ABSTRACT

COWPERTHWAITE, S. A. Physiological comparison of chair aerobics and cycle ergometry in young female subjects. MS in Adult Fitness/Cardiac Rehabilitation, December 1999, 38 pp. (C. Foster)

Chair aerobics (CA), a form of low-impact aerobics performed seated in a straight back chair, has been well received as an exercise mode for older populations. Few studies have assessed the aerobic responses to performing CA. Healthy volunteers ($N = 14$) (age 18-30) completed one varying intensity arm-leg cycling (ALC) test on a Schwinn Airdyne cycle to maximal exertion and one taped CA session (e.g., "Fit Over Fifty") while heart rate and oxygen cost were measured. Subjects reached a HR_{peak} of 189.9 ± 7.7 bpm and a VO_{2peak} value of 36.34 ± 4.7 $ml \bullet kg^{-1} \bullet min^{-1}$ during the ALC test. Subjects exercised at 11.2 ± 3.2 $ml \bullet kg^{-1} \bullet min^{-1}$ (3.3 METs, 31% VO_{2peak}) and 107.2 ± 10.34 bpm (57% HR_{peak}) which is at or below the lower limit of the ACSM $\%VO_{2max}$ and $\%HR_{max}$ guidelines for improving cardiovascular fitness. Regression analysis was used to compare the HR–VO_2 relationship for CA and ALC. There was no significant difference between the slope or y-intercept of the HR–VO_2 relationship. In conclusion, women who are untrained may achieve gains in CV fitness from CA, however CA may not provide sufficient intensity to increase CV fitness in trained young women.

PHYSIOLOGICAL COMPARISON OF CHAIR AEROBICS AND CYCLE ERGOMETRY IN YOUNG FEMALE SUBJECTS

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FACULTY

UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE

MASTER OF SCIENCE DEGREE

BY

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COLLEGE OF HEALTH, PHYSICAL EDUCATION, AND RECREATION

UNIVERSITY OF WISCONSIN-LA CROSSE

THESIS FINAL ORAL DEFENSE FORM

Candidate: Sarah Ann Cowperthwaite

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	3/26/99 Date
Thesis Committee Member Signature	3/26/99 Date
Thesis Committee Member Signature	6/4/99 Date
Thesis Committee Member Signature	6/2/99 Date

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

Associate Dean, College of Health, Physical Education, and Recreation	6-9-99 Date
Director of University Graduate Studies	6-9-99 Date

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INTRODUCTION

In recent years, the importance of improved cardiovascular fitness has become widely accepted. The Surgeon General's Report on Physical Activity and Health (1) suggests that regular physical activity performed on most days of the week may provide many health benefits. Exercise modalities such as walking, jogging, aerobics, and individual sports (e.g., golf) have received much attention and have been shown to improve cardiorespiratory fitness.

Recently, a new type of low-intensity exercise, chair aerobics (CA), has become popular in rehabilitation settings. This activity eliminates the orthopedic stress induced by most weight bearing modes of exercise. Literature on the effectiveness of CA as a mode of aerobic training is limited. McMurdo and Rennie (2,3) studied the implications of seated exercise on the elderly population who were living in nursing homes. They observed that seated exercise improved spinal flexion, chair-to-stand time, activities of daily living, and increased quadriceps and grip strength. VandeVoort, Wenaas, Butts, and Gotro (4) examined the heart rate (HR) responses to CA in healthy older women and male cardiac patients. They classified CA as a moderate-intensity exercise and observed that CA may render a sufficient stimulus of training in the subject population (4). To determine its effectiveness and potential for wider use, a physiological comparison between CA and conventional exercise modes is desirable. Such an analysis would provide a means of determining the effectiveness of CA as an alternative exercise modality to walking, jogging, and cycling.

It is unclear whether or not college-aged females can work at an intensity during CA which provides the dose of exercise needed for improvements in cardiorespiratory fitness. The American College of Sports Medicine (ACSM) (5) recommends an intensity of exercise that is 55/65-90% of an individual's maximal heart rate (HR_{max}). Similar to CA, arm-leg cycling (ALC) can be a self-regulated mode of exercise that utilizes movement of both arms and legs to achieve increases in heart rate and metabolic rate as an individual exercises in a seated position. Analysis of the heart rate–oxygen consumption ($HR-VO_2$) response to CA and ALC would provide comparative information about the exercise intensity that females between the ages of 18 and 30 reach during low-impact exercise utilizing the arms and legs. Therefore, the purpose of this study was first to document the aerobic requirements and hemodynamic responses to CA in young women and second to compare the $HR–VO_2$ relationship between CA and ALC in the same population. This study was designed as a companion to a similar study performed with middle-aged and older individuals.

METHODS

The subjects for this study were 14 female volunteers between 18 and 30 years of age. All volunteered and consented to participate in the study after being informed of the requirements of the protocol (see Appendix A). The study was approved by the University of Wisconsin-La Crosse Institutional Review Board. All subjects completed the Physical Activity Readiness Questionnaire (PAR-Q) (see Appendix B) designed to screen for contraindications to exercise prior to testing.

Prior to data collection, each subject attended at least three "Fit Over Fifty" CA sessions during its normally scheduled time, or participated in a CA session while watching a videotape of a "Fit Over Fifty" CA class. Subjects were tested on two separate occasions. The first test was ALC to peak exertion, requiring approximately 20 minutes. The second test was a CA session that lasted approximately 45 minutes.

During each test, respiratory metabolism was measured using open-circuit spirometry (Quinton QMC, Seattle, WA). The gas analyzers were calibrated immediately prior to each test using gases of known values. The pneumotach was calibrated using a calibration syringe. Heart rate response was measured using radio-telemetry (Polar Vantage XL, USA, Inc.). At the completion of each exercise bout, subjects indicated their rating of perceived exertion (RPE) using the Borg 6-20 scale (6) (see Appendix C).

Subjects performed the ALC test prior to the CA test, which was completed on a different day. During the ALC test, subjects were instructed to follow a varying intensity cycling protocol designed to mimic the increasing and decreasing intensity of the CA routine (see Figure 1). Audio and visual assistance was provided allowing each subject to maintain the required intervals of pedaling rate and power output. The test protocol began with a 5-minute warm-up that consisted of the subjects pedaling at a low power output. The test continued with a varying intensity protocol that involved 2 minutes of progressively higher intensity interspersed with 1 minute of lower intensity until the final minute which involved all out exertion.

