

ABSTRACT

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Eleven untrained female Ss were studied to determine if water aerobics would elicit cardiorespiratory and body composition changes similar to those elicited by aerobic dance. The Ss ranged in age from 18 to 22 yr and included 4 from an aerobic dance (AD) class, 4 from a water aerobics (WA) class, and 3 from a bowling class used as a control group. Both the WA and AD groups trained 4 d/wk, 40 min/session for 7 wk. All Ss were given pre-(T₁) and post-(T₂) volitional max treadmill tests using the Modified Astrand Protocol. A target HR based on 75% of the max HR value attained on the initial max test was assigned. Training HR's were monitored and recorded daily. The AD and WA groups worked at an average intensity of 78% and 71% of maximal HR, respectively. An independent t-test indicated that training HR's of the WA group were sig (p < .05) lower than those of the AD group. An ANCOVA with repeated measures showed no sig (p > .05) differences in: body weight, % body fat, Max $\dot{V}O_2$ (L.min.⁻¹ and ml.kg.min.⁻¹), treadmill run time, max $\dot{V}E$, and heart rate among groups at the post-test. These findings indicated that no differential changes occurred in the above variables as a result of the 7 wk training period. It was concluded that, in the present study, neither WA nor AD were effective exercise modes for improving cardiovascular fitness or body composition. Exercise in water may elicit a lower HR response than training on land due to physiologic adaptations to exercise in this medium.

TRAINING EFFECTS OF WATER AEROBICS
COMPARED TO AEROBIC DANCE

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In Partial Fulfillment
of the Requirements for the
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CHAPTER I

INTRODUCTION

There is little question that proper, regular exercise is a significant factor in reducing the incidence of cardiovascular disease, obesity, and other disease states prevalent in the United States today (Pollock, Wilmore, & Fox, 1978; Thomas, Lee, Franks, & Paffenbarger, 1981). As members of American society have become increasingly aware of the health benefits of exercise, they have begun to adopt various forms of activity in hopes of improving physical fitness and health.

While well established activities such as jogging, swimming, walking, bicycling, and cross country skiing have experienced a resurgence, new, alternative forms of exercise such as aerobic dance have captured the interest of many Americans. In the early 1970's, Jackie Sorenson developed and actively promoted aerobic dance (Schuster, 1979). This is a movement form which incorporates various dance steps and other whole body movements including running, walking, and skipping (Ibanugo & Gutin, 1977; Foster, 1975) and which utilizes the same basic training principles of frequency, intensity, and duration as any aerobic training program should (American College of Sports Medicine, 1978; Ibanugo & Gutin, 1977). Several alternative forms of dance exercise have developed from the aerobic dance concept. These include Jazzercise, low impact aerobics, and water aerobics or aquacize.

Bruno Balke, retired professor emeritus of physiology and education at the University of Wisconsin explained much of the reason for the

popularity of aerobic dance type activities:

...one of the oldest and most popular forms of exercise in all societies is dancing. With its many varieties and forms, dancing is always movement par excellence.... Although dance routines of various ethnic groups may be quite different from each other, they have in common the enjoyment and love of expressing oneself through body movements. The demands on the heart and lungs, and the high energy turnover are seldom fully realized in the enjoyment of dancing. Like jogging and other endurance exercise, dancing uses fat as the main energy source, thus making it helpful in weight control (Balke, 1983, p.13).

Furthermore, aerobic dance activities allow the inexperienced participant to perform a variety of dance routines and to do so in a relaxed, noncompetitive environment.

Water aerobics is a special form of aerobic dance exercise which is performed in the water and which has been gaining in popularity over the past several years. While water aerobics shares many of the same benefits as aerobic dance, this form of activity offers some additional advantages. Water has a buoyant, cushioning effect which can protect weight-bearing joints, water has a cooling, invigorating effect which may make exercise in this medium more comfortable for some, and work can be done against the resistance of the water to tone and condition muscles (Davis, 1986; deWette & Wood, 1983; Davis, 1986). Researchers who have studied exercise in water have noted some unique physiologic adaptations to exercise in this medium including a lowering of training heart rate (McArdle et al., 1971).

Purpose of the Study

The purpose of this study was to compare the physiological effects of a water aerobics program to those of an aerobic dance program for women.

Need for the Study

Though water aerobics is an activity which is rapidly gaining popularity, very little has been published in the research literature about its effects on fitness levels. Since it is a form of aerobic exercise, its effects on cardiorespiratory fitness and on body composition need to be studied.

In contrast, aerobic dance, the forerunner of water aerobics, has been aggressively researched over the past several years. A number of researchers have established that aerobic dance does provide similar training effects as other endurance type activities which repetitively use large muscle groups (Cearly, Moffat, & Knutzen, 1984; Dowdy, Cureton, DuVal, & Outs, 1985; Foster, 1975; Ibanugo & Gutin, 1977; Johnson, Berg, & Latin, 1984; Milburn & Butts, 1983; Vaccaro & Clinton, 1981). It would be of benefit to individuals who are developing, teaching, and participating in water aerobics to know how this activity compares to aerobic dance with respect to improvement of cardiorespiratory endurance and alteration of body composition.

Hypotheses

The null hypotheses for this study were: (1) there is no significant difference between the effects of a water aerobics program and the effects of an aerobic dance program on cardiovascular fitness of women; and, (2) there is no significant difference between the effects of a water aerobics program and an aerobic dance program on body composition of women. The rejection criterion used for this study was the 0.05 level of significance.

Delimitations

Delimitations of this study were:

- (1) The subjects were untrained female volunteers who were enrolled in Physical Education classes at the University of Wisconsin - La Crosse, during Fall Semester, 1986. Each subject had an initial max $\dot{V}O_2$ of 45.0 ml.kg.min.⁻¹ or less.
- (2) The study was conducted over a seven week period.
- (3) Each subject had to attend 90 percent of the training sessions and had to refrain from participation in any other regular activity during the study.
- (4) Subjects had just two components of fitness measured: cardiovascular fitness (max $\dot{V}O_2$, max $\dot{V}E$, maximal heart rate, and treadmill time) and percent body fat (hydrostatic weighing).
- (5) Smokers were excluded from the study.

Limitations

Possible limitations of this study were:

- (1) Volunteers were used rather than randomly selected groups of subjects.
- (2) A certain amount of learning occurs when starting aerobic dance and water aerobics programs which could influence training effect.
- (3) Motivation level of subjects could not be completely controlled.
- (4) Diet was not controlled although subjects were encouraged not to alter dietary intake during the course of the study.
- (5) A small number of subjects was included in each group.

Definitions of Terms

The following terms were defined in this study:

Aerobic Dance - a movement form which incorporates various dance steps and other whole body movements including running, walking, and skipping and which uses the basic training principles for aerobic activity.

Aerobic Exercise - submaximal exercise that involves repetitive contraction of large muscle groups and requires oxygen for energy substrate metabolism; this form of exercise enhances the capacity of the central circulation to deliver blood to the tissues and improves the ability of specific muscles to consume oxygen.

Body Fat - the storage form of energy in the human body which accumulates mainly in adipose tissue but also in body organs and

systems. While adipose fat is altered by dietary intake and physical activity, essential fat, found in bone marrow, around vital organs, and throughout the central nervous system is necessary for normal physiologic function and is relatively stable. In this study, body fat content was estimated from body density which was measured by hydrostatic weighing. The Brozek equation (Brozek et al., 1963) was used in making this estimation.

Cardiovascular Fitness - the ability of the cardiorespiratory system to take in and transport adequate amounts of oxygen to large groups of working muscles thus allowing them to perform activity such as water aerobics or aerobic dancing over long periods of time. Max $\dot{V}O_2$ was considered an indicator of cardiovascular fitness.

Control Group - the group which received only the pre-test and post-test with no intervening treatment. This group consisted of members of a bowling class.

Experimental Groups - the two groups which received both pre- and post-tests and the treatment of either a seven week aerobic dance program or a seven week water aerobics program. Experimental groups trained four days per week for 45 minutes. Each training session included 25 minutes of aerobic activity at 75 percent of maximal heart rate achieved during a maximal treadmill test.

Maximal Heart Rate - the highest heart rate which a subject achieves at or near max $\dot{V}O_2$ (Shepard, 1977). This was measured by counting the R to R intervals on a 15 second ECG strip which was taken at maximal workload.

Max $\dot{V}E$ - the maximal amount of air exchanged in a one minute

period at maximal workload.

Max $\dot{V}O_2$ - the maximal rate at which oxygen can be consumed; an indicator of aerobic capacity and cardiovascular fitness. This was measured by a treadmill test using a Modified Astrand Protocol (Pollock et al., 1978) and was expressed in both milliliters per kilogram of body weight (ml.kg.min.^{-1}) and in liters per minute (L.min.^{-1}).

Respiratory Exchange Ratio (R) - the ratio of the amount of carbon dioxide produced to the amount of oxygen consumed ($\dot{V}CO_2/\dot{V}O_2$). The Respiratory Exchange Ratio was considered an indicator of maximal effort when it reached a value of 1.00 or greater.

Training Effect - physiological adaptations which occur in response to work stress of a particular frequency, intensity, and duration. Max $\dot{V}O_2$ was used as a measure of training effect in this study.

Treadmill Run Time - a subject's total test time on the treadmill using a Modified Astrand Protocol from the start of the warm up through the maximal workload but not including the cool-down period.

Untrained - a female who had not participated in regular physical activity three months prior to the onset of the study and who had a max $\dot{V}O_2$ value of $45 \text{ ml.kg.min.}^{-1}$ or less.

Water Aerobics - a form of exercise performed in water to music which involves the continuous performance of various dance steps, calisthenics, and various other whole body movements such as jogging, jumping, skipping, hopping, and kicking.

CHAPTER II
REVIEW OF RELATED LITERATURE

Introduction

The review of the literature is divided into four parts. The first part is a discussion of cardiovascular fitness; the second part, a review of body density, hydrostatic weighing and determination of percent body fat; the third part, a review of literature related to aerobic dance; and the final part, a review of literature related to exercise in water.

Cardiovascular Fitness

Definition of Cardiovascular Fitness

Cardiorespiratory endurance is defined by Fox and Mathews (1981) to be:

...the ability of the heart and lungs to take in and transport adequate amounts of oxygen to the working muscles, allowing activities that involve large muscle masses to be performed over a long period of time (p. 634).

Most physiologists consider cardiorespiratory endurance to be an important indicator of general fitness (Foster, 1975; Katch & McArdle, 1977; Pollock et al., 1978; Shepard, 1977).

Measurement of Maximal Oxygen Uptake

Maximal oxygen uptake, the maximal rate at which an individual can consume oxygen, is generally accepted as the best physiologic indicator of

cardiorespiratory fitness (Fox & Mathews, 1981; McArdle, Katch, & Katch, 1981; Pollock et al., 1978; Shepard, 1977). Though maximal testing is not appropriate in all cases and for all populations, it is particularly recommended for athletic or occupational groups who must perform tasks at near maximal effort. This helps to ensure that an individual stresses the system to an appropriate degree and adapts well physiologically to a training regimen (Pollock et al., 1978).

Treadmill walking or running is one of the most frequently used exercise modes in determining $\dot{V}O_2$ (Pollock et al., 1978). Reasons for this are that treadmill tests tend to produce higher values for $\dot{V}O_2$ than do other tests because of the great amount of active muscle mass used during this type of activity (Fox & Mathews, 1981). Also, other types of activities such as bicycling are more likely to lead to localized muscle fatigue before $\dot{V}O_2$ is reached (Andersen, Shepard, Denolin, Varnaukas, & Masironi, 1971; Fox & Mathews, 1981; Shepard, 1977). Finally, walking and running are activities with which everyone is familiar. Results of other tests may be more influenced by prior training and skill of the individual than are results of treadmill tests (Andersen et al., 1971; Shepard, 1977).

The test protocol used in any given treadmill test depends upon the person being tested and on the preference of the test administrator. Pollock et al. (1976) considered the following guidelines in evaluating treadmill protocols.

- (1) Tests should be graded with an initial workload not exceeding two to three and one half METS. An exception to this would be if the individual being tested was of low risk and the test was not being

used for diagnostic purposes. In this case, the initial workload could exceed the above recommendation.

- (2) Progressive increases in workload should not exceed one MET per increase in increment for high-risk individuals and two to three METS for low risk individuals.
- (3) For continuous tests, each workload should be performed at least one minute before increasing to the next workload.
- (4) The initial phase of recovery should be with the individual in the supine position or continuing to exercise at a very low level of work.

