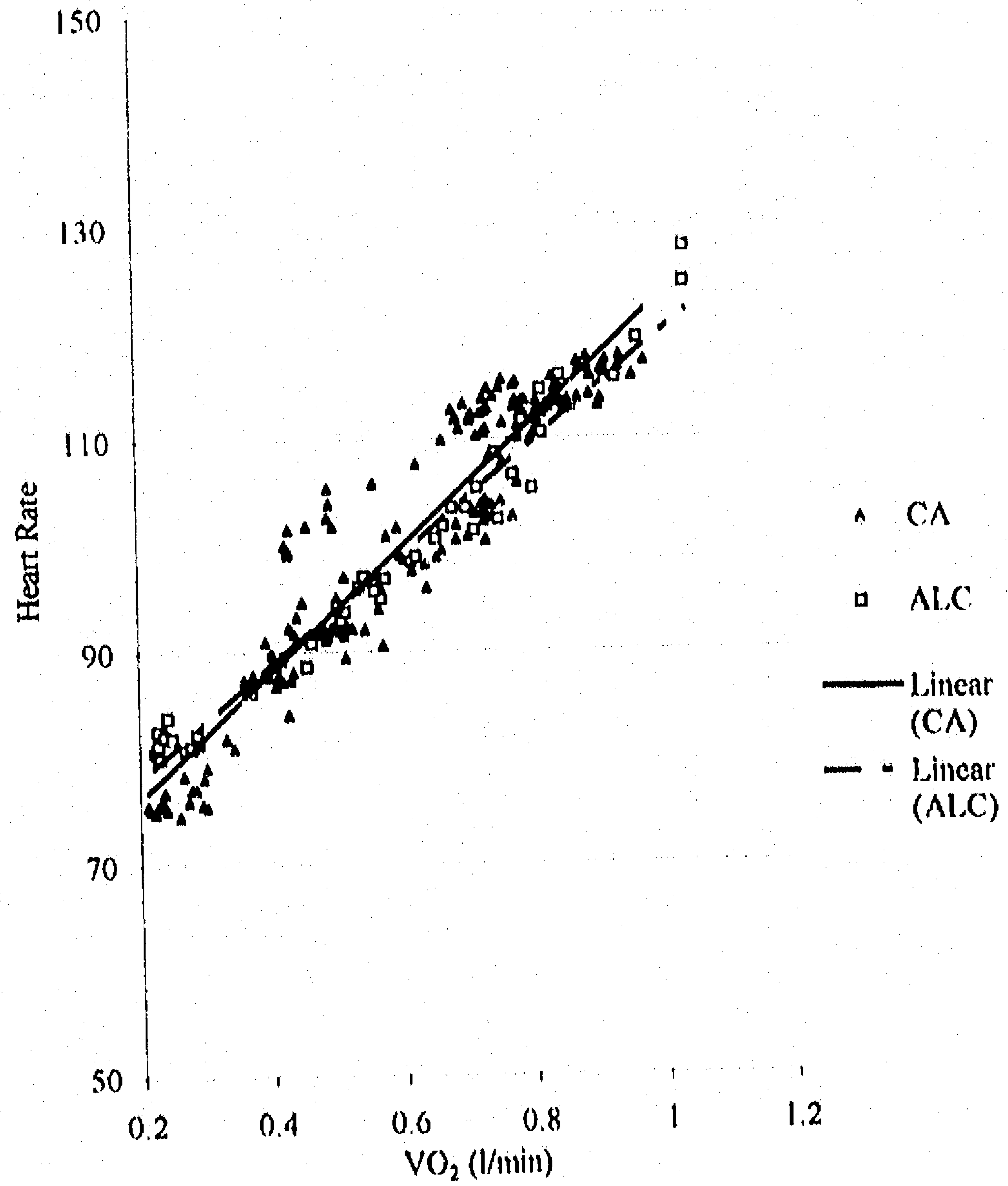


Figure 2. Mean HR-VO2 regression for chair aerobics and arm-leg cycling in 14 older females.