During the CA session, subjects were seated in a straight-back chair that was 0.5 m in height. They followed the instructions of the class leader by viewing a

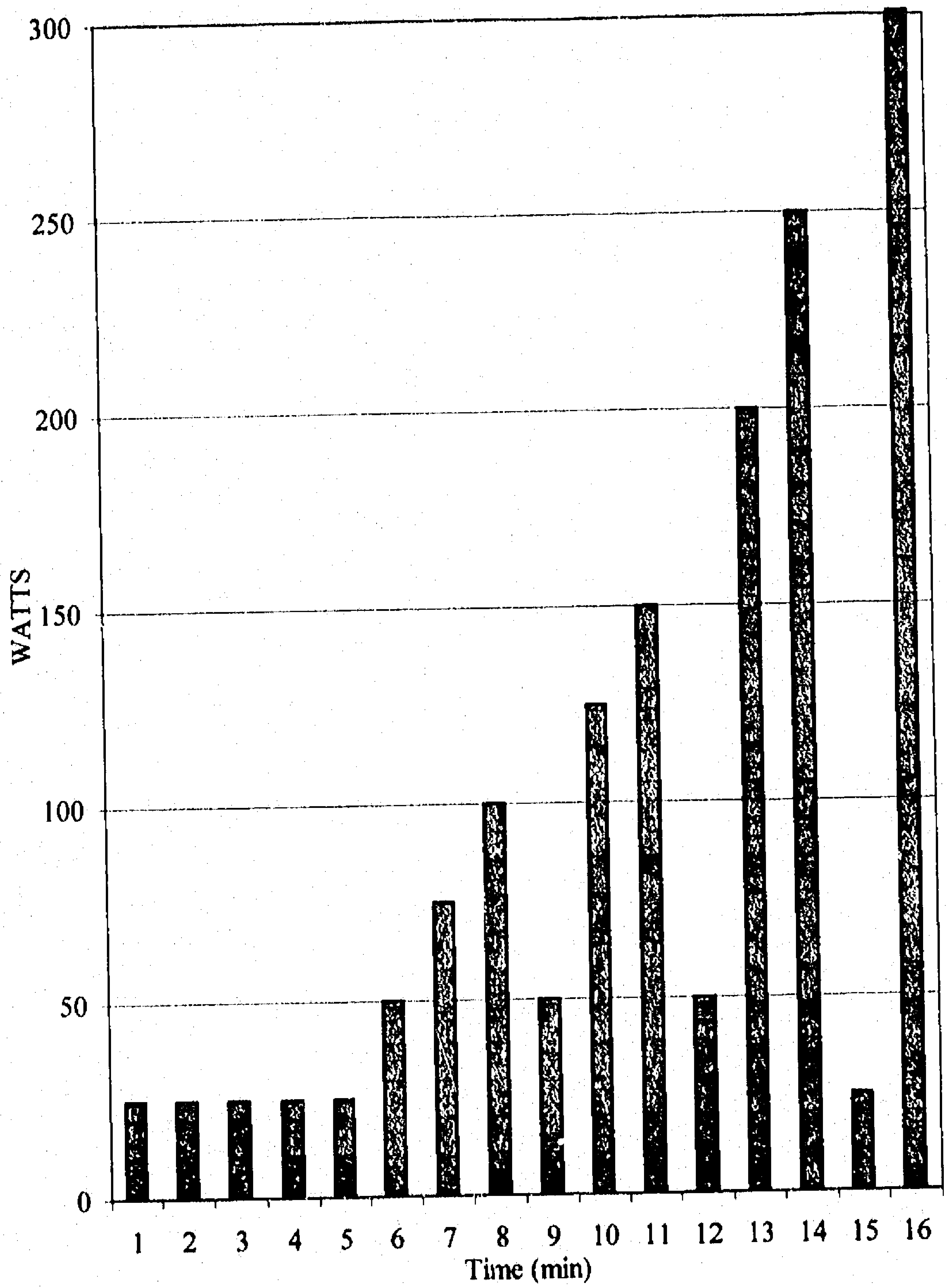

Figure 1 Seventeen-minute arm-leg cycling protocol utilized by young female subjects.

pre-videotaped class. The hose carrying expired air from the subject was held in place on each subject's body through the use of athletic tape and stretch bandages (see Figure 2). The class began with a 5 to 10 minute warm-up, consisting of stretching and full range of motion actions. Following the warm-up, a 20-minute seated aerobic portion consisted of actions and movements performed for cardiovascular and muscular endurance. Subjects then performed the aerobic portion in a standing position (with partial support from the chair) for 10 minutes prior to the 10-minute cool-down period. The taped session was 45 minutes in length.

Standard descriptive statistics were used to define the subject population. To test the hypothesis that there were no differences in the HR-VO_2 relationship between CA and arm-leg cycle ergometry, the 15-second HR values were regressed on the 15-second VO_2 values to yield the HR-VO_2 regression line for both the CA session and the ALC session. The slopes and intercepts of the HR-VO_2 regression lines for CA and cycle ergometry were compared using paired t-tests across data in the same VO_2 range. Significance was accepted at the $p < 0.05$ level of confidence. The serial HR and VO_2 data for all subjects across time were calculated from 30-second data collected during both the CA session and the ALC sessions. The peak values from the cycle test were used to determine the percent of peak values obtained by each subject during the CA session.

RESULTS

All 14 subjects completed the testing procedures without complication. Characteristics of the subjects are provided in Table 1.

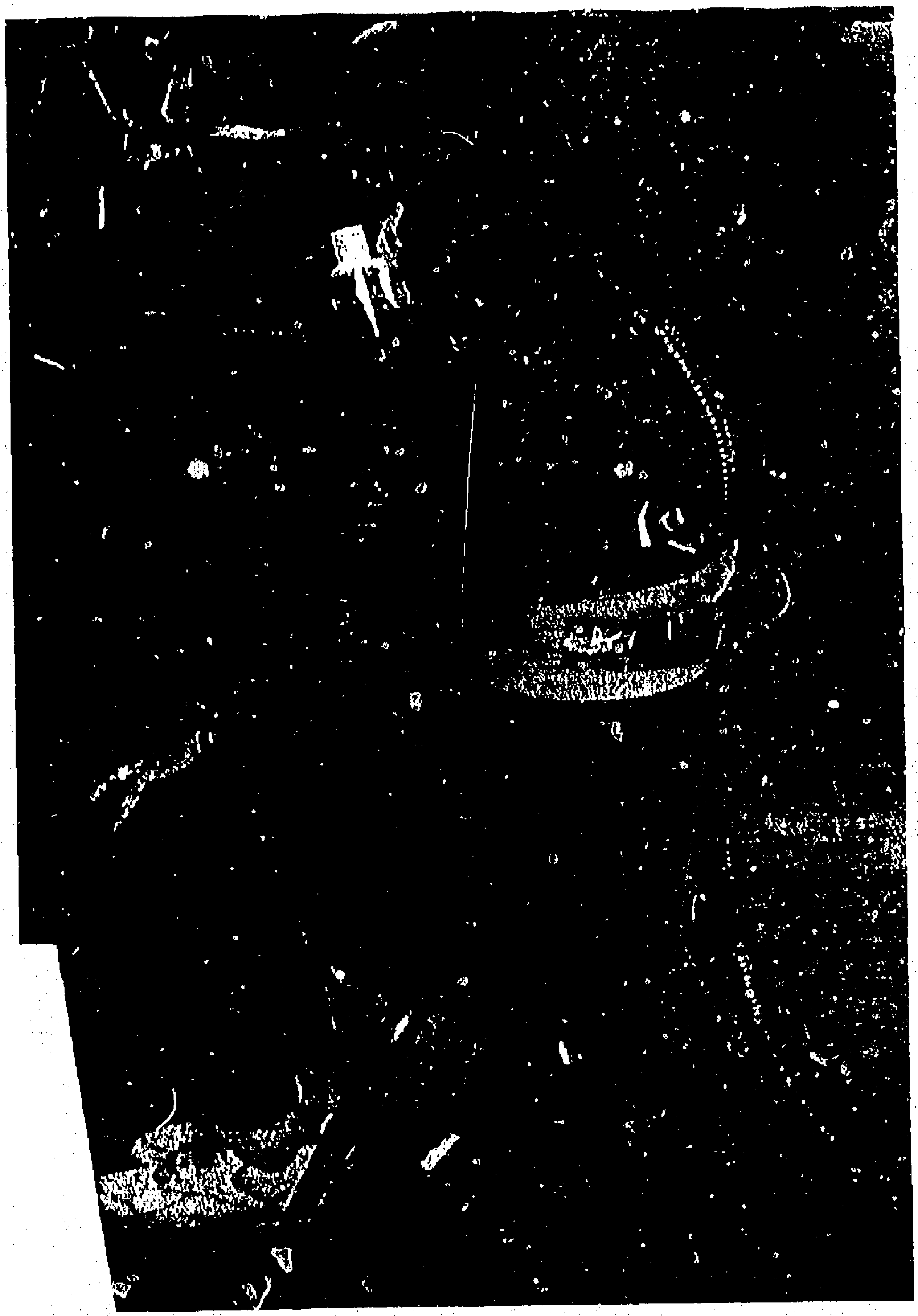

Figure 2 A subject wearing the vertical mouthpiece and bandage apparatus.