When applying these guidelines to the Modified Astrand Protocol, Pollock et al. (1976) found that all of the stated guidelines were met, but that a higher MET level than was recommended was achieved during the initial workload. Therefore, this protocol is appropriately used only when testing healthy, low risk individuals.

Though different exercise modes and protocols may be used in testing for maximal oxygen consumption, the same criteria are generally used to determine if an individual has reached max $\dot{V}O_2$ during a test. These criteria include: a leveling off or decrease in $\dot{V}O_2$ with increasing workloads, attainment of age predicted maximum heart rate, a respiratory exchange ratio (R) greater than 1.00, blood lactate levels of 70 or 80 mg. per 100 ml. or higher, and volitional exhaustion (Astrand & Rodahl, 1986; McArdle, Katch, & Katch, 1981).

Cardiovascular Fitness Training

The American College of Sports Medicine (1978) has made recommendations for the quantity and quality of exercise for developing

and maintaining cardiorespiratory fitness and optimal body composition. It is suggested that activities which use large muscle groups, which are rhythmical and aerobic in nature, and which can be maintained for prolonged periods of time are best for enhancing cardiorespiratory endurance. Such activities should be done at an intensity of 65 to 90 percent of maximal heart rate or 50 to 85 percent of max $\dot{V}O_2$. Duration should be 15 to 60 minutes of continuous or discontinuous aerobic activity. Lower intensity activity should be conducted over a longer period of time. These activities should be conducted at a frequency of three to five days per week. The rate of progression should be determined by conditioning effect which allows the individual to increase total work done per session. The most significant training effects may be observed during the first six to eight weeks of an exercise program.

A number of researchers have studied the question of appropriate frequency (Coffman & Timson, 1984, Cearly, Moffat, & Knutzen, 1984; Gettman, Pollock, Durstine, Ayres, & Linnerud, 1976; Jackson, Sharkey, & Johnston, 1968), intensity (Bhambhani & Singh, 1985; Edwards, 1974; Faria, 1970; Fox & Mathews, 1981; McArdle, et al., 1981; Sharkey, 1970; Sharkey & Holleman, 1967), and duration (Davies & Knibbs, 1971; Fox & Mathews, 1981; McArdle et al., 1981; Pollock et al. 1978; Shepard, 1968). Results of such research have, in general, supported the recommendations of the American College of Sports Medicine (1978).

Much training research has been done with male subjects. Results of studies done with males have shown that they respond similarly to training as females do. Thus, conclusions drawn from studies involving

males seem to be applicable to females as well (Cunningham & Hill, 1975; Fox & Mathews, 1981; Pedersen & Jorgensen, 1978).

Frequency. Though the American College of Sports Medicine (1978) recommends an exercise frequency of three to five times per week, researchers have debated and continue to question whether more or less frequent participation in activity is of the same or equal benefit. It is generally accepted that participation in activity less than two days per week does not promote adequate change in $\dot{V}O_2$ max (American College of Sports Medicine, 1978; Pollock, Cureton & Greninger, 1969).

Pollock et al. (1969) studied the effects of a two day per week versus a four day per week training program on working capacity, cardiovascular function, and body composition of adult men. Exercise sessions were 30 minutes in duration and consisted of continuous walking, jogging, or running. The two day per week group (Group I) showed an increase in max $\dot{V}O_2$ from 3.030 L.min.⁻¹ to 3.531 L.min.⁻¹; this was equal to a 17% increase. The four day per week group (Group II) showed an increase from 2.903 L.min.⁻¹ to 3.7521 L.min.⁻¹; this was a 35% increase. Body composition values remained relatively constant for Group I. For Group II, total body weight decreased by 2.9 kg. and percent body fat decreased by 1.0%. Based on these results, the authors (Pollock et al., 1969) concluded that the range for improvement in variables measured was significantly greater for a four day per week program than for a two day per week program and that improvements were manifested in accordance with frequency of participation.

A number of other researchers (Coffman & Timson, 1984; Gearly et al., 1984; Pollock, Ward, Ayres, & Linnerud, 1977; Jackson, Sharkey, &

Johnston, 1968) supported the contention that participation in exercise three to five day per week is most effective for promoting cardiovascular improvement.

Gettman et al. (1976) studied the physiological responses of males to running programs of one, three, and five day per week frequencies. Training sessions lasted for 30 minutes, were conducted at 85 to 90 percent maximum heart rate, and continued for 20 weeks. Improvements in $\dot{V}O_2$ for the one, three, and five day per week training groups were eight, 13, and 17 percent, respectively.

Cearly et al. (1984) compared the effects of two- and three- day per week aerobic dance programs on maximal oxygen uptake. Training sessions for the two groups were identical; aerobic dance began with 15 minutes of continuous dance routines at an intensity of 75% of maximal heart rate and progressed to 30 minutes by the end of the sixth week of training. Training sessions continued for 10 weeks. Max $\dot{V}O_2$ increased from 36.9 ± 4.61 ml.kg.min.⁻¹ to 38.7 ± 5.96 ml.kg.min.⁻¹ for the group training twice per week and from 40.1 ± 4.78 to 44.5 ± 6.03 ml.kg.min.⁻¹ for the group training three times per week. Treadmill run time to exhaustion was also found to be significantly greater for those training three as compared to those training two days per week. The authors concluded that cardiorespiratory fitness does appear to improve in direct proportion to the frequency of training and that aerobic dance training sessions should be conducted at least three days per week.

Coffman and Timson (1984) supported the idea that two day per week aerobic dance training may be of less than adequate frequency to promote improvements in cardiorespiratory endurance. The researchers found no

significant difference in max $\dot{V}O_2$ from pre- to post-test for aerobic dancers training twice per week. Max $\dot{V}O_2$ was $33.5 \text{ ml.kg.min.}^{-1} \pm 3.1$ at pre-test and $34.4 \text{ ml.kg.min.}^{-1} \pm 2.2$ at post-test.

Though a number of studies seem to indicate that an increased frequency of training will promote greater cardiorespiratory benefit, other studies show that more frequent training may not necessarily be better (Fox, Bartels, Billings, O'Brien, Bason, & Mathews, 1975; Johnson, Berg, & Latin, 1984; Jackson et al., 1968).

Fox et al. (1975) compared training effects of both seven and 13 week interval training programs for untrained college age males. Training frequencies were either two or four days per week. Results showed that all groups improved significantly in max $\dot{V}O_2$. Maximal heart rate was found to decrease significantly with training within groups. However, no significant difference was noted between change in maximal heart rate and training frequency. It was concluded that change in max $\dot{V}O_2$ was not related to frequency and duration of training and that a decrease in maximal heart rate following training was independent of both training frequency and duration (Fox et al., 1975). While these results appear to contradict those of Pollock et al (1969), it should be noted that average age of subjects in the Pollock (1969) study was 32.5 years and average max $\dot{V}O_2$ of subjects in that study was approximately 17 percent lower than that of subjects in the study by Fox et al. (1975). It is generally accepted that change in max $\dot{V}O_2$ is inversely related to subjects' initial max $\dot{V}O_2$ and may improve more slowly with increasing age (American College of Sports Medicine, 1978; Cearly et al., 1984;

Fox et al., 1975). This may explain differences in results and conclusions of these studies.

Jackson et al. (1968) supported the idea that optimal frequency of exercise participation required to elicit changes in physical fitness is dependent upon the age and initial fitness level of subjects involved as well as the intensity and duration of a training regime. These researchers (Jackson et al., 1968) trained 20 healthy male college students who rated either poor or very poor on the fitness scale suggested for the Balke test (Consolazio, Johnson, & Pegera, 1963). Subjects trained at frequencies of one, two, three, or five days per week. Training consisted of treadmill running at seven miles per hour for 10 minutes. Final endurance scores showed that two-, three-, and five-day per week groups all increased to about the seven percent grade on the treadmill. It was concluded that, considering initial fitness level of the subjects, training two or three times per week may have been as beneficial as training five days per week. Similarly, Johnson et al. (1984) found both two- and three-day per week aerobic dance programs to be effective in producing improvements in cardiorespiratory fitness in unfit females. Percent change in max $\dot{V}O_2$ was 11.1 percent for those training two times per week and 9.31 percent for those training three times per week. The greater percent changes in the two time per week group were thought to reflect their lower initial max $\dot{V}O_2$ (3 ml.kg.min.⁻¹ lower) and higher level of body fat (7.1 percentage points higher).

The American College of Sports Medicine (1978) in its position statement on the recommended quantity and quality of exercise for developing and maintaining fitness in healthy adults has proposed that:

The amount of improvement in $\dot{V}O_2$ max tends to plateau when frequency of training is increased above three days per week. For the non-athlete, there is not enough information available at this time to speculate on the value of added improvement found in programs that are conducted more than five days per week. Participation of less than two days per week does not show an adequate change in $\dot{V}O_2$ max. (p. vii)

The American College of Sports Medicine (1978) has emphasized that a high frequency of exercise, and especially weight bearing exercise, is associated with increased incidence of injury. Thus, caution should be taken when recommending type and frequency of activity for the beginning exerciser. Research has shown that exercise performed more than three days per week for longer than 30 minutes per session may be associated with increased incidence of foot, leg, and knee injury.

In determining optimal frequency of training, the guidelines established by the American College of Sports Medicine (1978) are generally accepted as appropriate. Factors to consider in establishing a training program include age, sex, and initial fitness level of subjects as well as intensity and duration of training (Jackson, et al., 1968).

Intensity. Training induced physiologic changes depend primarily on the intensity of an overload (McArdle et al., 1981; Shepard, 1968).

Intensity of exercise is usually assigned based on the relative stress placed on a person's physiologic systems and is usually described as a percentage of such maximal functions as max $\dot{V}O_2$ or maximal heart rate

(McArdle et al., 1981). Aerobic capacity will improve if exercise is of sufficient intensity to increase heart rate or $\dot{V}O_2$ beyond a certain percentage of maximal values. This percentage is considered a threshold level below which training improvements are thought not to significantly occur (American College of Sports Medicine, 1978; McArdle et al., 1981; Shepard, 1977). Threshold level varies among individuals and is related to such factors as age, sex, and initial fitness level (Fox & Mathews, 1981; McArdle et al., 1981).

McArdle et al. (1981) have stated that while the establishment of training intensity from measures of oxygen consumption is highly accurate, it is impractical without sophisticated equipment. For this reason, heart rate is usually used as a means of classifying exercise in terms of relative intensity and as a means of developing training protocols (Fox & Mathews, 1981; McArdle et al., 1981). It is generally accepted that percent of max $\dot{V}O_2$ and percent of maximal heart rate are related in a predictable way. The error in estimating max $\dot{V}O_2$ from percent maximal heart rate, or vice versa, is approximately plus or minus eight percent (McArdle et al., 1981). Therefore, by monitoring just heart rate, it is possible to estimate percent max $\dot{V}O_2$.

A minimal stimulus which will provide improvements in max $\dot{V}O_2$ is thought to be approximately 60 percent of maximal heart rate reserve (American College of Sports Medicine, 1978; Fox & Mathews, 1981). This is represented by a heart rate of approximately 130 to 140 beats per minute in young individuals (American College of Sports Medicine, 1978; McArdle et al., 1981) and can be as low as 110 to 120 beats per minute in older individuals (American College of Sports Medicine, 1978).

While researchers generally agree that there is a minimal threshold intensity below which a training effect will not occur, a number of researchers have hypothesized that this low threshold level may not promote as great an increase in physical work capacity as higher intensity training which stresses the cardiorespiratory system to a greater degree (Bhambhani & Singh, 1985; Edwards, 1974; Faria, 1970; Sharkey, 1970; Sharkey & Holleman, 1967).

Faria (1970) studied cardiorespiratory adaptations to four weeks of training at heart rates of either 120 to 130, 140 to 150, or 160 to 170 beats per minute. Training sessions occurred five days per week and consisted of bench stepping until assigned heart rates were achieved. Subjects were untrained, male university students with a mean age of 20.5 years. Results showed that for all groups, heart rate per minute of work decreased. This was thought to indicate that all groups experienced a training effect. Analysis of covariance indicated that the imposed treatments had significantly different effects upon the final performances of the four groups. Training to a heart rate of 140 to 150 or 160 to 170 beats per minute produced significantly greater effects on ability to perform work than did training to a heart rate of 120 to 130 beats per minute. No significant difference existed between training at 140 to 150 or 160 to 170 beats per minute. It was concluded that the training threshold for optimal improvement in cardiorespiratory fitness for the subjects of this study was somewhere below 140 beats per minute and that training at an intensity of greater than 150 beats per minute may not have been necessary to improve physical working capacity.