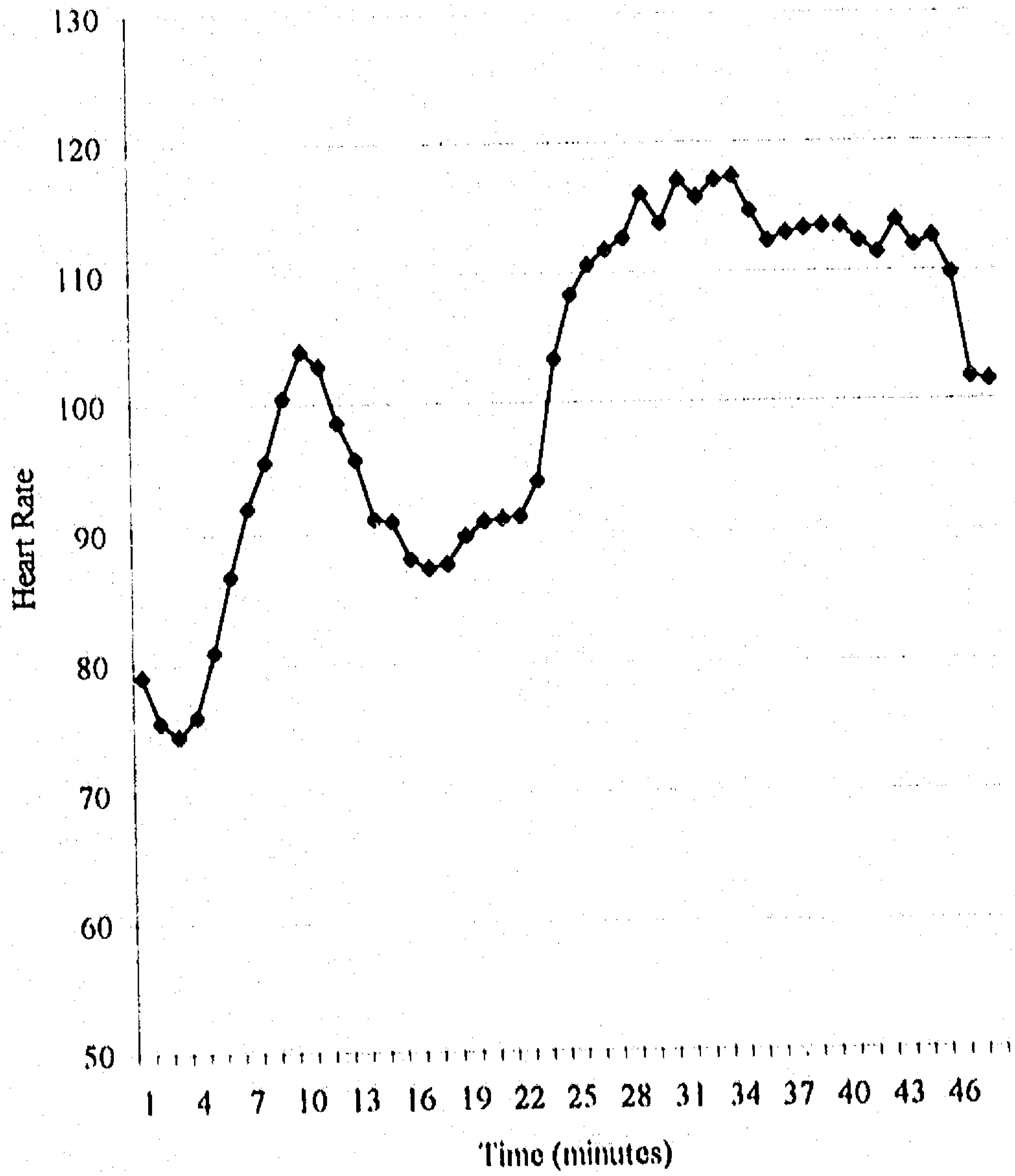


Figure 3. Mean 30-second HR values for 14 older women obtained during a chair aerobics session.

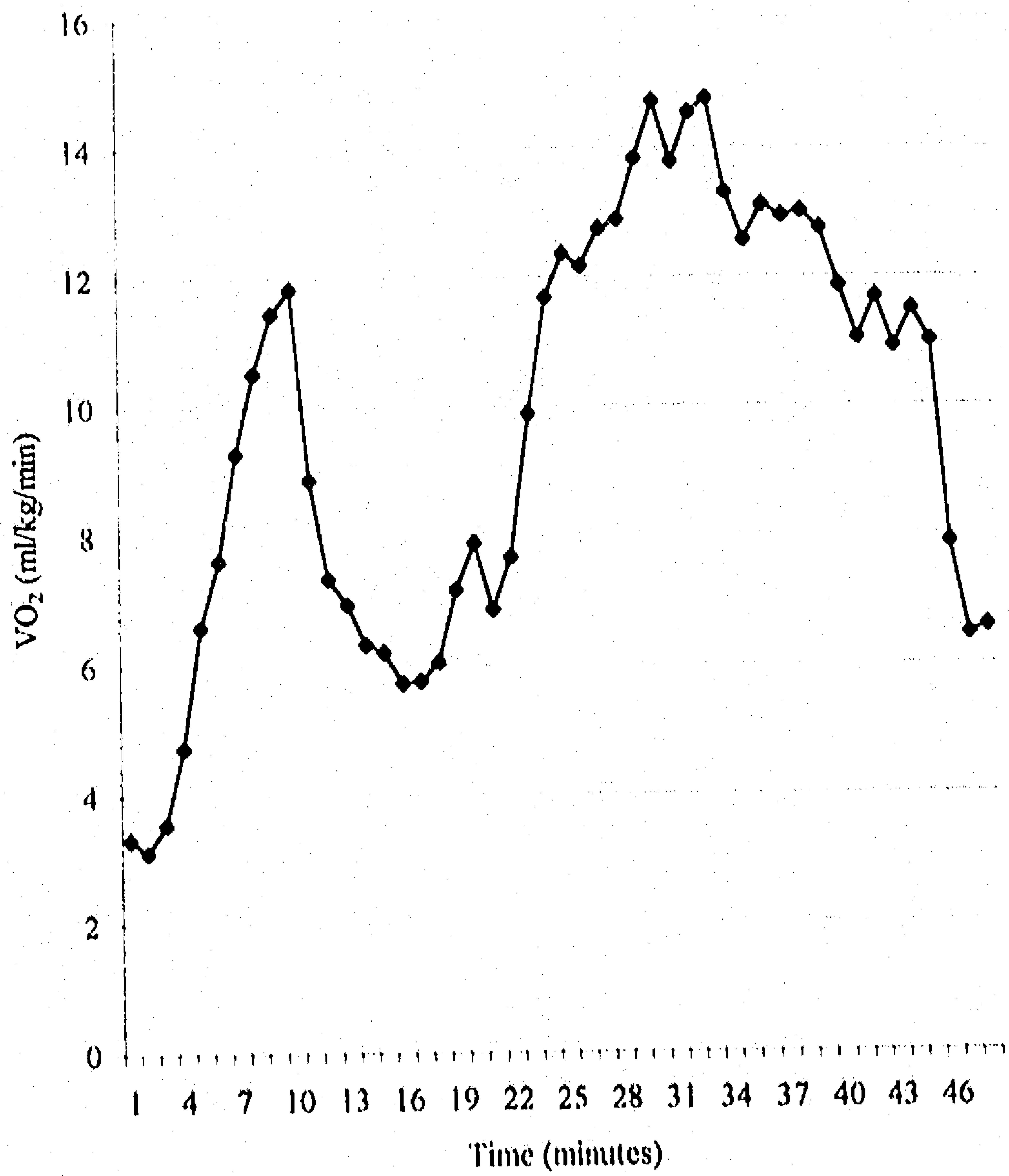


Figure 4. Mean 30-second $VO_2$ values for 14 older women obtained during a chair aerobics session.