Table 1. Physical Characteristics of Subjects (N = 14)

Variable	Mean	Standard Deviation	Range
Age (yr)	22.7	2.3	19 - 28
Height (cm)	166.4	8.2	155 - 185
Weight (kg)	59.3	7.7	47.6 - 75.7
VO_{2peak}† ($ml \bullet kg^{-1} \bullet min^{-1}$)	36.2	4.7	28.1 - 42.5
HR_{peak}† ($b \bullet min^{-1}$)	189.9	7.7	176 - 202

† During maximal arm-leg cycling

The highest HR obtained during CA was 134.2 ± 3.9 bpm, and the highest VO_2 was 17.8 ± 0.76 $ml \bullet kg^{-1} \bullet min^{-1}$. All data were averaged across the 45-minute CA session. The mean HR and VO_2 values during the entire CA session were 107.7 ± 10.3 bpm, and 11.2 ± 3.2 $ml \bullet kg^{-1} \bullet min^{-1}$, respectively, while the highest group mean minute-by-minute HR was 125.8 ± 14.8 bpm, and VO_2 was 16.2 ± 2.9 $ml \bullet kg^{-1} \bullet min^{-1}$ (see Figures 3 and 4, respectively). During the CA session subjects reached a peak respiratory quotient of 1.02 ± 0.07. They rated their perceived exertion as "11," or fairly light, on the Borg's 6-20 scale (6).

Each of the 14 subjects completed a varying intensity cycling test on a Schwinn Airdyne cycle designed to mimic the increasing and decreasing intensity of the CA routine. Subjects were asked to pedal at maximal intensity during the last stage of the

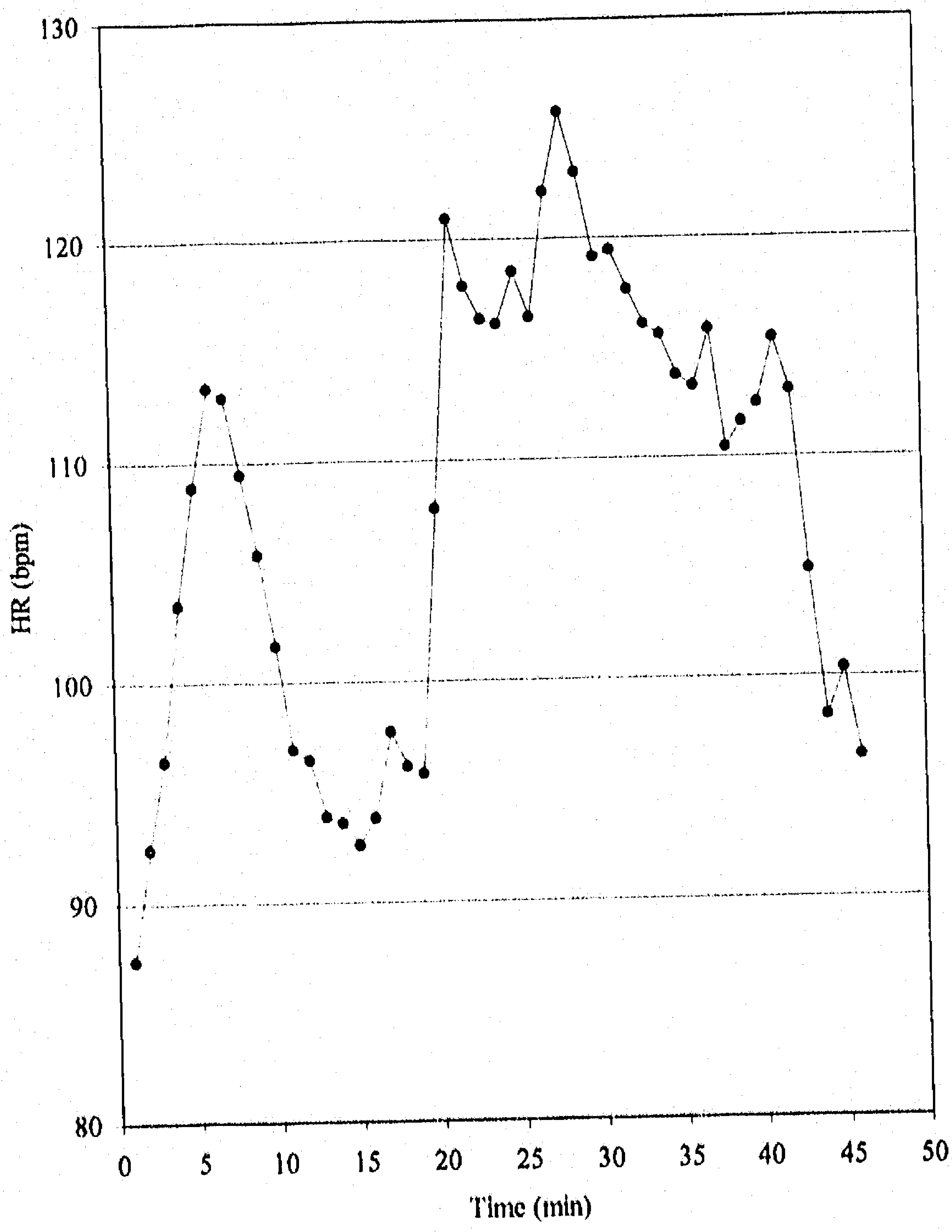

Figure 3 Mean HR values of 14 young female subjects during a 45-minute chair aerobics session.