The author (Faria, 1970) concluded that training effect is related to but not proportional to intensity of training.

Sharkey and Holleman (1967) trained college age males at heart rates of either 120, 150, or 180 beats per minute. Training consisted of walking on a treadmill for 10 minutes per day, three days per week for six weeks. Results showed that the group which trained at a heart rate of 180 beats per minute improved to the greatest degree for both tests. The group which trained at 150 beats per minute was also found to improve significantly more than either the group which trained at 120 beats per minute or than a non-exercising control group. Sharkey and Holleman (1967) concluded that intense activity is necessary to bring about physiologic changes associated with cardiorespiratory endurance. Training at a heart rate of greater than 150 beats per minute was probably necessary to bring about desired cardiorespiratory adaptations.

Edwards (1974) questioned whether training at 70 percent of maximal heart rate (approximately 150 beats per minute) actually was a threshold for training changes in normal sedentary adults. Twelve sedentary college women participated in a treadmill training program for 15 minutes daily for four weeks. Six subjects trained at a heart rate of 125 beats per minute (Group I) and six subjects trained at a heart rate of 145 beats per minute (Group II). Post-training comparison of the two groups showed a trend toward greater cardiorespiratory improvements with a higher level of training. However, this greater improvement was not confirmed by an independent t-test for two groups. A significant difference for the two training groups was not noted when comparing

changes. Percent gains in max $\dot{V}O_2$ for Group I was 25.8 percent and for group II was 34.3 percent.

Edwards (1974) concluded that training at a higher workload could produce training effects of larger magnitude than training at a lower workload. However, a low threshold stimulus approximately equal to a heart rate of 120 beats per minute seemed to induce cardiorespiratory benefits for the sedentary subjects in this study. Cooper (1966) and Kilbom (1971) found slightly higher workloads of 50 to 60 percent of max $\dot{V}O_2$ (heart rates of approximately 135 beats per minute) to elicit an adequate training stimulus for untrained, healthy females. Results of these studies, and particularly of Edward's (1974) study seem to indicate that while it may be appropriate for very fit athletes to train at high heart rates, this practice may not be necessary for all people and particularly for those who have been sedentary or who are just starting a fitness program due to medical reasons.

While it appears that there is a minimal training threshold below which a training effect will not occur, there may also be a ceiling threshold above which no further benefits are noted (McArdle, 1981). This ceiling threshold is thought to be around 85 percent of max $\dot{V}O_2$ which corresponds to 90 percent of maximal heart rate (McArdle, 1981). Though an exact ceiling threshold has not been established, studies have supported the existence of an upper training intensity above which no added cardiorespiratory benefit is derived. Eddy et al. (1976) found no significant difference in the improvement in max $\dot{V}O_2$ between a group of subjects that trained continuously at 70 percent of max $\dot{V}O_2$ and a group that trained intermittently at 100 percent of max $\dot{V}O_2$. Faria (1970)

observed no significant difference between training effects elicited by training at 140 to 150 beats per minute or training at 160 to 170 beats per minute.

Bhambhani and Singh (1985) noted similar increases in max $\dot{V}O_2$ among subjects of both fit and unfit categories who either interval trained at 100 percent of max $\dot{V}O_2$, continuously trained at an oxygen uptake that was 10 percent above the oxygen uptake when $\dot{V}E$ to $\dot{V}O_2$ ratio reached a minimum or continuously trained at an oxygen uptake that was mid-way between the oxygen uptake when the $\dot{V}E$ to $\dot{V}O_2$ ratio reached either its minimum or maximum. The $\dot{V}E$ to $\dot{V}O_2$ ratio (ventilatory efficiency) is considered an index of the economics of ventilation. A $\dot{V}E$ to $\dot{V}O_2$ ratio which reaches a minimum is considered an indicator of the onset of metabolic acidoses and therefore of an exercise intensity which metabolically stresses an individual (Bhambhani & Singh, 1985).

Though researchers generally agree with guidelines of the American College of Sports Medicine (1978) that intensity of training should be 60% to 90% of maximum heart rate, much of the research on exercise intensity does appear to be conflicting. Either an upper or lower limit in training threshold is probably influenced by such factors as age, initial exercise capacity, and state of training of any individual (McArdle, 1981; Pollock, 1973). Furthermore, Edwards (1974) cautions that comparison of results of one training study to results of another is often inappropriate because of the uniqueness of any study population and the diversity of methodology in fitness testing and training used from one study to another.

Duration. Though a threshold intensity of exercise for optimal cardiorespiratory improvement has been suggested, a threshold duration has not been identified. McArdle et al. (1981) indicated that such a threshold would probably be dependent on a number of factors including total work done, exercise intensity, training frequency, and initial fitness level. The American College of Sports Medicine (1978) and Pollock et al. (1978) especially emphasize that the total amount of work (energy cost) accomplished in a training program is an important factor in improvement of fitness.

A study done by Pollock et al. (1977) supported this notion. Males participated in either a fast-walking or jogging program for 20 weeks. Walkers exercised for 40 minutes four days per week; joggers exercised for 30 minutes three days per week. Total energy expenditure of the two programs was similar, thus the lower intensity of the walking program was offset by increased duration and frequency of training.

Though studies have shown improvement in aerobic capacity with moderate to high intensity training lasting only five to 15 minutes (Sharkey, 1970; Sharkey & Holleman, 1967), most researchers agree that 20 to 60 minutes of exercise per session is optimal (Fox & Mathews, 1981; McArdle et al., 1981; Pollock et al., 1978). Pollock et al. (1978) suggest that, in general, short duration programs of 10 to 15 minutes of moderate intensity exercise show significantly lower training effects than do training programs with a duration of 30 to 60 minutes.

Pollock et al. (1978) studied the effects of different training durations on maximum oxygen uptake of males who trained three days per

week for 20 weeks at an intensity of 85 to 90 percent of maximum heart rate range. Improvement in max $\dot{V}O_2$ was 8.5, 16.1, and 16.8 percent for 15, 30, and 45 minute duration groups, respectively. Results of this study seem to support the notion that improvement in cardiorespiratory fitness is directly related to duration of training given a certain training intensity.

Davies and Knibbs (1971) found intensity and duration to be interdependent variables which, together, influenced changes in max $\dot{V}O_2$ with training. Twenty eight males were trained at either 80, 50, or 30% of max $\dot{V}O_2$ for either 20, 10, or five minutes; either five, three, or one times per week. The subjects trained for eight weeks. Results showed that no subject who exercised at or below 50 percent of max $\dot{V}O_2$ improved in this variable. Among subjects who exercised at 80% of max $\dot{V}O_2$ improvement averaged just 2 ml.kg.min.⁻¹. However, for subjects who exercised for 20 minutes duration at this intensity, an average increase of 9 ml.kg.min.⁻¹, a 19 percent increase, was noted.

Shepard (1968) trained 39 sedentary subjects using one of three treadmill protocols which demanded exercise at different intensities: 39% of aerobic power, 75% of aerobic power, or 96% of aerobic power. Exercise sessions were either one, three, or five times per week and were maintained either five, 10, or 20 minutes per session. Results showed that training effects were greatest with exercise at 96% rather than at 75 or 39% of aerobic power. Also, exercise done five rather than three times per week and 20 rather than 10 or 5 minutes per session was found to be most beneficial. The most effective regime involved the combination of maximum frequency, intensity, and duration.

Research generally gives support to the practice of low-to-moderate intensity, long duration activity. This type of activity is recommended because "total fitness" seems to be better attained through longer duration activity. Also, potential hazards such as injury and problems with compliance seem to be less with low rather than high intensity activity (American College of Sports Medicine, 1978; Fox & Mathews, 1981; Pollock et al., 1978).

Body Density and Percent Body Fat

Definition of Body Composition

The human body is considered to consist of a number of components including muscle, bone, fat, and water. The main concern in measurement of body density is distinguishing between fat and fat free or lean body mass (McArdle et al., 1981). According to the two component model, lean body mass consists of muscle, bone, body fluids, connective tissue and organs. The remainder of body tissue is fat and is categorized as either being essential or storage fat. Essential fat is found in bone marrow, the central nervous system, and in body organs. Essential fat stores are necessary for normal physiologic function. Storage fat consists of fat that accumulates in adipose tissue. Fatty tissue that surrounds internal organs and subcutaneous fat deposits are forms of storage fat (Katch & McArdle, 1977).

The composition of any individual appears to be influenced by a combination of factors including age, sex, physical activity, nutritional status, ethnic background, and body type (Lohman, 1984).

Measurement of Body Density and Percent Body Fat

The physical principle which serves as the basis of body composition evaluation is Archimedes' Principle. According to this principle of physics, when an object is either submerged or floating in water, it is bouyed up by a counterforce. This buoyant force helps support the submerged object against the downward pull of gravity. Therefore, an object seems to "lose weight" in water as compared to on land. When an object is submerged, its loss of weight in water is equal to the weight of the water it displaces (McArdle et al., 1981).

Body density is the characteristic actually measured by hydrostatic weighing. Density is defined as mass per unit volume :

$$D = \frac{M}{V}$$

where D = density (g/cc), M = mass (g), and V = volume (cc). Mass is determined by the amount of water displaced.

If body weight in air and underwater are measured and if residual volume is determined, body density can be computed using the following formula:

$$D_b = \frac{BW_{air}}{\frac{BW_{air} - BW_{H2O}}{DW} - VR}$$

where:

BW air - body weight in air

BW H2O - body weight in water

DW - water density at water temperature

VR - residual lung volume

(McArdle et al., 1981, p. 273)

Residual volume must be accounted for when doing hydrostatic weighing (Lohman, 1984). Residual volume is the amount of air remaining in the lungs after maximal exhalation and averages between 1.0 and 1.2 liters for women and 1.2 and 1.4 liters for men (McArdle et al., 1981). Body volume is considered the difference between body weight measured in air and weight measured during submersion in water. Failure to consider gas volumes will decrease a subject's underwater weight and will, therefore, result in an overestimation of body volume (Brooks & Fahey, 1984). Furthermore, differences in water density as determined by water temperature must be accounted for. The volume of one gram of water occupies exactly one cubic centimeter (cc) at a temperature of 4° C. A rise or fall in temperature causes a respective increase or decrease in density of water (McArdle et al., 1981). Failure to recognize changes in water density could result in either over or under estimation of body density.

Conversion of Body Density to Percent Body Fat

The formulas most often used to calculate percent body fat from body density are equations developed by Siri (1961) and Brozek, Grande, Anderson, and Keys (1963).

The equation by Siri (1961) is:

$$f = (4.95/D) - 4.4142$$

where f = proportion of fat and D = density. This equation is based on fat-free body density of 1.100 g.cc and fat density of 0.900 g.cc (Lohman, 1984).

The equation by Brozek et al. (1963) is:

$$f = (4.570/D) - 4.142$$

where f = proportion of fat. This equation is based on chemical composition of the reference man (Lohman, 1984).

Lohman (1984) stated that while density of any given subject can be measured precisely ($\pm 0.0025 \text{ g.cc}^{-1}$) and perhaps accurately, the interpretation of density of the human body as fat and fat-free percentages is the cause of a significant amount of variance. This can be attributed to a number of assumptions. These include the assumption that the densities of fat and lean components are actually known. Also, the assumptions that the densities of the components are relatively constant among individuals and that the density of individual tissues that make up the lean component (bone, muscle, etc.) are constant among and within individuals; their proportional contribution to the density of the lean component is assumed to remain constant. Finally, it is an assumption that the reference man is a good standard for all populations. That is, that any individual differs from the reference man only in the amount of depot fat.

Though determination of body density and percent body fat is considered the "gold standard" in measurement of body composition, the above assumptions must be recognized when using the technique.

Body Composition and Training

A number of researchers have investigated the effects of endurance activity on body composition (Dowdy et al., 1985; Gettman et al., 1976; Johnson et al., 1984; Pollock, Cureton, & Greninger, 1969; Vaccaro & Clinton, 1981). Most physiologists would agree that exercise training appears to result in moderate losses in total body weight, moderate to large losses in body fat, and small to moderate increases in lean body

weight. Wilmore (1983) has suggested that these alterations vary directly with frequency, intensity, and duration of an activity. McArdle et al. (1981) have stated that effective exercise modes for reducing body weight, body fat, skinfold thickness, and girth measurements include activities like walking, running, and bicycling. Such endurance activities which demand much metabolic energy expenditure are generally considered the most effective for reducing total body mass and fat weight while maintaining or increasing lean body weight (American College of Sports Medicine, 1978; Novak, Bierbaum, & Hellerowicz, 1973). A number of researchers have studied the effects of endurance activity on body composition (Dowdy et al., 1985; Gettman et al., 1976; Johnson et al. 1984; Pollock et al., 1969; Vaccaro & Clinton, 1981).