# DISCUSSION

The lack of significant difference between the slopes of the HR-$VO_2$ regression lines for each modality suggests that older women respond similarly to CA and ALC. This finding indicates that older women experience similar elevations in HR and $VO_2$ during CA and ALC. Although a y-intercept difference of 4 bpm was considered statistically significant, this difference is likely to be of no clinical significance. Therefore, CA and ALC appear to be equivalent forms of aerobic exercise. Further, HR can be used to measure the intensity of CA.

The mean intensity of CA was 2.8 MET's. However, subjects sustained approximately 4 MET's for portions (10 to 15 minutes) of the CA routine. The subjects in this study whose data could be used to predict maximum HR and $VO_2$ exercised at a mean intensity of 72% of predicted maximum HR and 72% of maximum $VO_2$. According to the ACSM (12), this MET level and percentages of maximum HR and $VO_2$ correspond to light- to moderate-intensity exercise. This intensity is likely to be sufficient to improve or maintain the fitness level of older women.

The results of this study support the findings of VandeVoort, Wenaas, Butts, et al. (14) who used HR responses during CA to classify CA as a moderate-intensity exercise according to the ACSM. This study also supports the findings of McMurdo and Rennie (11) who demonstrated that seated exercise (of an intensity equivalent to the current study) can improve grip strength, spinal flexibility, chair-to-stand time, and the subjects' ability to perform activities of daily living.

A limitation of this study was that subjects did not perform a maximal exercise test. Estimations of $VO_{2max}$ and $HR_{max}$ are not as accurate as actual maximal data and cannot be determined for subjects taking medications affecting HR. In order to more accurately describe the intensity of CA, actual maximum $VO_2$ and HR need to be measured. Directions for further research should also include a longitudinal study assessing $VO_{2max}$ before and after a CA training program to determine whether or not CA presents a sufficient stimulus to elicit a training effect. In addition, research comparing CA to other exercise modalities performed at a self-regulated pace should be completed.

Chair aerobics seems to be an appropriate exercise mode to prescribe for older adults to offset age-related declines in physical fitness and to improve the quality and quantity of their lives. Chair aerobics allows participants to exercise without excessive orthopedic stress being placed on the lower body. Participants who find CA to be an enjoyable activity may use this activity as an alternative to ALC on an Airdyne cycle. This study provides evidence that participation in CA may promote an active lifestyle in older women.

Clinical Implications

There is no difference in the HR-$VO_2$ relationship between CA and ALC ergometry. Therefore, HR can be used to monitor intensity during CA. Older females (>50 years old) who participate in CA may attain HR and $VO_2$ values that are of light- to moderate-intensity as classified by the ACSM and should result in positive alterations in cardiorespiratory fitness.

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APPENDIX A

INFORMED CONSENT

# INFORMED CONSENT

## A PHYSIOLOGICAL COMPARISON OF CHAIR AEROBICS AND CYCLE ERGOMETRY IN OLDER FEMALES

BY
HEATHER HAGEN

I, ______________________________, give my informed consent to participate in a study to determine the aerobic requirement and oxygen consumption ($VO_2$) / heart rate relationship during chair aerobics and submaximal arm and leg cycling on an Airdyne bike. I consent to presentation and publication or other dissemination of results so long as information is confidential and disguised so that no individual identification can be made. I have been informed that although a record will be kept of my having participated in the experiment. I will be identified by number only.

1. I have been informed that the general purpose of this study is to establish an $VO_2$ / heart rate relationship for chair aerobics and submaximal arm and leg cycling to determine the effectiveness of chair aerobics as a mode of exercise.

2. I have been informed that my participation in this study will involve my participation in at least three chair aerobics sessions (during regular exercise with the La Crosse Exercise and Health Program (LEHP) prior to testing, one chair aerobics session and one submaximal cycle test for data collection. During both the chair aerobics and cycling testing sessions, I will be wearing headgear which holds a mouthpiece in place to collect physiological data. The head unit will be connected to the Quinton Metabolic Cart via a hose that is long enough to allow full movement to take place. I will also be wearing a Polar Vantage XL Heart Rate Monitor which will enable investigators to observe and record my heart rate during exercise. The heart rate monitor transmits signal from a chest strap to a wrist watch. I will perform chair aerobics while watching a video tape and listening to an audio tape recorded from an actual chair aerobics session led by an experienced instructor. The chair aerobics routine is similar to the one that I participate in during exercise with LEHP. I will also be exercising on an Airdyne bike following an intermittent protocol (alternating hard and easy segments to a rating of 16 (hard to very hard) on the Borg's Rating of Perceived Exertion Scale) which enables investigators to establish a $VO_2$ / heart rate relationship for arm and leg cycling.

3. I have been informed that there are minimal risks or discomforts during chair aerobics or arm and leg cycling, with the exception of the inconvenience of wearing a mouthpiece connected to the metabolic cart by way of a hose. However, with any exercise there exists the possibility of certain changes

occurring. These risks include abnormal blood pressure, fainting, abnormal heart rhythms, muscle soreness, and in rare cases, heart attack, stroke, or death. These risks have been minimized through an evaluation of my LEHP Medical/Health History Questionnaire on file and the Physical Activity Readiness Questionnaire (PAR-Q). I understand that the researchers are trained in emergency procedures.

4. I have been informed that I am responsible for reporting any information about my health status or previous abnormal responses to exercise. It is also my responsibility to promptly report feelings of discomfort during testing. Failure to do this may result in decreased safety as well as value of the test.

5. I have been informed that the results of this study may be beneficial to me because it will determine whether or not chair aerobics raises my oxygen consumption and/or heart rate sufficiently to elicit beneficial effects.

6. I have been informed that there are no "disguised" procedures in this experiment. All procedures can be taken at face value.

7. I have been informed that I am free to withdraw from the experiment at any time without penalty.

Questions or concerns about any aspect of this study may be referred to the principal researcher, Heather Hagen at 782-7320, or thesis advisor, Dr. Nancy Butts at 785-8177. Questions regarding the protection of human subjects may be addressed to Dr. Garth Tymeson at 785-8155, UW-La Crosse Institutional Review Board, for protection of human subjects.