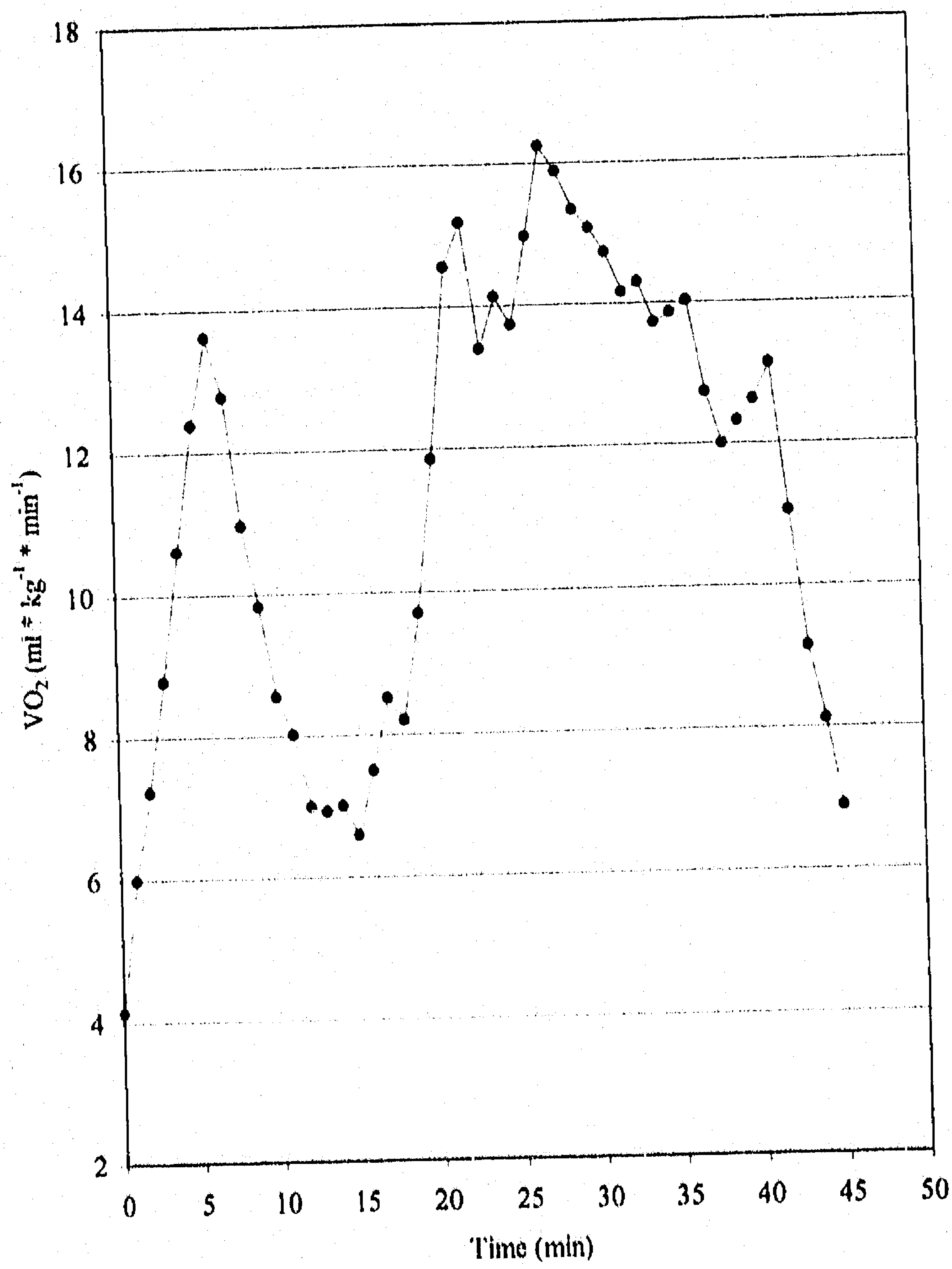

Figure 4 Mean VO_2 values of 14 young female subjects during a 45-minute chair aerobics session.

ranging protocol to provide peak HR and VO_2 values. Peak HR and peak VO_2 were defined as the highest HR and highest VO_2 reached during the cycling protocol. A mean HR_{peak} of 189.9 ± 7.7 bpm and mean $VO_{2\ peak}$ of 36.2 ± 4.7 ml • kg^{-1} • min^{-1} was obtained.

The HR-VO_2 regression lines generated for CA and ALC were compared. There was no significant ($p > 0.05$) difference for either the slope or y-intercept of the HR-VO_2 regression line between exercise modes (see Figure 5). The coefficients of determination for CA and ALC were $r^2 = .9825$ and $r^2 = .9391$, respectively.

The measure of the intensity of an exercise or activity may be calculated by determining the percentage of HR_{max} exhibited by an individual during the activity. Subjects in the present study were told to cycle as hard and fast as possible during the last minute of the ranging protocol. The HR value measured during the last minute of the cycling protocol was termed the HR_{peak}. The HR_{peak} value is not a true "max" value, but is representative of the peak value that may be attained during an exercise that utilizes movements of the upper and lower body in unison. The highest HR and VO_2 observed during CA corresponded to an intensity of 70.6% HR_{peak} (see Figure 6) and 49% VO_{2peak} (see Figure 7). Mean HR and VO_2 values averaged across the 45-minute CA session corresponded to 57% HR_{peak} and 31% VO_{2peak}. These values correspond to the lower limit of the ACSM (5) exercise prescription guidelines and differ from conclusions by VandeVoort et al. (1999) who found that older females exercise at moderate intensity during CA (4).

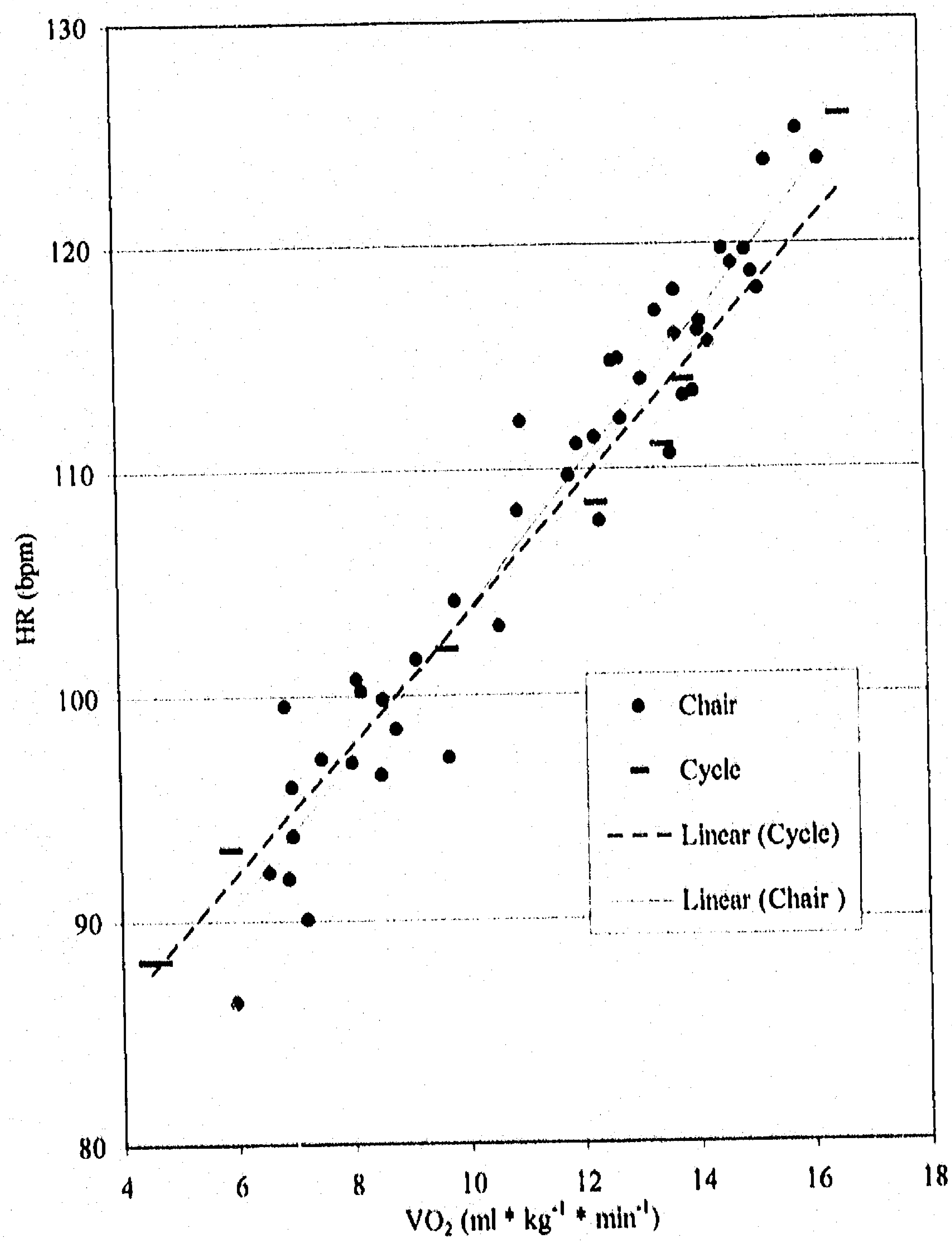

Figure 5 HR-VO_2 relationship during chair aerobics and arm-leg cycling in 14 young female subjects.