Wilmore et al. (1970) in a study of males age 17 to 59 years noted only small reductions in body fat among subjects who jogged three days per week for 10 weeks. Average distance run was 1.7 miles per day. Results of this study showed that reduction in percent body fat from pre-test values of 18.9% to post-test values of 17.8% represented a fat loss of 1.07 kg. Lean body weight did not change.

Pollock et al. (1969) specifically looked at the effect of frequency of training on body composition of men. Volunteer males, age 28 to 39 years exercised either two or four days per week. Exercise sessions consisted of 30 minutes of walking, jogging, or running. A group of eight sedentary men served as a control group. Body fat values tended to increase for the control group, remained the same for the group that exercised two times per week, and improved significantly for the group which exercised four times per week. For

the four time per week group, body weight decreased by 2.9 kg., percent body fat decreased by 1.0 percent, and the sum of six skinfold fat measures decreased by 23.6 mm. Between group analysis showed that improvements were manifested in accordance with frequency of participation in activity.

Gettman et al. (1976) assessed changes in body composition of males age 20 to 35 years who trained 30 minutes per day at 85 to 90 percent of max $\dot{V}O_2$ for 20 weeks. Subjects were placed into either a control, a one-day, three-day, or five-day per week training group. A general reduction in percent body fat occurred in all training groups, but only the reduction in the five-day per week group compared to the reduction in the control and one-day per week groups was significant. Body weight was not reduced in any of the treatment groups. Changes in body composition were found to be proportional to frequency of training. Results of this study support the idea that consistent reductions of body weight and of body fat generally occur with at least three days of training per week (McArdle et al., 1981; Pollock, 1973; Pollock et al., 1969). More frequent training may be even more effective (McArdle et al., 1981).

In addition to frequency of training, duration seems to have an effect on reduction of body fat (McArdle et al., 1981). Miles et al. (1976) studied the effects of different durations of physical training on body composition of males. Training consisted of walking and running for either 15, 30, or 45 minutes per workout. All three exercise groups significantly decreased in body fat, skinfold, and waist girth measurements. Body weight was significantly lowered for the 30 minute

group but remained essentially the same for the 15 minute group. When comparisons were made between the three groups, the 45 minute training group lost a greater percentage of body fat (from 13.2 % to 12.0 %) than either the 30 minute or 15 minute groups. These groups decreased body fat from 14.2 to 13.6 and 13.7 to 13.2 % fat, respectively. These results were attributed to the greater calorie-burning effect of longer duration exercise.

It is generally accepted that changes in body composition through exercise increase as frequency, intensity, and duration of training increase. This is most likely the result of added calorie stress provided by an increase in training (McArdle et al., 1981). It is generally recommended that exercise programs be conducted at least three days per week for a duration of 20 to 30 minutes per session if moderate or vigorous activities such as running, swimming, or bicycling are done. Forty to 60 minutes of activity is recommended for walking programs. Exercise sessions should be of sufficient intensity and duration to reach a threshold expenditure of 300 Kcals per session. This is considered a necessary level of caloric expenditure for reduction of total body mass and fat weight (American College of Sports Medicine, 1978; McArdle et al., 1981).

Aerobic Dance

Definition of Aerobic Dance

Aerobic dance is a choreographed routine of various types of dance steps combined with other whole body movements such as running, skipping, hopping, and jumping. This routine is performed continuously

to music (Dowdy et al., 1985; Foster, 1975). It is an activity which is usually performed by a group of people and, therefore, allows group support and camaraderie during exercise. Aerobic dance is a non-competitive activity which can be performed at low, medium, or high intensity (Ibanugo & Gutin, 1977). Thus, it is an activity which can be enjoyed by individuals of all skill and fitness levels.

Research on Aerobic Dance

Aerobic dance was developed and promoted by its originator, Jackie Sorenson, as an activity which could be useful in developing and maintaining cardiorespiratory endurance (Vaccaro & Clinton, 1981). Though the basic training principles of frequency, intensity, and duration which apply to other forms of endurance activity apply to aerobic dance as well, a number of researchers have questioned actual training effects of this form of activity (Cearly, Moffat, & Knutzen, 1984; Dowdy et al., 1985; Foster, 1975; Ibanugo & Gutin, 1977; Johnson, Berg, & Latin, 1984; Milburn & Butts, 1983; Vaccaro & Clinton, 1981). Generally, these researchers have agreed that aerobic dance does result in training effects similar to those of other forms of activity which involve repetitive use of large muscle groups and that aerobic dance can be an effective means of cardiorespiratory fitness training.

It appears that an average improvement in max $\dot{V}O_2$ as a result of aerobic dance training is approximately 10 percent. Stamford (1984) indicated that frequency, intensity, and duration are important determinants of results of any aerobic dance program. With respect to intensity, he suggested that heart rate should be elevated to between 70 percent and 85 percent of maximum level. Metcalf (1983) found that

heart rates of aerobic dancers stayed between 150 and 190 beats per minute during a 30 minute exercise period and averaged 73.5 percent of predicted maximum. Igbanugo and Gutin (1978) found that subjects performing high intensity aerobic dance achieved training heart rates that were above a critical threshold expressed as 60 percent of heart rate reserve. Below this critical threshold, improvements in cardiorespiratory fitness were thought not to occur.

Foster (1975) used $\dot{V}O_2$ as an indicator of exercise intensity. He found that mean total oxygen consumption for a group of aerobic dancers was $33.6 \text{ ml.kg.min.}^{-1}$ which was comparable to that of running at a 12 minute mile pace. The mean peak oxygen consumption of the dancers was $39.2 \text{ ml.kg.min.}^{-1}$ which was considered comparable to running a 9.5 minute mile pace. These mean oxygen consumptions represented 77 percent and 90 percent of the subjects' estimated max $\dot{V}O_2$ values respectively. An intensity of $29 \text{ ml.kg.min.}^{-1}$ was considered sufficient to elicit a training effect. These researchers (Foster, 1975; Igbanugo & Gutin, 1978; Metcalf, 1983; Stamford, 1984) concluded that aerobic dance could be performed at an intensity that would promote improvement in cardiorespiratory fitness.

With respect to frequency and duration of aerobic dance, Stamford (1984) suggested that 15 to 60 minutes of aerobic activity three to five times per week is best. Though most researchers agree that 15 to 60 minutes of aerobic dance is an appropriate duration of activity (American College of Sports Medicine, 1979), a number of individuals have questioned the appropriate frequency (Gearly et al., 1984; Coffman & Timson, 1984; Johnson et al., 1984) of aerobic dance training. As

discussed previously, Cearly et al. (1984) and Coffman and Timson (1984) both found three day per week aerobic dance programs to result in significantly greater improvements in $\max \dot{V}O_2$ than two day per week programs. In contrast, Johnson et al. (1984) noted significant changes in $\max \dot{V}O_2$ for both two and three day per week dance groups and noted no significant difference between groups. Though these results are somewhat conflicting, most researchers recommend aerobic training at a frequency of three to five days per week (American College of Sports Medicine, 1978).

Vaccaro and Clinton (1981) examined the effects of ten weeks of aerobic dance on the body composition and maximal oxygen uptake of ten women ages 19 to 27 years. The women participated in dance conditioning three days per week, 45 minutes per session. Body composition was assessed using hydrostatic weighing. $\max \dot{V}O_2$, $\max \dot{V}E$, and maximal heart rate were determined by a progressive treadmill test. All tests were administered before and after the ten weeks of training. Results showed a significant increase in $\max \dot{V}O_2$ following the training regimen; the average pre-test $\max \dot{V}O_2$ value was 31.11 ± 5.03 ml.kg.min.⁻¹ while the average post-test value was 38.24 ± 7.32 ml.kg.min.⁻¹. This represented a 10 percent change in $\max \dot{V}O_2$ following training. Percent fat from pre-training to post-training showed a slight increase from 26.57 percent to 27.20 percent, respectively. These researchers (Vaccaro & Clinton, 1981) concluded that aerobic dance appeared to provide sufficient cardiovascular stress to improve $\max \dot{V}O_2$. However, they stated that this form of activity probably did not provide the same degree of stress or promote the same amount of improvement in $\max \dot{V}O_2$ as

other modes of endurance activity such as running, bench stepping, or intermittent bicycling. Body composition did not appear to be favorably altered by the aerobic dance program.

Dowdy et al. (1985) studied the effects of aerobic dance on physical work capacity, cardiovascular function, and body composition of females age 25 to 44 years. Eighteen women participated in a 10 week aerobic dance training program. Training consisted of 45 minutes of aerobic dance performed three days per week at an intensity of 70 to 85 percent of heart rate reserve. Ten women served as sedentary controls. Results showed that max $\dot{V}E$, max $\dot{V}O_2$ ($L.min.^{-1}$ and $ml.kg.min.^{-1}$) and treadmill test time all increased significantly for the experimental group by eight percent, five to seven percent, and 16 percent, respectively. The control group showed no significant gains. Changes in body weight, body density, and percent fat, as determined by hydrostatic weighing were not significantly different in the experimental and control groups.

These researchers (Dowdy et al., 1985) concluded that aerobic dance could significantly improve physical work capacity and cardiovascular function. However, it was noted that changes in max $\dot{V}O_2$ and cardiorespiratory capacity were smaller than changes typically obtained with other modes of endurance training, and that aerobic dance did not appear to lead to significant changes in body weight or body composition. These conclusions were similar to those drawn by Vaccaro and Clinton (1981).

Milburn and Butts (1983) compared training effects of a seven week aerobic dance training program to those of a seven week jogging program.

Females age 18 to 29 years participated in either an aerobic dance, jogging, or bowling class which served as a control group. The joggers and dancers trained four days per week, 30 minutes per day at an intensity of approximately 83 to 84 percent of maximal heart rate. All subjects were pre- and post-tested using a maximal treadmill test.

Results of this study (Milburn & Butts, 1983) showed that both the joggers and dancers increased their ventilatory volumes by 9.4 and 8.4 percent, respectively, as a result of training. Small, but significant decreases in maximal heart rate of 2.9 beats per minute for the joggers and 2.8 beats per minute for the aerobic dancers were noted. Relative max $\dot{V}O_2$ increased by 8.2 percent for the joggers and by 10.2 percent for the aerobic dancers. There was no significant difference in these increases between the two training groups. Increases in treadmill run time were 14.4 percent and 20.7 percent for the joggers and dancers, respectively. No significant changes in body weight were noted for any group.

Results of this study (Milburn & Butts, 1983), in contrast to those of Vaccaro and Clinton (1981) and Dowdy et al. (1985), seemed to indicate that when jogging and aerobic dance programs were equated as much as possible, there was no difference in training effects. It was concluded that both jogging and aerobic dance could result in similar cardiorespiratory improvements if performed at similar frequencies, intensities, and durations (Milburn & Butts, 1983).

Cearly et al. (1984), in a study to determine effects of two and three day per week aerobic dance training of 10 week duration, also, found improvements in max $\dot{V}O_2$ resulting from aerobic dance training.

Improvements in max $\dot{V}O_2$ of dancers were found to be comparable to those noted by researchers using different modes of training (Burke, 1977; Eisenman & Golding, 1975; Magel, Faglia, McArdle, Gutin, Pechar & Katch, 1975; Shire, Avallone, Boileau, Lohman & Wirth, 1977). Mean max $\dot{V}O_2$ was 36.9 ml.kg.min.⁻¹ pre-test and 38.7 ml.kg.min.⁻¹ post-test for two day per week aerobic dancers and 40.1 ml.kg.min.⁻¹ pre-test and 44.5 ml.kg.min.⁻¹ post-test for three day per week dancers (Gearly et al., 1984). The increase in max $\dot{V}O_2$ for the latter group of dancers was approximately a 10.7% improvement.

As with evaluation of any type of training study, caution must be taken in comparing results of one aerobic dance training study with those of another study. Difference in study populations and their fitness levels, the structure of the aerobic dance programs, and testing procedures used must all be considered.

Water Aerobics

Definition of Water Aerobics

A relatively new and increasingly popular form of exercise which has evolved from aerobic dance is water aerobics. Water aerobics is exercise performed in water, to music, and involves the continuous performance of various dance steps, calisthenics, and other whole body movements such as jogging, jumping, skipping, and kicking. The same basic principles which apply to other forms of exercise apply to water aerobics as well.