______________________________ Participant's Signature __________Date

______________________________ Researcher's Signature __________Date

## APPENDIX B

## MEDICAL HEALTH HISTORY QUESTIONNAIRE

**Medical/Health History Questionnaire**

**La Crosse Exercise and Health Program**
**University of Wisconsin – La Crosse**

**Identification Data:** **Please fill in the following information.**

Name ______________________ Date ______________________

Address ______________________________________________

City ______________________ State ________ Zip ____________

Date of Birth ______________ Age ____________ Home Phone: ______________
Work Phone: ______________

Personal Physician ______________________ Clinic ______________________

Date of Last Check Up ______________

**Sex**
( ) Male
( ) Female

**Current Marital Status**
( ) Single
( ) Married
( ) Separated
( ) Divorced
( ) Widowed

**Race**
( ) Caucasian
( ) Black
( ) Hispanic
( ) Asian
( ) Other ______________

How many years of formal education have you completed?

( ) No High School
( ) Some high school
( )High School Diploma
( ) Some college
( ) College degree
( ) Graduate school

What is your occupation? ______________________

Would you consider your job stressful? (Circle appropriate number)
1 = not at all; 10 = very stressful

1 2 3 4 5 6 7 8 9 10

**Medications:**
What prescribed medicines do you presently take? Why do you take them?

What non-prescription medicines (over-the-counter) do you take and why?

**Allergies:**
Are you allergic to or have you had a "bad reaction" to any medicines or other substances?

If yes, please list the medicine and reaction.

**Physical Activity History:**
Have you ever had an exercise test? ( ) Yes ( ) No

If yes, please answer the following questions:

Location of test ____________________

Date of test __________ Results of test: ( ) Abnormal
( ) Normal
( ) Don't Know

If the test was abnormal, please explain.

Are you aware of any physical limitation that would prevent you from exercising regularly?
( ) Yes ( ) No

If yes, please specify. ____________________

Do you currently exercise on a regular basis? ( ) Yes ( )No

**If yes, please answer the following questions:**
How many times per week do you exercise? __________
How long do you exercise per session? __________
What types of exercise do you perform? __________

**If no, what types of exercise are you interested in?** __________

Did you participate in high school or college sports? ( ) Yes ( ) No

If so, please specify. ____________________

How would you rate your level of fitness?
( ) Poor
( ) Fair
( ) Average
( ) Above Average
( ) Excellent

**I hereby certify all statements provided by me in this questionnaire are complete and true to the best of my knowledge. Further, I give my permission to the La Crosse Exercise and Health Program staff to contact my personal physician or the program's medical director should there be questions or concerns about information in this medical history form.**

Signature: ____________________ Date: __________

**Personal History:** Have you ever had:

| | Yes | No | When? |
|---|---|---|---|
| Heart Attack | ( ) | ( ) | ____ |
| Open Heart Surgery (CABG, valve, other) | ( ) | ( ) | ____ |
| Angioplasty | ( ) | ( ) | ____ |
| Congential heart problems | ( ) | ( ) | ____ |
| Congestive heart failure (fluid in the lungs) | ( ) | ( ) | ____ |
| Angina / chest pain, pressure, or discomfort | ( ) | ( ) | ____ |
| Abnormal heart beats (palpitation) | ( ) | ( ) | ____ |
| Heart murmurs | ( ) | ( ) | ____ |
| Stroke | ( ) | ( ) | ____ |
| Rheumatic fever | ( ) | ( ) | ____ |
| Thyroid problems | ( ) | ( ) | ____ |
| Diabetes (IDDM, NIDDM) | ( ) | ( ) | ____ |
| High blood pressure | ( ) | ( ) | ____ |
| Swelling of the feet or ankles | ( ) | ( ) | ____ |
| Cramping in the lower legs or feet with exertion | ( ) | ( ) | ____ |
| Blackouts / fainting spells | ( ) | ( ) | ____ |
| Shortness of breath at rest or with exertion | ( ) | ( ) | ____ |
| COPD | ( ) | ( ) | ____ |
| Asthma | ( ) | ( ) | ____ |
| Bronchitis | ( ) | ( ) | ____ |
| Emphysema | ( ) | ( ) | ____ |
| Arthritis | ( ) | ( ) | ____ |
| Low Back Pain | ( ) | ( ) | ____ |
| Joint pain or swelling | ( ) | ( ) | ____ |
| Other orthopedic problems (knees, hips) | ( ) | ( ) | ____ |
| Emotional Disorders | | | |
| Anxiety | ( ) | ( ) | ____ |
| Depression | ( ) | ( ) | ____ |
| Other | ( ) | ( ) | ____ |

If you answered yes to any of the above questions, please elaborate:

Do you know your cholesterol level? __________

HDL __________ LDL __________ Triglycerides __________

**Hospitalizations:** List all your hospitalizations as best as you can.
Type of illness / surgery (please be specific) YEAR

1. ________________________________________ ______
2. ________________________________________ ______
3. ________________________________________ ______
4. ________________________________________ ______

**FAMILY HISTORY:** Has any blood relative had any of the following?

| | Yes | No | Relation | Age of occurrence |
|---|---|---|---|---|
| Diabetes (IDDM, NIDDM) | ( ) | ( ) | ________ | ______ |
| High Cholesterol | ( ) | ( ) | ________ | ______ |
| High Blood Pressure | ( ) | ( ) | ________ | ______ |
| Heart Attack | ( ) | ( ) | ________ | ______ |
| Open heart surgery | ( ) | ( ) | ________ | ______ |
| Stroke | ( ) | ( ) | ________ | ______ |
| Lung problems | ( ) | ( ) | ________ | ______ |
| Cancer | ( ) | ( ) | ________ | ______ |
| Obesity | ( ) | ( ) | ________ | ______ |

**HEALTH HABITS:**

Do you currently smoke cigarettes? Yes ( ) No ( )

If you do not currently smoke cigarettes, have you ever smoked? Yes ( ) No ( )

If you currently smoke or have ever smoked:
How many packs per day? ____________
For how many years? ____________

If you are a former smoker, how long ago did you stop smoking? ____________

On the average, how many drinks do you have per day on weekdays? ____________
on weekends? ____________

One Drink = One 12 oz beer
= One 4oz glass of wine
= One 1 oz liquor

On the average, how many cups / cans of the following beverages do you consume per day?