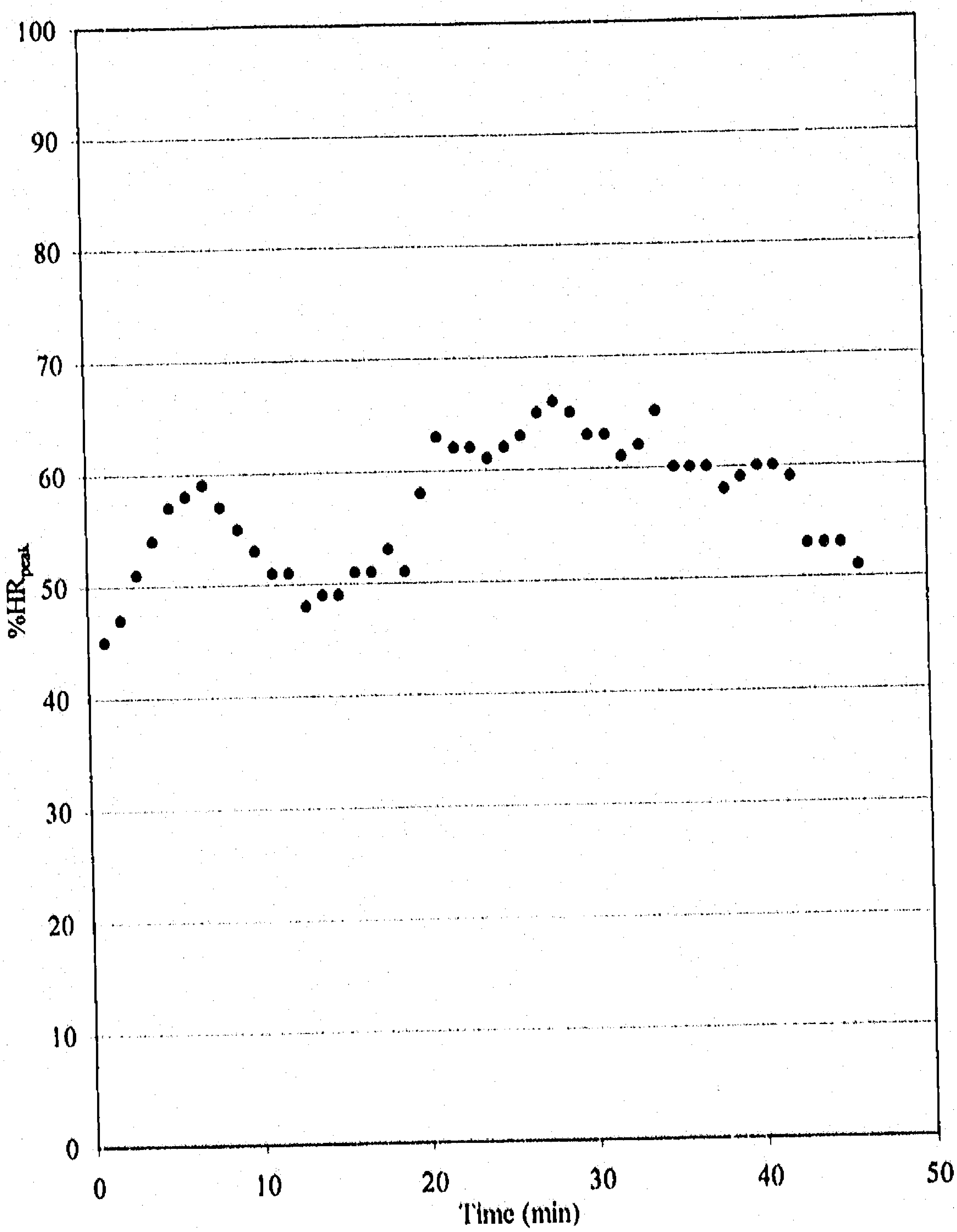

Figure 6 Percentage of HR_{peak} achieved during a 45-minute chair aerobics session in 14 young female subjects.