Physical educators who have implemented water aerobics programs have noted some unique benefits of and applications for this activity. Because water has a buoyant, cushioning effect, weight-bearing joints,

ligaments, and internal organs are protected from jolting and ballistic impact (Davis, 1986; Share, 1983). Therefore, water aerobics can be a good alternative to jogging, aerobic dance, and other activities performed on land. This is especially true for people who have temporary or permanent physical limitations due to lack of prior physical activity, pregnancy, obesity, low back pain, or knee or ankle problems. Water aerobics may be appropriate for people recovering from orthopedic injury or surgery (deWette & Wood, 1983; Davis, 1986). Water aerobics is good for conditioning and toning muscles. Arms, legs, and torso can be used in either isolated or combined movement patterns to work against the resistance of the water. In addition, people may be more comfortable exercising in water than on land because water has a cooling effect. Finally, water aerobics is performed in a non-threatening, non-competitive environment. It is an activity which allows for socialization and camaraderie among its participants (deWette & Wood, 1983; Davis, 1986; Share, 1983).

Research on Exercise in Water

Though water aerobics is rapidly becoming a popular activity, the scientific literature investigating its training effects is surprisingly sparse. A number of investigators (Avellini, Shapiro, & Randolph, 1983; Craig & Dvorak, 1969; Denison, Wagner, Kingsby & West, 1972; McArdle, Magel, Lesmes, & Pechar, 1976; McMurray, Horvath, & Miles, 1983), however, have studied cardiorespiratory physical training in water as compared to on land.

Denison et al. (1972) contended that immersion in water exposes the body to hydrostatic, viscous, inertial, and thermal conditions which

could alter cardiorespiratory responses to exertion. They further hypothesized that the effects of these changes vary with posture, work load, type of limb movement, mean intrathoracic pressure, and water temperature.

Denison et al. (1972) measured respiratory gas exchange, end-tidal gas tension, alveolar ventilation, respiratory frequency, cardiac output, and pulse rate in four adult male subjects. Measurements were taken with subjects in air (18 to 22° C) and in water (35.0 to 35.5° C) while at rest and while performing mild and moderate exercise. Subjects exercised in a supine position by pedaling a cycle ergometer; they respired at eupnic pressures from the same breathing circuit throughout the study. The subjects showed no change in alveolar ventilation and a slight (10 percent) increase in pulse and cardiac output when exercising at oxygen uptakes of 0.2 to 2.1 L.min.⁻¹ in water and in air (Denison et al., 1972). The researchers (Denison et al., 1972) concluded that under circumstances studied, there were no important differences in cardiorespiratory response in air and in water. Similar findings have been reported by a number of researchers (Avellini et al. 1983; Craig & Dvorak, 1969; McArdle et al., 1976) who have compared exercise in air to exercise in thermoneutral water.

Craig and Dvorak (1969) compared exercise in air to exercise in water at 35, 30, and 25° C. Two subjects were studied: one was lean and the other was moderately obese. Pulse pressure, breathing frequency, $\dot{V}O_2$, $\dot{V}CO_2$, $\dot{V}E$, heart rate, and ear and skin temperatures were measured during the study. Subjects exercised on a battery generated bicycle ergometer which provided a constant workload independent of pedaling

speed when this speed was greater than 25 pedal revolutions per minute. The subjects pedaled at a rate of 30 revolutions per minute under all three test conditions. This pedal speed was quite slow so that energy output in water was not significantly greater than in air.

Results indicated that under all conditions, $\dot{V}O_2$ was linearly and directly related to any added external work load (Craig & Dvorak, 1969). Maximal oxygen uptake for a given load was found to be the same in air and in water of 30° C and 35° C but was .14 L.min.⁻¹ greater in 25° C water than under the other conditions. Ventilation seemed to be somewhat greater during work in 25° C water than under the other conditions, but when VE was plotted against $\dot{V}O_2$, no significant difference was noted. Respiratory frequency was slightly greater and tidal volume less in water than in air during added work loads but not during rest or during exercise without a load. Heart rate for a given $\dot{V}O_2$ averaged 10 beats per minute slower in 25° C water than in warmer water or in air. Ear temperature was found to be directly related to water temperature in the lean subject but not in the obese subject.

Craig and Dvorak (1969) concluded that the subjects functioned similarly in both 30° C and 35° C water. An increase in $\dot{V}O_2$ in cool water (25° C) may have been attributed to shivering or increased voluntary activity. They hypothesized that lower heart rate responses to exercise in water of lower temperatures may have been related to an increased venous return which is possibly secondary to the negative pressure breathing and support of the venous system by hydrostatic pressure. Temperature regulation, they concluded, was as much a function of individual thermoregulatory response as it was of

environmental temperature and qualitatively, thermal regulation seemed to be the same in water as it was in air.

McArdle et al. (1976) studied circulatory dynamics during exercise in water at 18, 25, and 33° C in comparison to exercise in air. Under each condition, oxygen consumption, cardiac output, stroke volume, and heart rate were measured at rest and during varying intensities of work. Work was performed on the air-water cycle ergometer described by Craig and Dvorak (1969).

McArdle and associates (1976) found that $\dot{V}O_2$ was similar in air and in water at 33° C. However, in 25 and 18° C water, the $\dot{V}O_2$ averaged 9.0 and 25.3 percent higher, respectively, than values observed in 33° C water. Heart rate and $\dot{V}O_2$ were found to be linearly related during work in air and in 33° C water, but heart rate was significantly lower for a given $\dot{V}O_2$ in 25° and 18° C water. When cardiac output, stroke volume, and a-v O_2 difference were plotted as a function of $\dot{V}O_2$, the relationship between cardiac output and $\dot{V}O_2$ was linear with no effect of water temperature being observed. The predominant adjustment to the decrease in heart rate in cooler water, therefore, appeared to be an increase in stroke volume. Neither water immersion nor temperature appeared to affect pulmonary ventilation ($\dot{V}E$). McArdle et al. (1976) concluded that the reduction in heart rate during work in cold water was entirely compensated for by a proportional increase in the stroke volume and that cardiac output was, therefore, maintained at similar levels of energy expenditure in air and in 18, 25, and 30° C water.

Avellini et al. (1983) trained 15 young men of similar maximal aerobic power in 32° C water, or in 20° C water to determine if physical

training in water and in air differ. Physical training consisted of one-hour daily exercise, five times each week on a Monarch cycle ergometer. Exercise intensity was readjusted each week to maintain a constant training stimulus approximately equal to 75 percent of $\dot{V}O_2$ max. Throughout the training period, heart rates of individuals exercising in 20° C water averaged 20 beats per minute less than those of individuals exercising on land and 10 beats per minute less than those of individuals exercising in 32° C water even though work was performed at the same percent $\dot{V}O_2$ max for all groups. Training elicited a 16 percent increase in $\dot{V}O_2$ max for individuals exercising on land, a 13 percent increase for those exercising in 32° C water, and a 15 percent increase for those exercising in 20° C water. A higher stroke volume was noted for subjects exercising in 20° C water (Avellini et al., 1983). Avellini et al. (1983) concluded that training in water produced physiological adaptations similar to training on land and that because $\dot{V}O_2$ max is improved while training in cold water despite a significantly lower heart rate, training in cold water may take place more efficiently than in warmer water or on land.

Hemodynamic responses of runners and water polo players during exercise in water were studied by McMurray et al. (1983). Six trained water polo swimmers and five trained runners exercised on a modified bicycle ergometer for 30 minutes at 60 percent $\dot{V}O_2$ max while immersed to the neck in 20, 25, 30, and 35° C water.

Findings indicated that metabolic rates and cardiac outputs, were independent of water temperature or time in the water. In 30 and 35° C water, runners were able to maintain stroke volume throughout the

duration of exercise while swimmers' stroke volumes declined significantly with training in these water temperatures (by 9.2 and 11.5 percent, respectively). In contrast, in 20^o C water, swimmers maintained their stroke volume while the stroke volume of the runners decreased significantly by 10.5 percent after the initial ten minutes of exercise. The heart rates of the swimmers were consistently higher than those of the runners at all water temperatures (McMurray et al., 1983).

These results appeared to indicate that cardiovascular responses of trained runners and trained swimmers to exercise during prolonged immersion were different and may have reflected the environment in which training was conducted. Although cardiac output was independent of water temperature for both groups, stroke volume responses of the runners suggested a cardiovascular system more adapted to heat than those of the water polo players. At the same time, water polo players appeared to be better adapted to cold. It appeared, therefore, that specific environmental factors may have imparted unique cardiovascular and thermoregulatory adaptations to exercise in water (McMurray et al., 1983).

In summary, findings of these studies (Avellini et al., 1983; Craig & Dvorak, 1969; Denison et al., 1972; McArdle et al., 1976; McMurray et al., 1983) indicate that training in water should induce training effects similar to training on land. Furthermore, it is possible that training in water may be more efficient. Training effects may be achieved with individuals working at lower heart rates in water than on land (Avellini et al., 1983). This especially seems to be true at lower water temperatures. McArdle et al. (1976) postulated that there may be

a significant increase in central venous pressure, transmural pressure, and heart volume during immersion in water due to a shift in blood volume from the periphery into the thorax. The hydrostatic effect of immersion combined with peripheral vasoconstriction to diminish heat loss may result in increased filling pressure of the heart. This could lead to a considerable increase in stroke volume.

Because cardiorespiratory response to exercise in water may be somewhat different from the response to exercise on land, the issue of training subjects in water but treadmill testing them on land cannot be ignored. Holmer, Stein, Saltin, Ekholm and Astrand (1974) and McArdle, Glaser, and Magel (1971) have compared hemodynamic, metabolic, and cardiorespiratory effects of swimming and treadmill walking or running. Other researchers have studied the specificity of swim training on max $\dot{V}O_2$ (Holmer & Astrand, 1972; Magel & Faulkner, 1966; Magel et al., 1974). Results of such studies have been conflicting. Magel and Faulkner (1966) observed no significant difference between max $\dot{V}O_2$ during tethered swimming ($4.14 \text{ L}\cdot\text{min}^{-1}$) and during treadmill running ($4.20 \text{ L}\cdot\text{min}^{-1}$). In contrast, Magel et al. (1974) found that that swim training significantly increased swimming max $\dot{V}O_2$ (by $380 \text{ ml}\cdot\text{min}^{-1}$), max VE (by $14.9 \text{ L}\cdot\text{min}^{-1}$), and max swim time (by 40 minutes), but did not significantly improve max $\dot{V}O_2$ when the subjects were evaluated by a treadmill running test. Differences in max $\dot{V}O_2$ and other physiological indicators of exercise in water and on land have been largely attributed to differences in body position, thermal exchange, contracting musculature, restriction of ventilation in swimming, increase in external pressure in water, and relative skill in swimming and running

(Holmer et al., 1974; Magel & Faulkner, 1966). In any case, physiologic responses to exercise in water or on land appear to be significantly influenced by the unique physiology of the individual and the environment to which he or she is most adapted.

CHAPTER III

METHODS

The purpose of this study was to compare the physiological training effects of a water aerobics program to those of an aerobic dance program for women. Measures of body composition and cardiorespiratory endurance were determined pre- and post- training in order to determine effects of activity.

Subject Selection

Eleven untrained females who were enrolled in Physical Education classes at the University of Wisconsin - La Crosse during first semester of the 1986 - 1987 school year participated in this study. Subjects were enrolled in either a water exercise class (n=4), an aerobic dance class (n=4), or a bowling class (n=3) which, it was believed, would not influence cardiorespiratory endurance or body composition.

Subject selection was based on activity levels during the three months prior to the start of the class. Those individuals who had been participating in rhythmic, large muscle activity two or more times per week with a duration of greater than 15 minutes per day and individuals who smoked were excluded from the study. A questionnaire (see Appendix A) was distributed to all female class members in order to obtain information concerning exercise and smoking habits and to determine the number of class members interested in participating in the study.

All subjects selected to participate in the study completed an

initial max $\dot{V}O_2$ test. If the max $\dot{V}O_2$ of any subject was determined to be greater than $45.0 \text{ ml.kg.min.}^{-1}$, she was excluded from the study. Katch and McArdle (1977) consider a max $\dot{V}O_2$ of this level or greater to indicate a high level of fitness.