Tea ____________ Coffee ____________ Colas ____________

How many times per week do you eat:

Cheese _______ Yogurt _________ Fish _________ Salad _________
Sweets (cookies/cake) _________ Eggs _________ Skim Milk _________
Butter or Shortening _________ Instant or Frozen Entrees _________
Whole grain breads _________ Red meats (beef or pork) _________
Fried fish or poultry _________ Breakfast meats (saus/ham/bacon) _________

How many time do you dine out per week? _________

Of these, how many are fast food restaurants? _________

Overall, how would you rate your diet? (Circle appropriate number)
1 = unhealthy
10 = healthy
1 2 3 4 5 6 7 8 9 10

On average, how many hours of sleep do you get per night? _________

# APPENDIX C

# RATING OF PERCEIVED EXERTION

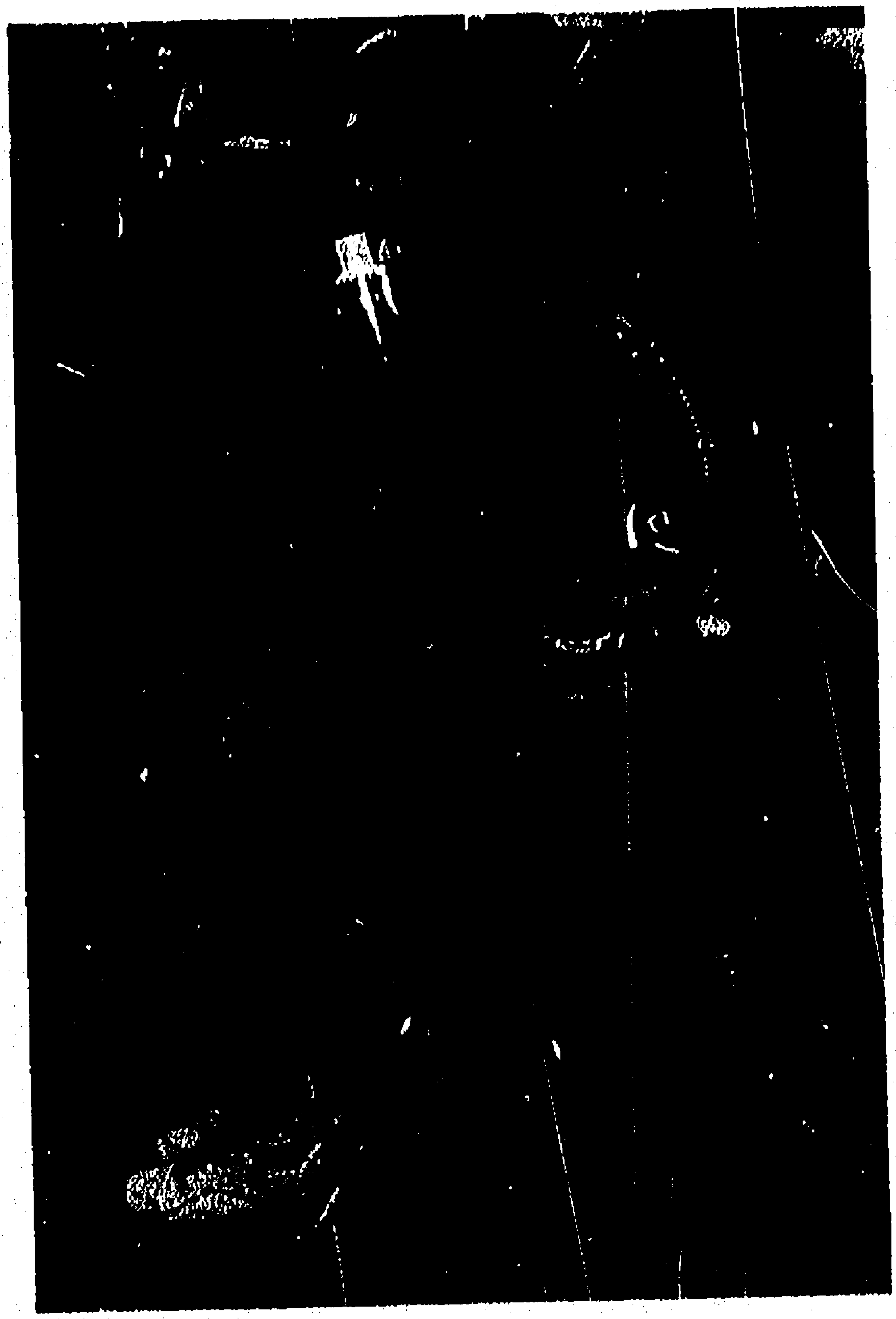
Rating of Perceived Exertion Scale*

| | |
|---|---|
| 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 | |

*Borg GA (1973). Perceived exertion: a note on "history" and methods. *Med Sci Sports Exerc*. 5:90-93.

# APPENDIX D

# PICTURE OF CHAIR AEROBICS TESTING



# APPENDIX E

# REVIEW OF RELATED LITERATURE

## REVIEW OF RELATED LITERATURE

### Introduction

According to the American College of Sports Medicine (ACSM) position statement (1) regarding the recommended quantity and quality of exercise in healthy adults, 85% of adults do not participate in exercise activities that meet the minimum ACSM recommendations for fitness. Particularly for older adults who may have multiple risk factors, exercise helps to reduce risk factors for heart disease, obesity, hypertension, and osteoporosis (2). Further, exercise is especially important for the older segment of the population to combat the physical decline associated with the aging process.

A sedentary lifestyle has been shown to contribute to coronary heart disease (CHD), noninsulin dependent diabetes mellitus (NIDDM), and colon cancer. In 1994, Powell and Blair (3) determined that the mortality rates for CHD and NIDDM would decrease by 35% while mortality rates would decrease by 32% from colon cancer if everyone became vigorously active. Although everyone will not start a vigorously active lifestyle, a significant reduction in the risks for these diseases would still be seen with even mild habitual exercise. The most notable contribution to the reduction in mortality from CHD, NIDDM, and colon cancer would result if the people who are currently exercising irregularly and the individuals who are currently sedentary increased their activity level. The results of Powell and Blair's study should encourage people to start incorporating regular leisure-time activity and exercise into their daily lives.