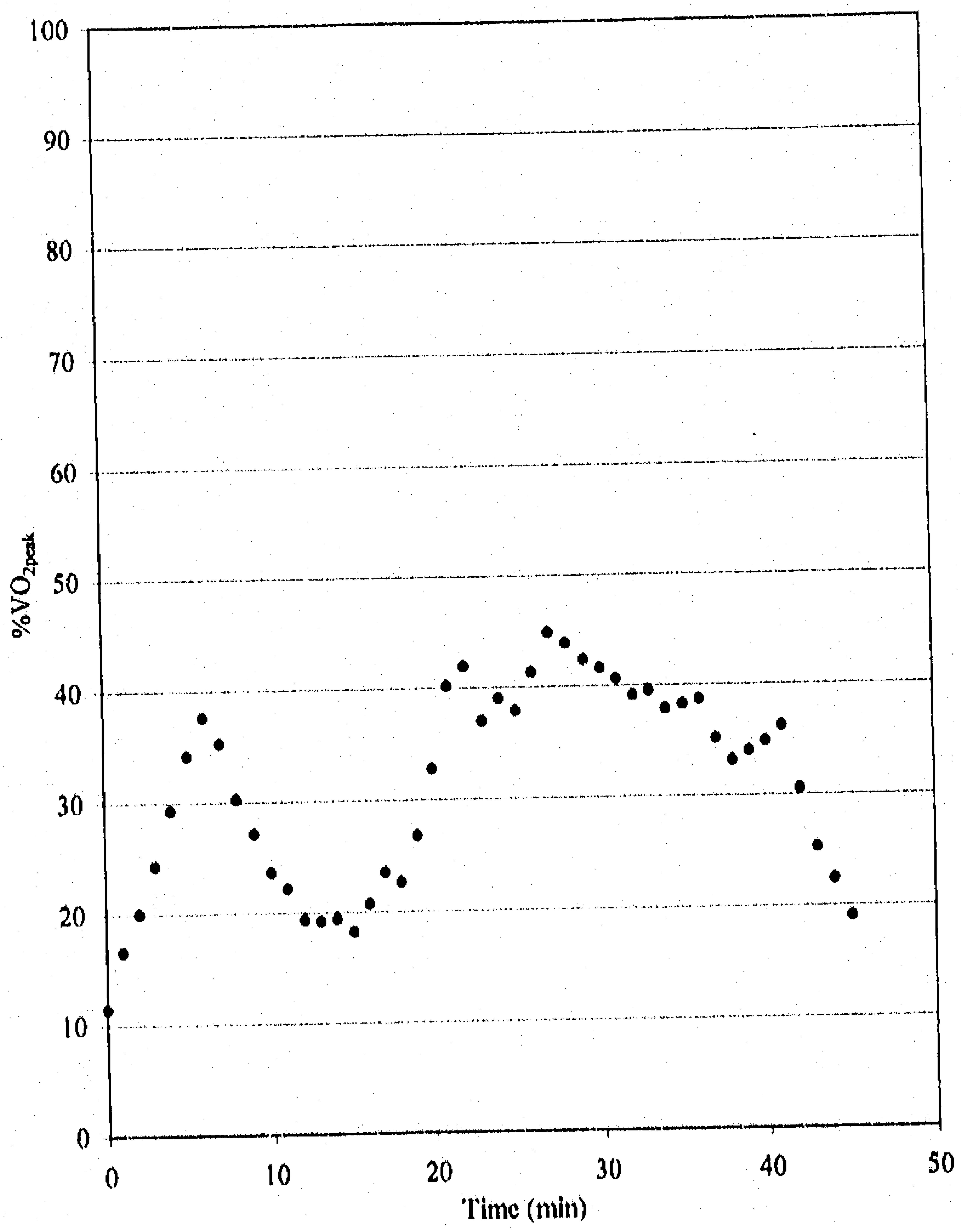

Figure 7 Percentage of VO_{2peak} achieved during a 45-minute chair aerobics session in 14 young female subjects.

DISCUSSION

The primary results of this study are in agreement with Williford, Scharff-Olson, and Blessing (7) who found that individuals who are not sedentary and who are physically fit reach only the minimal intensity required to achieve improvements in cardiorespiratory fitness when participating in low-impact low-intensity exercise. The linear relationship between the HR-VO_2 relationship during CA is indicative of aerobic exercise. Subjects reached intensity levels that correspond to the lower intensity limit of the ACSM recommendations for improvements in cardiorespiratory fitness. One possible explanation for the attainment of low HR and VO_2 values was the level of fitness of all subjects at the time of testing. Other possible explanations, as discussed by Williford et al. (7), include the motivation of participants or the instructor, the music, or the temperature on any given day.

From the findings of the present study, we suggest that a longitudinal CA training study assessing VO_{2max} before and after the study would provide beneficial information. It is also suggested that a comparison of CA to other exercise modalities that are performed at self-regulated paces be made. Information obtained may be used to further determine the effectiveness of CA as an exercise modality that increases cardiorespiratory fitness.

Clinical Implications

These results suggest that the HR-VO_2 relationships recorded during CA and ALC ergometry do not differ. Young females, aged 18–30, who participate in CA may attain HR and VO_2 values that correspond with the lower limit of exercise intensity recommended by the ACSM for improving cardiorespiratory fitness. This implies that young females who are sedentary, untrained, or otherwise limited may attain improvements in cardiorespiratory fitness when CA is utilized as a form of aerobic activity.

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APPENDIX A

INFORMED CONSENT FORM

INFORMED CONSENT
PHYSIOLOGICAL COMPARISON OF CHAIR AEROBICS AND CYCLE ERGOMETRY: YOUNG FEMALE SUBJECTS

BY
SARAH COWPERTHWAITE

I,_________________________, give my informed consent to participate in a study to determine the heart rate/VO_2 relationship of chair aerobics and arm/leg cycle ergometry. I consent to presentation and publication or other dissemination of results so long as the 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, only a subject number will identify all my experimental data.

1. I have been informed that the general purpose of this study is to establish an oxygen consumption/heart rate relationship between chair aerobics and intermittent arm/leg cycling to determine the aerobic requirement and effectiveness of chair aerobics as a mode of exercise training. I have been informed that all testing will be conducted in Mitchell Hall at the University of Wisconsin La Crosse. I have also been informed that I will be required to continue arm/leg cycling until maximal VO_2 is reached for the purpose of determining what percentage of my maximal heart rate and VO_2 are reached during chair aerobics and intermittent arm/leg cycle ergometry.

2. I have been informed that my participation in this study will involve participating in three chair aerobics sessions prior to testing, as well as one chair aerobics session and one arm/leg cycle test until maximal oxygen consumption is achieved for data collection. During both the chair aerobics and cycling test, I will be wearing headgear that holds a mouthpiece in place to collect my exhaled air for metabolic calculation. 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 be wearing a heart rate monitor that will enable experimenters to observe and record my heart rate during exercise. The heart rate monitor will enable experimenters to monitor my heart rate as the monitor will detect my heart beat via a strap worn around my chest which will send an electrical impulse to the wrist monitor for reading. I will complete one chair aerobics session while watching an actual taped chair aerobics session and listening to an audio tape from the "Fit Over Fifty" class at the La Crosse Exercise and Health Program. I will be wearing the mouthpiece and headgear as well as the heart rate monitor. I will also participate in one arm/leg cycle ergometry maximal test for data collection while wearing the mouthpiece, headgear, and heart rate monitor. I will be exercising on an arm/leg cycle ergometer following an intermittent protocol (alternating hard and easy segments) which will enable experimenters to

develop a heart rate/VO_2 relationship. Near the end of this cycling protocol, I will be asked to exercise at maximal effort for approximately two minutes or until volitional fatigue is reached to determine my maximal oxygen consumption and my maximal heart rate.

3. I have been informed that there are minimal risks and discomforts associated with chair aerobics and arm/leg cycle ergometry, including the inconvenience of wearing a mouthpiece connected to the metabolic cart by way of a hose. I have been informed that with any exercise there exists the possibility of certain changes occurring. These changes 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 the PAR-Q. I have been informed 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 to the investigators. 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 the value of the test.

5. I have been informed that the results of the study may be beneficial to me because they 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 thr 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, Sarah Cowperthwaite at 782-0773, or the thesis advisor, Dr. Nancy Butts, 785-8177. Questions regarding the protection of human subjects may be addressed to Dr. Garth Tymeson, Chair of the UW-La Crosse Institutional Review Board for the protection of human subjects 785-8155.

________________________________Participant's Signature

________________________________Researcher's Signature

______________Date

APPENDIX B

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

PAR – Q & YOU*
(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR – Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

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

**ACSM's Guidelines for Exercise Testing and Prescription* (5th Ed.). Baltimore, MD: Williams & Wilkins (1995).

APPENDIX C

BORG'S RATING OF PERCEIVED EXERTION SCALE

RATINGS OF PERCEIVED EXERTION

6	Very, very light
7	
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	

APPENDIX D

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Introduction

The American College of Sports Medicine (ACSM) (1) position stand, "The Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness, and Flexibility in Healthy Adults," along with the Surgeon General's Report (2) on physical activity and health have successfully identified and justified the need for daily physical activity among all American adults. The Surgeon General's Report (2) notes that 60% of the population are not regular exercisers, and only 15% of Americans regularly exercise vigorously. The Surgeon General's Report also indicates that sedentary living increases with age and is more common in women than men (2).

The ACSM, as well as numerous investigators, have suggested that sedentary aging reduces most health components of fitness; therefore, decreasing the ability of aging Americans to perform necessary daily physical activities. A joint recommendation from the Centers for Disease Control and Prevention and the ACSM on Physical Activity and Public Health (3) emphasizes the health benefits of accumulating 30 minutes of moderate-intensity continuous or intermittent activities on most days of the week. In a study of physical fitness and all-cause mortality, Blair et al. (4) concluded that individuals who were more fit were at a lower risk of all-cause death than those who were less fit. The literature on physical activity and its benefits to the health of people who incorporate some form of activity on most, if not all, days of the week provides strong evidence for the advocacy of exercise for all people.