Testing Procedure

All testing was done in the Human Performance Laboratory in Mitchell Hall on the University of Wisconsin - La Crosse campus. Max $\dot{V}O_2$ tests were done on all subjects one week prior to and one week following the seven week training period. These tests were done to determine pre- and post-training cardiovascular fitness levels. Hydrostatic weighing was done to determine pre- and post-training percent body fat for each of the groups.

Testing instructions for both the max $\dot{V}O_2$ and underwater weighing tests were distributed to each class member (see Appendix B). Prior to the time of the initial treadmill test, each subject signed an informed consent form which explained the nature of the study and any risks involved (see Appendix C). All testing procedures and protocols to be used and any potential risks were explained. Questions which the subjects had were answered at this time. Subjects were encouraged to put forth their best effort during the testing sessions.

Max $\dot{V}O_2$ Testing

Prior to each pre-test, a practice run was administered on the treadmill. Each subject practiced getting on and off the treadmill and walking and running at test speeds. The subjects were fitted with the head gear, mouthpiece, and noseclip and practiced breathing with the

testing apparatus. Use of the Perceived Exertion chart (Borg, 1982) was explained. This scale was used to evaluate level of exertion and thereby to determine when maximum exercise was being approached and whether or not a test was truly maximal.

Before each treadmill test, each subject's weight was recorded to the nearest quarter pound. Preparation of the skin for electrode placement involved abrasion and cleansing with an alcohol swab. Electrodes were placed in a lead II position at the following sites: the superior aspect of the right pectoralis major distal to the sternum, the right sixth rib distal to the sternum, and the left sixth rib distal to the sternum.

Upon connection of the electrodes, the subject performed a maximal treadmill run using the Modified Astrand Protocol (see Table I). After a warm-up period of five minutes at 2.5 percent grade and 3.5 miles per hour, the treadmill speed was increased to 6.0 miles per hour then was held constant. Elevation was increased by 2.5 percent every two minutes after stage I. The following variables were measured during the test: $\dot{V}O_2$ (L.min.⁻¹ and ml.kg.min.⁻¹), VE, heart rate, and treadmill run time. Respiratory data were collected using the Beckman Metabolic Measurement Cart, an open circuit system, which consists of a carbon dioxide analyzer (LB-2) and an oxygen analyzer (OM-11). Calibration was done before each test with a known gas sample previously determined by the Scholander technique. The breathing apparatus consisted of a Colling rubber mouthpiece, Rudolph Valve #2700, and headgear. These were connected to plastic tubing which attached to the mixing chamber of the Metabolic Cart.

Table I
Modified Astrand Treadmill Protocol

	Minutes	Speed	Grade
Warm-up	5	3.5 mph	2.5%
Stage I	3	6.0 mph	0.0%
Stage II	2	6.0 mph	2.5%
Stage III	2	6.0 mph	5.0%
Stage IV	2	6.0 mph	7.5%
Stage V	2	6.0 mph	10.0%
Stage VI	2	6.0 mph	12.5%

(Pollock, Wilmore, & Fox, 1978. p.292)

Heart rate was monitored with a Burdick E320 electrocardiograph and M305 monitor. Heart rates were taken during the last 15 seconds of each minute, at maximal effort, and every two minutes as the subject cooled down and heart rate returned to a level below 100 beats per minute. The heart rate was determined by counting the number of R waves on a 15 second EKG strip. The R wave of the QRS complex represents a single heart beat. The number of R waves recorded in 15 seconds multiplied by four is an indicator of heart rate. Measurements were taken with the Beckman Metabolic Measurement Cart every minute during warm-up and exercise periods.

The test was terminated when the following criteria were met: $\dot{V}O_2$ leveled off or decreased with an increase in workload, RER was greater than 1.0, heart rate reached adjusted maximal (220 minus age), or volitional exhaustion.

Hydrostatic Weighing

Pre- and post-training percent body fat for all subjects were determined by hydrostatic weighing. Subjects were instructed not to eat 12 hours prior to the test. A Collins Nitrogen Analyzer (model number 212320) was used to analyze inspired and expired air and thus, to determine residual volume. This was done with subjects seated. A modification of the oxygen dilution technique described by Wilmore (1969) was used to determine residual volume.

The apparatus for hydrostatic weighing consisted of: a 4' by 4' by 4' S.S. Hydrotesting tank (model number 09771), a 15 kg. autopsy scale (Chatillion and Sons, N.Y. model number 8.20961) in 25 gram increments, a submersible seat, water thermometer, and nose clip.

Each subject was weighed barefoot and in swimsuit, on a calibrated, Health-O-Meter scale (Continental Score Corporation model number 400 DLK). Weight was recorded to the nearest 0.25 pounds and converted to kilograms. Height was recorded to the nearest 0.25 inches and converted to centimeters. Subjects were asked to shower to remove dirt and oil from the skin. Temperature of the water in the tank was recorded and water density was determined. The weight of the weighing apparatus was recorded (kg). The subject was then seated on a light weight polyethylene chair which was suspended from the autopsy scale.

The test procedure was explained to the subject. A nose clip was placed on the subject's nose, and just before submerging, she was asked to forcefully expire as much air as possible from the lungs. The subject was then told to gently submerge while continuing to expel as much air as possible from the lungs. When the subject was completely submerged, the tester steadied the scale and took a reading to the nearest 25 g. The tester then tapped the tank to signal the subject to come to the surface. Six test trials were completed and readings recorded. Any "outlyer" scores were disregarded; consistently repeated values were considered indicators of body density. The Brozek equation (Brozek et al., 1963) was used to determine percent body fat from the body density measurements recorded (see appendix B).

Training Procedures

Training Program for the Aerobic Dance Group

The training program for the aerobic dancers was a 40 minute long class which met four days each week for seven weeks. Each session included an eight to ten minute warm-up period, a 25 minute aerobic phase which consisted of continuous dance movements, and a brief cool-down period (see appendix D).

At the onset of the study, each subject was instructed by the investigator to take her pulse either at the carotid or radial artery for a 10 second count. She was instructed to achieve a heart rate which represented 70 to 80% of the maximal heart rate reached on the initial treadmill test. Heart rates were taken at 8 to 9, 16 to 18, and 23 to 25 minutes during each class session and were recorded at the end of

class on forms provided (see Appendix E). Maintenance of continuous movement was encouraged throughout the class.

Training Program for the Water Aerobics Group

The training program for the water aerobics group was a 40 minute long class which met four days per week for seven weeks. Each class session included an eight to ten minute warm-up of mainly stretching and conditioning exercises, a 25 minute aerobic phase which consisted of continuous movement: jogging, skipping, sliding, and jumping movement across the pool, and kicking and bicycling exercises along the sides. A 10 minute cool-down which consisted of stretching and low intensity conditioning exercises using the resistance of the water followed the aerobic phase (see appendix D).

At the beginning of the training program, the investigator instructed each subject to take her pulse either at the carotid or radial artery for a 10 second count. She was instructed to achieve a maximal heart rate which represented 70 to 80 percent of the maximal heart rate reached on the initial treadmill test. Heart rates were taken three times each class session at 8 to 9, 16 to 18, and 23 to 25 minutes. These were recorded at the end of each class period on forms provided (see Appendix E) Maintenance of continuous movement was encouraged throughout the class.

Procedure for the Control Group

The subjects serving as the control group were selected from bowling classes which met four times each week. Criteria for subject selection were the same as those described for the experimental groups. All subjects completed a questionnaire and were pre- and post-tested

with the same procedures used for the aerobic dancers and participants of water aerobics. Members of the control group were asked not to participate in any regular physical activity outside of their bowling class for the duration of the study.

Statistical Analysis

Upon completion of the post-test, the data collected were analyzed to determine whether or not significant changes had occurred as a result of the training programs. Descriptive measures were calculated on all variables. A Nonequivalent Control Group Design Analysis of Covariance with repeated measures (BMD statistical program) was used. Hypotheses were tested at the .05 level of significance. If no significance on the covariate (the pre-test) was found, Anova would be used, and if the Analysis of Covariance had yielded a significant F ratio, a Scheffe post hoc test would have been calculated to determine the significant differences among the groups. An independent t-test was calculated to compare mean exercise heart rate intensities of the aerobic dance and water aerobic groups.

CHAPTER IV
RESULTS AND DISCUSSION

Introduction

The purpose of this study was to compare the training effects of a water aerobics program to those of an aerobic dance program for untrained female subjects.

Standard descriptive statistics were calculated for all groups, and an independent t-test was utilized to compare the average exercise heart rates of the two experimental groups. Pre- (T_1) and post- (T_2) tests of the experimental and control groups were analyzed using a two-way ANCOVA with repeated measures. The .05 level of significance was the critical value used for acceptance or rejection of the null hypotheses.

The purpose of this chapter is to present an analysis and interpretation of the following parameters which were measured in this study: physical characteristics, percent body fat, intensity of training, $\dot{V}O_2$, treadmill run time, $\dot{V}E$, and maximal heart rate.

Physical Characteristics of Subjects

All subjects in this study were female students attending the University of Wisconsin La Crosse during the first semester of the 1986 - 1987 school year. Twenty seven initial volunteers were screened for acceptance into the study. Of this group, eight were not accepted because they did not meet criteria delineated for participation. Six of these individuals were participating in regular, physical activity prior

to the onset of the study and two were cigarette smokers. After the initial screening, 19 subjects were pre-tested including eight subjects from aerobic dance, six subjects from water aerobics, and five subjects from bowling classes. Of these subjects, one participant in water aerobics was unable to complete all tests and one participant in the bowling group was found to have a max $\dot{V}O_2$ greater than $45 \text{ ml.kg.min.}^{-1}$ and, therefore, had to be excluded from the study. During the course of training, one participant in aerobic dance dropped out of the class and three were unable to complete the study due to illness or injury. One participant in water aerobics had to be excluded from the study because of too many absences, and one participant in the bowling group became pregnant and, therefore, could not complete the post-tests. Thus, the results of this study are based upon four subjects in the aerobic dance group, four subjects in the water aerobics group, and three subjects from the bowling control group.

Mean age of subjects in the aerobic dance group was 20.0 ± 2.3 years, that of subjects in the water aerobics group was $18.8 \pm .5$ years, and that of subjects in the control group was $18.3 \pm .6$ years. The heights of subjects in the aerobic dance and water aerobics groups were similar at 164.8 ± 3.8 cm. and 164.3 ± 5.5 cm., respectively. The average height of individuals in the control group was greater than that of the other two groups at 168.7 ± 7.8 cm. Weights of subjects in the water aerobics and control groups were similar at 61.1 ± 5.2 and 62.4 ± 7.6 kg., respectively. Subjects in the aerobic dance group were heavier with a mean weight of 69.3 ± 12.1 kg. (see Table 2).

Table 2
Means and Standard Deviations for
Physical Characteristics of Subjects

VARIABLE	GROUP								
	Aerobic Dance (n=4)			Water Aerobics (n=4)			Control (n=3)		
	Pre-	Post-	Adjust. Post-	Pre-	Post-	Adjust. Post-	Pre-	Post-	Adjust. Post-
Age (yr)	20.0a 2.3b	---	---	18.8 .5	---	---	18.3 .6	---	---
Ht. (cm)	164.8 3.8	---	---	164.3 5.5	---	---	168.7 7.8	---	---
Wt. (kg)	69.3 12.1	69.9 12.4	65.0 ---	61.1 5.2	60.6 4.3	64.0 ---	62.4 7.6	62.8 7.3	64.8 ---
Fat	29.6 4.6	29.6 4.7	28.4 ---	26.9 3.0	25.8 1.6	26.5 ---	26.9 2.3	27.5 1.4	28.1 ---

a = mean

b = standard deviation

Body Weight and Percent Body Fat

At the pre-test, individuals in the aerobic dance group were, on the average, 8.2 kg. heavier than individuals in the water aerobics group and 6.9 kg. heavier than individuals in the control group. No significant ($p > .05$) differences were noted in total body weight at the post-test for either of the training groups or for the control group. This indicated that no differential changes in body weight occurred for among groups as a result of the seven week training period (see Table 3). However, a slight decrease in body weight for the water aerobics group and a slight

increase in body weight for both the aerobic dance and the control groups were noted from T_1 to T_2 .

Body weight is influenced by caloric intake as well as by total energy expenditure during activity. For this reason, body weight becomes quite difficult to strictly control in most training studies. In this study, no attempt was made to control caloric intake of subjects, though they were asked not to alter their dietary intakes.