There are many favorable changes associated with regular exercise in older adults. Blumenthal et al. (4) found that many of the age-associated changes in the cardiovascular system can be improved with aerobic exercise. Following 4 months of aerobic training, Blumenthal et al. demonstrated that older subjects evidenced lower cholesterol levels, a decrease in diastolic blood pressure, and an increase in bone mineral content. The ACSM (2) noted that exercise produces greater postural stability which translates into a decreased risk of falling and suffering injury. Exercise in the older population also increases $VO_{2max}$ (5).

The physiological effects of aging in the cardiovascular system, the training effect observed in older adults, appropriate exercise prescription for older adults, concerns for maximal exercise testing in older adults, and the heart rate-$VO_2$ relationship are addressed in this chapter. Additionally, research on low-impact and chair aerobics and arm-leg cycling are presented and discussed in relation to older adults.

## The Physiological Effects of Aging in the Cardiovascular System

There is little question that the physical abilities of older persons are significantly less than those of younger individuals. The degree to which the reduction in functional ability is due to the natural aging process or to sedentary lifestyle practices remains unclear. Studies that concentrate on the physiological effects of aging must be careful to identify differences in physiological functioning that are due to inactivity, disease states, or natural aging.

Posner, et al. (6) reported that systolic and diastolic blood pressure increase with age. These researchers also stated that the rise in systolic blood pressure was due to both an increase in vascular resistance and hardening of the arterial tree. Although there is no significant change in resting heart rate due to aging, older adults demonstrate a lower maximum exercise heart rate which influences exercise capacity. This is significant in determining the exercise prescription for an older person.

Maximal oxygen consumption ($VO_{2max}$) also declines with age, usually 9-15% per decade in sedentary adults over 30 years of age (1). Kasch, Boyer, VanCamp, et al. (7) determined that the loss in $VO_{2max}$ is largely due to a decrease in maximal heart rate and stroke volume. Older persons have also demonstrated smaller increases in ejection fraction and larger relative increases in end-diastolic volume during exercise than younger persons (5). These factors, combined with a lower maximal heart rate, limit an older person's cardiac output during exercise. Ogawa et al. (8) found that 72% of the reduction in $VO_{2max}$ could be explained by a smaller cardiac output. The decreases seen in $VO_{2max}$ have also been attributed to a reduced oxygen extraction in the skeletal muscles.

A relationship between body composition and $VO_{2max}$ has also been determined (9). Jackson et al. found that as percentages of fat increased, relative $VO_{2max}$ decreased. They suggested that this relationship was due an increase in fat weight over a person's lifetime and the age-dependent decline seen in fat-free mass.

The reduction in $VO_{2max}$ seems to be affected by physical activity. In a longitudinal study, Kasch et al. (7) examined the reductions seen in $VO_{2max}$ in older men over approximately 20 years. Two groups of physically active subjects were used. One group maintained their exercise throughout the years of the study while the other group became essentially sedentary. Researchers noted almost a threefold difference in $VO_{2max}$ between the 2 groups after 20 years. The exercise group experienced a 13% reduction in $VO_{2max}$ in 23 years; however, a 41% reduction in $VO_{2max}$ was observed in the group that remained inactive for 18 years. These researchers assumed that the 13% decline in the exercise group was largely a function of aging. By applying this finding to the nonexercise group, they found that one-third of the reduction of $VO_{2max}$ was due to aging and two-thirds the result of physical inactivity. Furthermore, Kasch et al. determined that the loss of $VO_{2max}$ that is primarily due to aging is the result of a 20 beat drop in maximal heart rate and an 8.5 ml decrease in stoke volume.

Fitzgerald, Tanaka, Tran, et al. (10) examined the relationship between habitual exercise and the rate of decline in $VO_{2max}$ and maximum heart rate in adult women. These researchers determined that the decline in maximal heart rate with age was not related to habitual exercise status since sedentary women experienced similar declines in maximum heart rate similar to women who led active lifestyles.

## The Training Effect in Older Adults

There seems to be little argument that a sedentary lifestyle is detrimental to an older person's health. However, researchers have questioned the trainability of older adults. It is important to determine what benefits can be expected with training this population and the extent of those benefits. Furthermore, the exercise intensity necessary to elicit favorable changes needs to be determined.

In an early study, the effect of treadmill exercise at 70% of maximum heart rate on 25 older men was examined (11). Stamford demonstrated that geriatric men (mean age = 71.5 years) who trained for 6 weeks experienced a lowered exercise heart rate response and systolic blood pressure during a constant submaximal workload on a treadmill and cycle ergometer compared to a control group that remained sedentary. Stamford explained that his study demonstrated that older men are capable of producing a training response.

Adams and deVries (12) examined the physiological changes associated with 35 to 40 minutes of vigorous physical activity (above 60% of age predicted maximum heart rate) in older women. The experimental group in this study reported significantly higher $VO_{2max}$ values and physical work capacity and significantly lower resting heart rate values than the control group following three months of training. Researchers determined that this population demonstrated a training effect similar to younger subjects and male subjects.

Stratton et al. (5) compared the changes in $VO_{2max}$ following 6 months of endurance training in young (24 to 32 years of age) and old (60 to 82 years of age) adults. Despite age-related differences in physiological responses to exercise, the improvement in $VO_{2max}$ of each group was not significantly different. Stratton and associates concluded that the young and old respond similarly to endurance training.