A misconception exists in America that participating in physical activity to achieve health/fitness related results requires vigorous exercise. Research indicates that activity need not be vigorous to be healthful. The ACSM (1) indicates that individuals may participate in either continuous or intermittent exercises at 55/65-90% of maximum heart rate to achieve levels of cardiorespiratory fitness and positive changes in body composition. Exercise need not be competitive and should be prescribed on an individualized basis. There are numerous exercise modalities that tax the cardiorespiratory system without being strenuous and produce health benefits while appealing to the individual when chosen on an individualized basis.

Exercise Prescription

Prescribing exercise involves careful analysis of the medical history, needs, and goals of each individual. No two individuals are alike and many suffer from at least one malfunction or ailment. Cardiovascular (CV) disease, diabetes, cancer, asthma, and high blood pressure are a few examples of pathologies that should be considered when determining an exercise prescription.

The 1998 ACSM Position Stand describes the most appropriate frequency, intensity, duration, and mode of physical activity for the healthy adult population that include continuous exercise at approximately 55-90% of the maximal heart rate for at least 20-60 minutes, three to five days per week to achieve maximal benefits (1). It is recommended that individuals who are undertrained or sedentary exercise at approximately 55-64% of their maximal heart rate, while those who are in superior condition exercise in the 85-90% range of their maximal heart rate (1).

Exercise Modalities

The ACSM (5) indicates that activities such as swimming, walking, hiking, running, cycling, arm and leg ergometry, dancing, skating, cross-country skiing, rope skipping, machine-based stair climbing, and other endurance game activities provoke reliable increases in maximal oxygen uptake (VO_{2max}). These activities all involve the use of the large muscle groups of the body, are rhythmic, and may be performed continuously over periods of time. All individuals may be accommodated when exercise is prescribed due to the vast number of activities that may be offered that are aerobic and rhythmic in nature, and produce positive gains in cardiorespiratory fitness. Numerous studies have been conducted that provide evidence for the use of the many modalities of aerobic exercise available today (5-9).

Aerobic Dance

According to Cleary, Moffat, and Knutzen (10), aerobic dance has been identified as "the incorporation of various dance steps, calisthenics and other whole body movements into specially choreographed routines." Aerobic dance was noted by Williford et al. (9) as one of the most frequently practiced adult physical activities. Due to the popularity of this form of exercise, research has been conducted to determine its effectiveness on increasing or maintaining physiological functioning of the body. It has been determined that aerobic dance enhances cardiorespiratory fitness and increases the VO_{2max} of sedentary individuals who begin a program of regular aerobic dance (10).

Furthermore, in comparing aerobic dance to walk-jog training, Garber, McKinney, and Carleton (11) found that, "...aerobic dance is an effective method for improving cardiorespiratory fitness and may be recommended as an alternative to a walk-jog exercise regimen."

Cleary et al. (10) assigned 7 female college students to a sedentary control group, (enrolled in a physical education badminton course), while 14 college students were enrolled in one of two aerobic dance classes. The two experimental groups were assigned to either a two-day-per-week group that met for 20 minutes on Monday and Wednesday, or the three-day-per-week group that met for 20 minutes on Monday, Wednesday, and Thursday. The groups participated in the classes for a total of 10 weeks. The aerobic sessions were the same for both aerobic groups. The sessions began with a 10-15 minute warm-up including calisthenics, and ended with 5-10 minutes of cool-down activities, while the aerobic dance portion of the session lasted from 15 minutes initially, to a total of 30 minutes by the end of the sixth week. Statistically significant differences were evident between the three-day-per-week group and the control group when comparing VO_{2max}, maximal ventilatory threshold, and time to exhaustion from pre- to post- training. In the summary of their work, Cleary et al. (10) noted that aerobic dance enhances cardiorespiratory fitness in college-aged females as indicated by VO_{2max} improvements.

Williford, Scharff-Olson, and Blessing (9) presented similar evidence in a review of the physiological effects of aerobic dance. However, they indicated that great individual variability exists amongst participants in aerobics classes, related to the intensity of exercise. Factors such as participant motivation on any given day, the instructor, the music, or the temperature may affect the physiological functions of the participant. The investigators indicate that more research must be conducted to clarify the issues of individual variability, as well as the issue of injuries that may result from excessive high-intensity aerobic actions.

Garber, McKinney, and Carleton (11) followed 45 females and 15 males ages 24-50 as they participated in one of three groups for eight weeks. Twenty-two subjects were assigned to an aerobic dance group, 23 subjects were assigned to a walk-jog exercise group, and 15 subjects were assigned to a control group. Prior to and following the eight-week training period each subject performed a maximal graded exercise test on a treadmill. Of the 35 subjects who successfully completed the study, increases in peak oxygen uptake were observed in both exercise groups, 3.9 $ml \cdot kg^{-1} \cdot min^{-1}$ for the dance aerobics group and 3.4 $ml \cdot kg^{-1} \cdot min^{-1}$ for the walk-jog training group (11).

Low Impact Aerobic Dance

As previously noted, numerous studies are available which describe and explain the impact of aerobic dance on the human body. Williford et al. (9) summarized the changes in cardiorespiratory fitness and body composition resulting from a variety of aerobic dance forms. The authors describe low-impact dance and high-impact dance as different dance forms, and explain the "paucity of information" concerning low-impact aerobic dance. Characteristics of low-impact aerobic dance include those of aerobic dance except the subject maintains contact with the floor with at least one foot at all times, and there is no hopping, bouncing, or jumping involved. Williford et al. (9)

reviewed a number of studies that examined the effects of low-impact aerobics and discovered that low-impact aerobics were beneficial to sedentary individuals; whereas, previously trained individuals may receive no additional benefits.

A study by Gillette and Eisenman (12) conducted in 1987 demonstrated that an increase in VO_{2max} could be achieved from low-impact aerobics. Their results conflict with most of the previous research related to low-impact aerobics. It has been suggested that their results might have differed due to the longer training period in their study (9).

Low-impact exercise does not necessarily have to be low-intensity exercise. Low-impact aerobic dance moves may be conducted at a high-intensity and have been found to produce increases in exercise heart rate (HR), VO_{2max}, and MET levels (9, 13). As sedentary individuals age, the bones of the body become weak and frail because the weight bearing activity that helps to maintain the strength of the bones is lacking. Low-impact aerobic exercise would benefit this population as gains in physiological function result, yet there is a decreased risk of the orthopedic injuries which typically accompany most high-impact activities.

According to Hopkins, Murrah, Hoeger, and Rhodes (14), the developers of fitness measurement and evaluation tools have frequently overlooked the elderly population. They studied 65 sedentary elderly women to determine the effects of low-impact aerobic dance class on functional fitness. The subjects were 57 to 77 years of age and were divided into two groups. Thirty-five subjects were placed in an experimental group that attended three 50-minute low-impact aerobics classes per week for 12 weeks. The classes began with a 15-minute warm-up followed by 20 minutes of aerobics and concluded with a 15-minute cool-down. Dependent variables included six selected functional fitness items using the test protocols presented by the task force at the 1987 American Association of Health, Physical Education, Recreation, and Dance national convention (14). The fitness items assessed prior to and immediately after training were cardiorespiratory endurance, flexibility, strength/endurance, body agility, motor control and balance, and the sum of three skinfolds. Results of the study indicated that all experimental subjects demonstrated significant improvements on all fitness components except motor control and coordination (14).