An important consideration when discussing body weight is percent body fat. At the pre-test, the aerobic dance group had more body fat than did the water aerobics or the control groups. The latter two groups both averaged 26.9% fat while the aerobic dance group averaged 29.6% fat which was 2.7% more fat than the other two groups (see Table 2). There were no significant ($p > .05$) differences in percent body fat at T_2 among groups (see Table 4). This indicated lack of differential change in percent fat as a result of training, although the percent fat of the water aerobics group did decrease by 1.1%. Percent fat of the aerobic dance group remained the same, and that of the control group increased by less than one percent.

Conflicting results have been reported by researchers who have studied changes in body composition as a result of training. A number of studies have shown no significant changes in body weight (Flint, Drinkwater & Horvath, 1974; Milburn & Butts, 1983) or percent body fat (Coffman & Timson, 1984; Dowdy et al., 1985; Vaccaro & Clinton, 1981) as a result of training. Other studies have shown significant decreases in body weight and percent body fat of subjects (Eickhoff, Thorland &

Table 3
Analysis of Covariance for Weight

	SS	DF	Mean Square	F	Signif. of F
Main Effects	2.057	2	1.028	0.873	0.459
Group	2.057	2	1.028	0.873	0.459
Explained	784.165	3	261.388	221.819	0.000
Residual	8.249	7	1.178		
Total	792.413	10	79.241		

Table 4
Analysis of Covariance for % Fat

	SS	DF	Mean Square	F	Signif. of F
Main Effects	7.397	2	3.698	0.845	0.469
Group	7.397	2	3.698	0.845	0.469
Explained	74.704	3	24.901	5.687	0.027
Residual	30.652	7	4.379		
Total	105.356	10	10.536		

Ansofrage, 1983; Johnson et al., 1984; Moody et al., 1969). Variability in reported results of these studies may be due to differences in frequency, intensity, and duration of training.

The American College of Sports Medicine (1978) has recommended that exercise programs be conducted at least three days per week for at least 20 minutes per session. Further, activity should be performed at sufficient intensity and duration to expend approximately 300

kilocalories (Kcals) per session. Pollock et al. (1969) have noted a trend toward greater body weight loss with an increased frequency of training. In support of this notion, Johnson et al. (1984) noted a greater percent fat loss in subjects exercising three as opposed to two times per week. Pollock et al (1975) noted that subjects who trained four times per week decreased skinfold thickness and body weight more than subjects who exercised three times per week. Those who exercised two times per week did not change body weight or percent fat. Vaccaro and Clinton (1981) attributed lack of significant change in percent body fat to the relatively short duration of their study (10 weeks). Similarly, Dowdy et al. (1985) noted no change in body composition as a result of 10 weeks of training. Wilmore et al. (1970) noted only small reductions in percent body fat, from 18.9% pre-test to 17.8% post-test, as a result of a 10-week jogging program. These researchers (Wilmore et al., 1970) attributed this small reduction in body fat to the relatively short duration of the study. Most researchers would agree that it is cumulative caloric expenditure brought about by longer duration training programs and more frequent activity that will lead to changes in body composition and percent body fat.

Dietary habits of participants may contribute to lack of change in body weight and body composition. Dowdy et al. (1985) stated that although subjects in their study were asked not to alter their eating habits, caloric intake may have increased enough to offset extra energy utilized through activity. Further, these researchers estimated that energy expended in a typical aerobic dance session was 150 to 300 Kcals and that alterations in body weight and body composition could not be

expected without restriction of dietary intake as well. Finally, lack of significant change in body weight and percent body fat may be attributed to subjects who are of an appropriate percent body fat and body weight prior to training. These subjects would not be expected to show significant alterations in these parameters (McArdle et al., 1981).

McArdle et al. (1981) have stated that precise norms and standards have not been established for comparing average body composition of men and women of different ages and fitness levels. However, several researchers have developed mean values of body fat for specific population groups. Wilmore and Behnke (1970) have estimated that for younger women, average percent fat should be 25.5% with a 68% variation limit of 23.4 to 33.3%. Katch and McArdle (1973) have estimated that for this population group, average percent fat is approximately 26.2% with a range being 23.4 to 33.3 percent. Initial percent body fat in the present study was 29.6% for the aerobic dance group, 26.9% for the water aerobics group, and 26.9% for the controls. Subjects in this study, therefore, could be considered within, or slightly above, an average percent body fat range. Therefore, the present training program may not have been an adequate stimulus to lead to a significant decrease in percent fat or in body weight.

Based on the results of this study, it was not possible to reject the null hypothesis which stated that there is no significant difference between the effects of a water aerobics and an aerobic dance program on body composition of women. Regular participation in aerobic dance or in water aerobics appeared not to significantly affect body composition or

gross body weight. An important consideration which may have influenced these results was the small sample size included in this study.

Intensity of Training

McArdle et al. (1981) have stated that training induced physiologic changes depend primarily on the intensity of training and that as a general rule, aerobic capacity will improve if exercise is of sufficient intensity to increase heart rate to about 70% of maximum. Training intensity is usually assigned based on relative stress placed on an individual's physiologic system and is determined by calculating some percentage of maximum function such as max $\dot{V}O_2$, maximum heart rate, or maximum work capacity.

In the present study, a training intensity of 75% of a subject's maximal heart rate reached during the initial treadmill test was assigned throughout the training period. A range of 144 to 180 beats per minute with a mean intensity of 78% of maximal heart rate, approximately 160 beats per minute, was reported for the aerobic dancers. A range of 114 to 174 beats per minute with a mean intensity of 71% of maximal heart rate, approximately 142 beats per minute, was reported by the water aerobics group (see Appendix F). An independent t-test comparing the mean daily heart rates of the two experimental groups indicated that there was a significant difference ($p < .05$) between the heart rate values reported for the two groups. This difference was an 18 beat per minute lower average training heart rate for the water aerobics compared to the aerobic dance group.

Based on reported heart rate ranges, it appears that water aerobics was performed at a lower intensity than was aerobic dance (see Appendix F). However, Katch and McArdle (1981) have stated that when swimming is used as training, an adjustment should be made in estimating maximum heart rate. McArdle et al. (1971) have estimated that heart rate during swimming is nine to 13 beats per minute lower than heart rate during walking. Therefore, these authors (McArdle et al. 1981) have suggested that a difference of 13 beats per minute should be subtracted from age predicted maximal heart rate when establishing appropriate exercise intensity for swimming.

McArdle et al. (1971) have stated that several factors inherent in activity in water as opposed to on land must be considered when attempting to explain a significantly lower heart rate response to exercise in water. These include: the medium in which each activity is performed, the position of the body, and the active muscle mass involved in each form of exercise. Also, the diving reflex, an oxygen conserving reflex, which slows heart rate and causes peripheral vasoconstriction and redistribution of blood flow from peripheral areas to vital organs such as the brain and heart is known to decrease heart rate response to exercise (Kawakami, Natelson & DuBois, 1967; Stromme, Kerem & Elsner, 1970; Whayne & Killip, 1967). This reflex is elicited by application of a cold, wet stimulus to the face or by immersion of the nose and face in water (Kawakami et al., 1967; Whayne & Killip, 1967). Cold water (10 -17° C) enhances this reflex (Whayne & Killip, 1967).

Research has not indicated whether heart rate response to water aerobics is significantly different from heart rate response to aerobic

dance performed on land through results of this study indicate that such a difference may indeed exist. Special considerations which differentiate water aerobics from swimming are: water aerobics is performed in shallow water in a vertical position, participants are often only partly submerged in water, and leg and arm movements are equally important in water aerobics. Because the diving reflex is elicited by application of a wet stimulus to the face, and water aerobics is performed with head out of the water, this reflex may not contribute to lower heart rates in water aerobics. Finally, water aerobics is usually performed in relatively warm water temperatures. Average temperature of the pool used in the present training study was 31.4° C. McArdle et al. (1976) have suggested that the most significant reductions in heart rate are noted in cool water temperatures of 18 to 25° C.

Though there was a significant difference in training heart rates of the two training groups in the present study, it is possible that these groups were training at similar energy expenditures. Avellini et al. (1983) have stated that physical exercise in water may produce different physiological responses than exercise in air due to the hydrostatic effect of water on the cardiovascular system and to the enhanced heat-dissipating quality of water compared to air. These authors (Avellini et al., 1983) have hypothesized that increased pressure in the lower body regions and peripheral vasoconstriction to diminish heat loss, together, may increase venous return and increase stroke volume. Such a mechanism would allow individuals exercising in water to accomplish the same work output with significantly lower heart

rates than those on land. An important consideration particular to this study is the small sample size included. If any subject trained consistently above or below the prescribed heart rate of 75% of maximum, the average training heart rate of the group would be drastically effected. One subject in the water aerobics group did exercise, during a number of class sessions, at a lower heart rate than the training heart rate prescribed for her (see Appendix F), and this could have contributed to the lower training heart rates noted for the water aerobics group.

Maximal Performance Data

In this study, if at least one of the following criteria was achieved, a maximal level was considered to have been attained: a decrease or leveling off of $\dot{V}O_2$ with an increase in workload, an RER value greater than 1.0, achievement of a heart rate equal to age predicted maximum, or volitional exhaustion. Using the above criteria, all subjects were considered to have reached maximal effort when tests were terminated. Two subjects failed to attain R values greater than 1.0 for T_1 but did reach heart rates which exceeded age predicted maximum and stopped due to exhaustion (see Appendix G). All subjects attained R values of 1.0 or greater for T_2 .

Max $\dot{V}O_2$

At the pre-test, max $\dot{V}O_2$ expressed relative to body weight was 40.9 ml.kg.min.⁻¹ for the aerobic dance group, 41.5 ml.kg.min.⁻¹ for the water aerobics group and 39.7 ml.kg.min.⁻¹ for the bowling controls (see Table 5). When expressed in absolute terms, max $\dot{V}O_2$ was higher for the

Table 5
Means and Standard Deviations of
Physiological Responses to the Max $\dot{V}O_2$ Test

Variable	Group								
	Aerobic Dance (n=4)			Water Aerobics (n=5)			Control (n=3)		
	Pre-	Post-	Adjust. Post	Pre-	Post-	Adjust. Post	Pre-	Post-	Adjust. Post
Max $\dot{V}O_2$ (ml.kg.min. ⁻¹)	40.9a 3.0b	40.4 2.3	40.4 ---	41.5 3.7	40.1 3.8	39.8 ---	39.7 2.5	38.3 1.9	38.8 ---
Max $\dot{V}O_2$ (L.min. ⁻¹)	3.1 .466	3.0 .539	2.6 ---	2.5 .103	2.4 .215	2.6 ---	2.5 .330	2.4 .282	2.7 ---
Treadmill Run (sec.)	481.8 33.3	493.6 63.5	475.3 ---	388.7 76.5	416.5 56.7	441.4 ---	461.4 138.0	448.0 72.0	439.1 ---
Max HR (BPM)	200.0 13.0	195.0 9.3	195.8 ---	199.5 8.1	199.5 9.0	200.7 ---	204.7 1.2	204.0 1.0	201.3 ---
Max $\dot{V}E$ (L.min. ⁻¹)	94.6 10.1	96.7 10.9	92.2 ---	81.6 10.8	86.3 8.6	90.2 ---	86.2 17.1	83.2 10.3	84.1 ---

a = mean

b = standard deviation

Table 6
Analysis of Covariance for $\dot{V}O_2$ (L.min.⁻¹)

	SS	DF	Mean Square	F	Signif. of F
Main Effects	0.011	2	0.005	0.425	0.669
Group	0.011	2	0.005	0.425	0.669
Explained	1.885	3	0.628	49.157	0.000
Residual	0.089	7	0.013		
Total	1.974	10	0.197		

Table 7
Analysis of Covariance for $\dot{V}O_2$ (ml.kg.min.⁻¹)

	SS	DF	Mean Square	F	Signif. of F
Main Effects	4.218	2	2.109	0.285	0.760
Group	4.218	2	2.109	0.285	0.760
Explained	21.373	3	7.124	0.963	0.462
Residual	51.809	7	7.401		
Total	73.182	10	7.318		

aerobic dance group (3.1 L.min.⁻¹) than it was for either of the other two groups which each achieved maximal values of 2.5 L.min.⁻¹ (see Table 5).