The degree to which $VO_{2max}$ increases following training varies from study to study depending on the type and amount of exercise that was completed. One year of endurance training at approximately 60% of $VO_{2max}$ produced a 12% increase in $VO_{2max}$ in elderly men (mean age 62.9) (13). Blumenthal et al. (4) examined the effect of 4 months of aerobic exercise at 70% of heart rate reserve for a duration of 60 minutes 3 times per week and found that $VO_{2max}$ increased 11.6% as a result of training. In another study, 55-70 year old sedentary men and women exercised for 1 hour 3 times per week at 60 to 85% of maximal heart rate for 4 months (14). These researchers noted a significant gain in $VO_{2max}$ from 19.4 $ml \cdot kg^{-1} \cdot min^{-1}$ to 26.4 $ml \cdot kg^{-1} \cdot min^{-1}$ in the exercise group while the control group's $VO_{2max}$ did not change. Steinhaus et al. also found significant reductions in resting systolic blood pressure as a result of training. The findings of these studies demonstrate that older adults are quite responsive to aerobic training and will experience health benefits by starting an exercise program.

## Appropriate Exercise Prescription for Older Adults

Depending on physical capacities and limitations as well as underlying disease states, the amount of exercise that the older adult can tolerate varies. Because vigorous exercise can be dangerous especially in the older, sedentary, and diseased populations, the minimum training stimulus needed to increase aerobic capacity, produce positive cardiovascular changes, and impose health benefits needs to be identified.

Several studies have found that low to moderate intensity exercise (40-60% $VO_{2max}$) is often sufficient to improve the fitness levels of older adults (13,15). Because many older adults are in poor physical condition, lower intensity exercises may produce a training effect. This would imply that older adults should incorporate more leisure time activities such as walking into their daily lives especially when beginning an exercise program (2). Ideally, however, ACSM (1) recommends 20 to 60 minutes of physical activity 3 to 5 days per week.

In the 1998 position statement for exercise intensity for healthy adults, ACSM states that 40-50% of $VO_2$ reserve (% $VO_2$ R) is sufficient to improve fitness levels. This is a change in the manner in which intensity of exercise is prescribed (1). Swain, Leutholtz, King, Haas, and Branch (16) concluded that a percentage of heart rate reserve (%HRR) is better related to a percentage of $VO_2R$ than a percentage of $VO_{2max}$. The % $VO_2R$ is more appropriate because it takes into account resting oxygen values as does %HRR. Prescribing exercise at intensities of 40-50% of $VO_2R$ is lower than ACSM has recommended in the past. This reflects the current trend that a minimal exercise stimulus is actually needed to improve health.

Maximal Exercise Testing in Older Adults

Maximal exercise testing in older adults is usually completed on a treadmill or cycle ergometer. Several different protocols exist for exercise tests. Most involve an increasing workload to bring the subject to maximum at which point maximal heart rate and $VO_2$ are recorded. A true maximal exercise test requires maximal effort by the subject. Particularly in older subjects, maximum tests are often influenced by factors such as muscle fatigue, perceived exhaustion, ECG abnormalities, lung capacity, external motivation by the examiner, and whether the examiner is willing to allow the subject to reach maximum (6). Posner et al. also suggested that leg muscles in elderly persons usually fatigue before maximal values for heart rate and $VO_2$ are obtained, especially during graded treadmill exercise tests.

As a result of these complications, many researchers have tried to find ways to estimate $VO_{2max}$ using a submaximal exercise test. Recently, Milani, et al. (17) examined

9 equations (7 for submaximal treadmill exercise and 2 for submaximal cycle ergometry exercise) that estimate $VO_{2max}$ from submaximal workloads. This study revealed that the accuracy of the treadmill equations decreased as workloads increased. Researchers determined that accurate representations of $VO_{2max}$ were received from each of the equations in 13 men without coronary artery disease (CAD). Most equations significantly overestimated $VO_{2max}$ by 9 to 20%. In the CAD and non-CAD groups, both cycle ergometry equations accurately represented $VO_{2max}$ when subjects were demonstrating maximal effort, but underestimated $VO_{2max}$ at low submaximal workloads. Due to these results, it is more accurate to complete a true maximum test to determine $VO_{2max}$ than to rely on a prediction equation for an estimate. However, maximal tests on elderly persons require a physician to be present and may not be feasible in some cases.

## Relationship of Heart Rate and $VO_2$

It is widely accepted that heart rate increases with $VO_2$. In 1976, Londeree and Ames (18) compared the linear, quadratic, cubic, and quartic regression equations for heart rate and $VO_2$. Although more variability was explained by the quadratic and quartic equations, these differences were of no practical importance since the slopes of the regression lines were not found to be significantly different. Londeree and Ames also stated that the linear relationship between heart rate and $VO_2$ can be used to estimate $VO_{2max}$ from submaximal heart rate by extrapolating the regression line to age-predicted maximal heart rate. They also noted that the equation was consistent for different fitness classifications, age groups, and body weight ranges. Further, no differences between the linear regression lines for men and women and for pre- and posttraining were reported by Franklin, Hodgson, and Buskirk (19).

## Low-impact Aerobics

Low-impact aerobics started gaining popularity in the late 1980s. There are many different forms of low-impact aerobics, but all types have 2 characteristics in common. First, low-impact aerobics are performed with at least 1 foot maintaining contact with the floor at all times. Second, low-impact aerobics incorporate large upper body movements above the level of the heart combined with leg movements (20). There are no ballistic movements during low-impact as there are in high-impact aerobics.

Many studies have examined the physiological effects of low-impact aerobics. This review will focus on injury rates, energy cost, and training responses to low-impact aerobics with consideration to older adults.

### Injury Rates

Low-impact and nonweightbearing activities cause fewer injuries than high-impact forms of exercise such as running and jumping (1). Hainschfeger et al. (21) examined the incidence and severity of injuries in low-impact aerobics and in running. They observed that running produced more severe and a greater number of injuries than low-impact aerobics. For this reason, low-impact activities seem to be appropriate for people with physical limitations or a preexisting disposition to orthopedic injury.

### Energy Cost

Williford, Scharff-Olson, and Blessing (22) observed that low-impact aerobics usually require 4 to 5 kcal$\cdot$min$^{-1}$ while high-impact aerobics can demand 10 to 11

$kcal \cdot min^{-1}$. The researchers commented that low-impact aerobics are less stressful to the lower body by virtue of incorporating considerably less leg muscle involvement. However, Williford et al. (22) determined that low-impact aerobic exercise is capable of eliciting heart rates within the target range but require significantly less energy.