Numerous researchers have concluded that most individuals achieve cardiovascular benefits when participating in a program of low-impact aerobic dance. Sedentary individuals who begin a form of low-impact aerobic dance consistently show significant improvements on functional capacity. Individuals who have previously participated in regular physical activities may need to increase the intensity of their workout during low-impact aerobics to maintain or increase fitness levels. Many older individuals have been sedentary. Therefore, aerobics would be expected to significantly improve physical functioning when incorporated into a 20-minute/three day-per-week exercise program. The Surgeon General's Report indicates that 50% of young adults aged 12-21 participate regularly in vigorous activity, therefore such individuals would need to increase the intensity of low-impact aerobics in order to achieve benefits from the activity.

Chair Aerobics

Chair aerobics (CA) is a special type of low-impact aerobics in which much of the routine is performed with the subject seated in a straight back chair, the intent being to minimize the impact of the exercise session. Studies related to CA are sparse, but are beginning to increase in number as CA is becoming the activity of choice for many segments of the American population. Chair aerobics is ideal for individuals that use wheelchairs, who are rehabilitating from injuries, or who have markedly lost their ability to perform weight bearing activities and cannot meet the recommended 20-60 minutes of activity three to five days per week as recommended by the ACSM (1). McMurdo and Rennie (15) studied the implications of CA on older or elderly individuals who are living in nursing homes. In their study, 49 residents of nursing homes volunteered to participate in either twice-weekly seated exercise sessions or a control group. Seated exercise was chosen by the researchers due to the "frailty of the group." The exercise sessions included a 10-minute warm-up followed by a 35-minute session of seated aerobics. The exercise portion of each session consisted of upper and lower limb exercises of increasing repetitions. Results of the study indicated differences between the exercise and control group. The exercise group demonstrated improvement in the following variables: grip strength, spinal flexion, chair-to-stand time, and activities of daily living. The control group deteriorated in all measurements.

McMurdo and Rennie (16) further studied seated exercise. The researchers proposed to answer the question: "in the institutionalized elderly, does participation in regular seated exercise strengthen the quadriceps muscles?" Sixty-five residents (mean age of 83 years) from various homes for the elderly volunteered to participate in the study. McMurdo and Rennie found that seated exercise did increase the strength of the quadriceps muscle in a safe and effective manner while providing an opportunity for the frail elderly to exercise and prolong life expectancy (16).

VandeVoort, Wenaas, Butts, and Gotro (17) evaluated the HR response to CA in 12 healthy older women and 12 male cardiac patients. Subjects wore a Polar Vantage XL HR Monitor for two 24-hour periods that included sleep, activities of daily living, and one CA session. Subjects also utilized an activity log to record activities during the 24-hour monitored periods. Results of the study indicated that CA is a moderate intensity exercise (55-66%HR_{max}) according to the ACSM guidelines (17).

Although additional studies on CA are needed to fully identify and understand its implications on the functional capacity, the studies that have been conducted have concluded that its benefits are identifiable and significant.

Arm-Leg Cycling

Arm-leg cycling (ALC) is a mode of exercise that requires the use of large masses of muscle in coordination to produce work on an ALC ergometer. The effectiveness of such exercise training for the populace has been investigated with positive outcomes. A decrease in total peripheral resistance in the body results during ALC when compared to leg cycling or arm cycling alone. The decrease in resistance reduces the stress or workload on the myocardium and skeletal muscles of the body.

Hoffman, Kassay, Zeni, and Crawford (18) attempted to determine the influence of muscle mass on the oxygen cost of exercise. The subjects of the study performed tests of arm-only exercise, leg cycling, and combined arm and leg exercise on a Schwinn Airdyne cycle. Each subject performed all three modalities on the cycle using a discontinuous protocol consisting of four-minute stages and two-minute rest periods. Heart rate and VO_2 were continuously measured during the arm, leg, and combined arm and leg cycling sessions. They concluded that increasing the muscle mass used during exercise increases the VO_2 for a given external output. However, the researchers expected the additional VO_2 resulting from incorporation of the upper body in the exercise would be higher than measured (18). It is important to note that the expected VO_2 was extrapolated from the summation of leg cycling and arm cycling. The researchers found that the VO_2 during combined arm and leg cycling were higher at specified blood lactate concentrations and RPE values than those during leg cycling. Thus, the researchers concluded that utilization of "muscle mass larger than that used during leg cycling should allow a greater cardiorespiratory effect if training intensity is established by RPE or blood lactate concentration" (18).

The Heart Rate-Oxygen Consumption Relationship

The HR-VO_2 relationship has received much attention in that the two variables have been shown to be linearly related during dynamic exercise. Heart rate increases linearly with exercise intensity and VO_2 in healthy individuals due to the increased demand for oxygenated blood by the working muscle tissues. Such increases are related to the age and fitness level of the individual, the type of activity performed, the presence or absence of cardiovascular disease, and other factors such as temperature. The HR-VO_2 relationship is commonly used to predict the HR_{max} and VO_{2max} of individuals when maximal exercise testing is not feasible (5).

Berry, Camala, Berry, and Davis (7) compared aerobic dance with the arms below the level of the head (BELOW), aerobic dance with the arms above the level of the head (ABOVE), and treadmill running to compare the hemodynamic response and sympathetic nervous system activity responses between the three activities. Nine female subjects with a mean age of 25.6 ± 4.6 yr, performed each of the three submaximal modalities during different visits to the laboratory. The ABOVE and BELOW routines consisted of the same leg movements performed while watching a videotaped routine. The ABOVE routine required that subjects perform dynamic arm movements above the head for 15 minutes during the 25-minute routine. Core temperature, blood pressure response, heart rate response, and gas exchange variables were determined for each modality. Based on regression of HR on VO_2 responses for the three modalities, there were no significant differences in the slopes of the three regression lines. The results indicate that the HR responses of aerobic dance is similar to that of treadmill running at an intensity of 50% of VO_{2max} (7). The investigators suggest that aerobic dance elicits similar cardiovascular responses to treadmill running and is as effective a training modality as treadmill running (7).

Summary

The question of whether CA induces benefits to the physiological functioning of young women has not been fully determined. A recent study conducted at the University of Wisconsin-La Crosse attempted to determine the heart rate response to CA in older male and female chair aerobic participants (17). Results demonstrated that the heart rate was responsive to exercise performed while seated in a chair. The use of CA in many settings is on the rise; therefore, research conducted to determine the VO_2 cost of CA in relation to the VO_{2max} of young women who participate in such form of activity would provide useful information to health clubs, rehabilitation programs, aerobics instructors, and participants. Because a large portion of the America population is sedentary, an exercise modality such as CA would provide an excellent means to get people moving in a safe, fun, and effective manner. Chair aerobics is a low-impact exercise modality that could replace high-impact activities such as running or high-impact dance aerobics on some days of the week to reduce the risk of injuries. The determination of the HR–VO_2 relationship of CA in females ages 18-30 years may be useful in determining whether or not it is an appropriate means of increasing cardiorespiratory fitness. Measuring the HR-VO_2 relationship during ALC to peak exertion would provide a means of comparing the relationship and intensity of CA to an effective modality such as ALC which involves the use of large muscle groups in a rhythmic manner.

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