Other studies have determined the energy cost of low-impact aerobics. In 1988, Williford, Blessing, and Scharff (23) determined that high-intensity low-impact aerobic dance (at 85% of maximum heart rate) produced an oxygen cost of 32.4 $ml \cdot kg^{-1} \cdot min^{-1}$. Low-intensity low-impact aerobic dance produced a $VO_2$ of 18.2 $ml \cdot kg^{-1} \cdot min^{-1}$. These researchers concluded that low-impact aerobics needs to be performed at a high intensity to be considered a significant training stimulus. However, since this study was completed on younger subjects (23 years), older adults and people of lower fitness levels may benefit from low-intensity aerobic dance. The $VO_2$ values obtained during low-impact aerobics were not found to be significantly different than $VO_2$ values during high-impact exercise in another study involving 12 subjects (24).

Additionally, Stanforth, Hamman, and Senechal (25) examined the effects of arm, leg, and a combination of arm and leg low-impact aerobic dance movements at an intensity of 75% of maximum heart rate. A consistent HR-$VO_2$ relationship was reported by these researchers for leg exercise and a combination of arm and leg exercise. Aerobics that did not incorporate significant lower body involvement did not have a consistent HR-$VO_2$ relationship. This led the researchers to suggest that low-impact aerobics at 75% of maximum heart rate using leg and arms is an appropriate exercise to improve physical fitness. Furthermore, the use of hand weights was not shown to affect the oxygen cost of low-impact aerobics (25-28).

These studies suggest that low-impact aerobics is usually performed at low to moderate intensities which have been shown to facilitate training responses and health benefits in older populations. Therefore, low-impact aerobics may be prescribed in this population to improve physical fitness.

Training Response

The physiological benefits of low-impact aerobic training have also been examined. Hopkins, Murrah, Hoeger, et al. (29) determined the functional fitness of 35 elderly sedentary women before and after 12 weeks of low-impact aerobic dance exercise compared to 30 elderly women who remained sedentary. The exercise group participated in 50 minutes of low-impact aerobics three times a week at an unspecified intensity. The control group that remained sedentary showed a decline in functional fitness over the 12 weeks. In contrast, the exercise group showed significant improvements in cardiorespiratory endurance measured by a half-mile walk test, strength/endurance, body agility, flexibility, body fat, and balance.

In 1992, Garber et al. (30) observed a 10% increase in $VO_{2max}$ in response to 8 weeks of low-impact aerobic dance compared to an 11% increase in subjects that trained with walk/jog exercise. Trained and sedentary subjects were compared following 12 weeks of low impact aerobic exercise by Moore, Banning-Schaffner, and Whaley (31). The trained group showed an increase in $VO_{2max}$ and a decrease in body weight. As a result, the previously sedentary subjects in the training group experienced a decrease in body fat percentages and an increase in $VO_{2max}$. The results of these studies show that low-impact aerobics produce similar training responses as other modes of exercise and are likely to improve fitness levels especially in people with a lower exercise tolerance.

Chair Aerobics

Very few studies have examined chair aerobics. McMurdo and Rennie (32) observed the changes in 41 subjects residing in a nursing home. Subjects were either placed in a reminiscence group designed to promote social interaction or a exercise group that participated in 45 minutes of exercise performed in a chair. After 7 months, the exercise group showed improvements in grip strength, spinal flexion, chair-to-stand time, and activities of daily living that were significantly different than the reminiscence group. One study examined 24-hour heart rate responses to chair aerobics (33). The highest heart rate obtained during the 24-hour monitoring was observed during a chair aerobics session. Based on their results, chair aerobics was classified as moderate-intensity exercise and as meeting ACSM recommendations. These studies support the effectiveness of chair aerobics. However, further investigations into the duration and intensity of this type of exercise is needed.

Arm-Leg Cycling

Hoffman, Kassay, Zeni, et al. (34) compared $VO_2$ and rating of perceived exertion (RPE) during leg cycling and combined arm and leg cycling on an Airdyne cycle. This study demonstrated that $VO_2$ for arm and leg cycling was significantly greater than for leg cycling. Subjects reported a lower RPE during arm and leg cycling at the same workload versus leg cycling. Heart rate during both exercises at the same power output were not found to be significantly different . However, $VO_2$ and heart rate were significantly higher at a given RPE during combined arm and leg cycling. Because most people judge exercise intensity by perceived exertion, combining the legs and arms should elicit a greater training effect.

Mostardi, Gandee, and Norris (35) compared the effects of 6 weeks of leg cycling and arm-leg cycling. Both groups exercised at the same power output. This study revealed no significant differences in $VO_{2max}$ between the two groups as a result of training. However, they observed that subjects in the arm-leg group did more work at a lower heart rate during the conditioning program, and concluded that the combined group exercised with less stress on the cardiovascular system. They also suggested that cardiac patients use arm-leg cycling as a part of rehabilitation for maximum training benefits at a reduced feeling of exertion.

## Summary

It has been determined that older adults are able to achieve many benefits by incorporating aerobic exercise into their lifestyles. Older adults have shown an increase in $VO_{2max}$ and a decrease in the rate of decline of $VO_{2max}$ due to aging. It is important to promote exercise to older adults as the population of people over 60 years of age continues to grow.

Low-impact aerobics seems to be an appropriate exercise mode to prescribe for older adults. This type of exercise allows participants to experience increases in fitness levels without excessive stress being placed on the lower body. Chair aerobics is a type of low-impact aerobics that has become quite popular among older adults. However, there is limited research available that determines the effectiveness of this mode of exercise. By measuring the $VO_2$ during a chair aerobics exercise session, the intensity of this exercise can be determined. The relationship for heart rate and $VO_2$ during chair aerobics should be compared to that for a well researched activity such as arm-leg cycling. This comparison will identify if heart rate and $VO_2$ responses are similar in both modalities. These findings will be useful in determining if chair aerobics is an appropriate exercise mode for older adults.

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