No significant ($p > .05$) differences in relative or absolute maximal oxygen consumptions were noted among groups at the post-test (see Tables 6 and 7). These results indicate that no differential

changes in $\max \dot{V}O_2$ occurred with training and are contrary to results of similar training studies in which subjects showed significant improvements in $\max \dot{V}O_2$ values (Cunningham & Hill, 1975; Dowdy et al., 1985; Milburn & Butts, 1983; Vaccaro & Clinton, 1981). Increases in $\max \dot{V}O_2$ for subjects in these studies ranged from 5 to 34% as a result of seven to 10 weeks of training. Fox and Mathews (1981) have stated that an average improvement in $\max \dot{V}O_2$ of 5 to 20% should be anticipated for college age women following eight to 12 weeks of training. Brooks and Fahey (1984) have estimated an expected range of improvement to be from 10 to 20%. According to Wilmore et al. (1980) probable sources of variation of improvement in $\max \dot{V}O_2$ values are differences in intensity, duration, frequency, and mode of training. Therefore, it is important to compare studies of similar design when discussing effects of training on $\max \dot{V}O_2$.

In addition to the training regime, Brooks and Fahey (1984) and Katch and McArdle (1981) have stated that improvements in oxygen consumption as a result of training may be dependent on and limited by the current fitness level of an individual. In the present study, variability in the fitness level of the subjects was controlled for by criteria set for participation in the study. These included the requirement that subjects must not have participated in regular, physical activity for three months prior to the onset of the study and that subjects must have had an initial $\max \dot{V}O_2$ that did not exceed 45.0 ml.kg.min.⁻¹. It is generally agreed upon that gains in $\max \dot{V}O_2$ are inversely related to initial $\max \dot{V}O_2$ levels (American College of Sports Medicine, 1978; Brooks & Fahey, 1984; Fox & Mathews, 1981; Katch &

McArdle, 1981). In the present study, initial maximal levels for aerobic dance and water aerobics groups were 40.9 and 41.5 ml.kg.min.⁻¹, respectively. These values placed subjects in a good fitness category (Katch & McArdle, 1981). Therefore, potential for improvement may have been limited by the already relatively high fitness levels of subjects. It may have been necessary for individuals in this study to train at higher intensities than 78% of maximal heart rate for the aerobic dance group and 71% of maximal heart rate for the water aerobics group for cardiorespiratory training effects to occur. Individuals are known to need higher thresholds of stimulation as they become more fit (American College of Sports Medicine, 1978)

A factor which may have contributed to lack of significant improvement in max $\dot{V}O_2$ values in this particular study was the small sample size of the two experimental and the control groups. Also, the relatively short length of the training period could have contributed to the lack of significant results.

Treadmill Run Time

Initial run time for the water aerobics group was 388.7 seconds, for the aerobic dance group was 481.8 seconds, and for the control group was 461.4 seconds (see Table 5). As with max $\dot{V}O_2$, no significant ($p > .05$) differences in mean adjusted treadmill run time at T_2 were noted among groups. (see Table 7). Though this finding indicated that differential changes in treadmill run time failed to occur with training, run time did increase slightly for the two training groups. The water aerobics group increased run time by 27.8 seconds from T_1 to T_2 and the aerobic dance group increased run time by 11.8 seconds from

T₁ to T₂. Run time of the control group decreased slightly from pre- to post-test by 13.4 seconds. An increase in treadmill run time,

Table 8
Analysis of Covariance for Treadmill Run Time

	SS	DF	Mean Square	F	Signif. of F
Main Effects Group	2,763.3	2	1,381.7	0.501	0.626
Explained	24,782.7	3	8,260.9	2.993	0.105
Residual	19,318.0	7	2,759.7		
Total	44,100.7	10	4,410.1		

especially when accompanied by an increase in max $\dot{V}O_2$, is indicative of increased work capacity of subjects.

Authors of similar training studies (Cearly et al., 1984; Dowdy et al., 1985; Milburn & Butts, 1983) have found treadmill run time to increase as a result of training. Cearly et al. (1984) found a 2% increase in treadmill run time for a two day per week group and a 14.5% increase for a three day per week group in a 10 week aerobic dance training study. Similarly, Dowdy et al. (1985) noted a 16% increase in treadmill run time for a three day per week, 10 week duration aerobic dance study. Milburn and Butts (1983) found a 20.7% increase for aerobic dancers in a four day per week, seven week duration training study.

Lack of significant difference in treadmill run time may have been

related to the relatively short length of training and to the small number of subjects included in this study.

Maximal Ventilation (Max $\dot{V}E$)

Increases in maximal ventilation were noted from T_1 to T_2 for both of the experimental groups. The aerobic dance group increased max $\dot{V}E$ by 2.1 L.min.⁻¹ while the water aerobics group increased this value by 4.7 L.min.⁻¹. Max $\dot{V}E$ for the control group decreased by 3.0 L.min.⁻¹ (see Table 5). However, no significant ($p > .05$) differences in maximal ventilation were noted among the groups at the post-test (see Table 9). This indicated that differential changes in ventilation did not occur with training.

Table 9
Analysis of Covariance for max $\dot{V}E$

	SS	DF	Mean Square	F	Signif. of F
Main Effects	112.818	2	56.409	1.414	0.305
Group	112.818	2	56.409	1.414	0.305
Explained	880.929	3	293.643	7.363	0.014
Residual	279.158	7	39.880		
Total	1160.187	10	116.009		

Authors of studies similar to the present one have reported conflicting results with respect to max $\dot{V}E$. Some have reported significant increases in ventilation (Cearly et al., 1984; Milburn & Butts, 1983) while others (Vaccaro & Clinton, 1981) have reported no significant changes with training. Fox and Mathews (1981) have stated

that maximal minute ventilation is generally increased following training. According to Astrand and Rodahl (1986) and McArdle et al. (1981), this increase in maximal ventilation is partly due to an increase in maximal aerobic power which leads to a larger oxygen requirement, to an increase in CO_2 production, and to an increase in maximal lactate level. Any of these conditions can stimulate an increase in ventilation. Therefore, any rise in $\dot{V}\dot{E}$ should be considered secondary to a rise in $\dot{V}\dot{O}_2$, and $\dot{V}\dot{O}_2$ should not be considered to be limited by ventilation (Fox & Mathews, 1981).

As previously stated, lack of significant results may have been due to the initial fitness levels of subjects, to the relatively short duration of this study, and to the small number of subjects included in each group.

Maximal Heart Rate

Initial maximal heart rates of the aerobic dance and the water aerobics groups were 200.0 and 199.5 beats per minute, respectively. That of the control group was 204 beats per minute (see Table 5). Analysis of Covariance revealed no significant ($p > .05$) differences in maximal heart rate at T_2 for either of the experimental groups or for the control group (see Table 10) and therefore, indicated that no differential changes in heart rate occurred with training. Maximal heart rate of the aerobic dance group did show a slight decrease of 5 beats per minute from pre- to post-test. Maximal heart rate remained the same for the water aerobics group and decreased by .7 beats per minute for the control group (see Table 5).

Reductions in resting and submaximal heart rates are known to result from training (Astrand & Rodahl, 1986; Brooks & Fahey, 1984). However,

maximal attainable heart rate is thought to either remain unchanged or to decrease only slightly (Fox & Mathews, 1981; Kilbom, 1971). Dowdy et al. (1985) and Milburn and Butts (1983) have noted significant decreases in maximal heart rate as a result of training. Other researchers (Cearly et al., 1984; Eisenman & Golding, 1975; Vaccaro and Clinton, 1981) have found training to induce no significant decreases in maximal heart rate.

Table 10
Analysis of Covariance for Maximal Heart Rate

	SS	DF	Mean Square	F	Signif of F
Main Effects	66.721	2	33.361	2.283	0.172
Group	66.721	2	33.361	2.283	0.172
Explained	540.612	3	108.204	12.331	0.004
Residual	102.297	7	14.614		
Total	642.909	10	64.291		

Fox and Mathews (1981) have stated that a decrease in maximal heart rate with training is probably related to three factors: an increase in heart volume resulting from cardiac hypertrophy, a decrease in sympathetic drive, and a decrease in intrinsic pacemaker rate. These authors (Fox & Mathews, 1981) have indicated that a decrease in maximal heart rate is particularly evident in athletes who endurance train but also may occur in sedentary individuals who begin a training program.

Another possible explanation for a decrease in heart rate from pre- to post-test is that a true maximal level of work capacity was not

achieved by individuals on the post-test. This may explain the decrease in heart rate for the aerobic dance group. However, other criteria including RER value greater than 1.0, achievement of age predicted maximal heart rate, and volitional exhaustion indicated that subjects had achieved maximal exercise. An explanation for lack of significance in this particular study is the small sample size.

Summary

In this study, statistical analysis revealed no significant differences in percent body fat or in physiologic responses to maximal exercise tests at the post-test, and therefore, indicated that no differential changes in the variables measured occurred with training. Thus, in no instance was it possible to reject the null hypotheses.

Other researchers have reported variable changes in body composition as a result of training. Much of this reported variability may be attributed to differences in frequency, intensity and duration of training programs; to lack of control of subjects' caloric intakes; and to variability in body composition of subjects at the onset of the studies. It is possible that dietary habits of subjects in the present study and initial, percent fat values, which placed subjects in an average range for females, contributed to lack of significant change in body composition. A greater training stimulus may have been necessary to promote body composition changes in this population.

Researchers would hope to find an increase in maximal oxygen uptake (ml.kg.min.^{-1} and L.min.^{-1}), an increase in treadmill run time, an increase in maximal ventilation, and no change, or a slight decrease in

maximal heart rate as a result of training. In the present study, these changes were not noted though slight increases in treadmill run time and in ventilation did occur for the two training groups. Lack of significant results may have been due to the relatively short duration of the study, the relatively high initial fitness level of the subjects, and to the small sample size studied.

A significant finding of this research was the difference in training heart rates of the water aerobics and the aerobic dance groups. Subjects in the water aerobics group trained at an average heart rate of 18 beats per minute less than subjects in the aerobic dance group. An explanation for the lower, average training heart rate in the water may be physiologic adaptations to training in this medium. If lower heart rates were indeed due to physiologic adaptations, subjects in the two groups may have actually been training at similar intensities despite lower heart rates in the water. The difference in training heart rates may also have been influenced by the small sample size included in this study.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to compare the training effects of a water aerobics program with those of an aerobic dance program. Eleven untrained female volunteers who were enrolled in Physical Education classes at the University of Wisconsin - La Crosse participated in the study. These volunteers ranged in age from 18 to 22 years and had initial max $\dot{V}O_2$ values of 45 ml.kg.min.⁻¹ or less. Four subjects were in the water aerobics group, four in the aerobic dance group, and three in the bowling control group.

Each subject completed a pre- and post- maximal treadmill test using the Modified Astrand Protocol to determine maximal oxygen uptake (L.min.⁻¹ and ml.kg.min.⁻¹), maximal heart rate, and $\dot{V}E$ max. Each subject was hydrostatically weighed to determine pre- and post- percent body fat. During the seven week training period, individuals in the water aerobics and aerobic dance groups trained at heart rates approximately 75% of the maximal heart rate achieved during the treadmill test. Class sessions in both the water and dance aerobic programs were held four days per week and consisted of an eight to ten minute warm-up period, a 25 minute phase of continuous, aerobic activity, and a brief cool-down.

Pre- and Post- test data were collected and analyzed to determine whether or not significant differences in physiologic parameters

occurred at the post-test. Significant differences at T_2 would have indicated that differential changes had occurred as a result of training, and therefore, that a training effect had occurred. Standard descriptive statistical values were calculated for all variables. These variables included: percent body fat, weight, $\max \dot{V}O_2$ ($L \cdot \min^{-1}$ and $ml \cdot kg \cdot \min^{-1}$), maximal treadmill run time, $\max \dot{V}E$, and maximal heart rate. Nonequivalent Control Group Design Analysis of Covariance with repeated measures was used to determine if differences in variables at the post-test occurred as a result of training. The .05 level of significance was used to determine acceptance or rejection of the null hypotheses. An independent t-test was used to compare mean exercise heart rates of the aerobic dance and the water aerobics groups.

Conclusions

Numerous limitations and delimitations should be considered when drawing conclusions from results of this limited research. Based upon the present study, the following conclusions were drawn:

Training heart rates of the water aerobics group were significantly ($p < .05$) lower than training heart rates of the aerobic dance group. This finding may be due to physiologic adaptations to training in water which result in lower heart rate response to exercise in this medium, however, it may also have been influenced by the small sample size included in this study.

There was no significant ($p > .05$) difference between the effects of a water aerobics program and the effects of an aerobic dance program on body composition of women. No significant ($p > .05$) differences were

noted in body weight for either of the experimental groups or for the control group at the post-test. This indicated that no differential changes in percent body fat occurred for any group as a result of training, and therefore, that neither aerobic dance nor water aerobics of the intensity and duration used in this study provided an adequate training stimulus to bring about changes in body composition.

The null hypothesis that there is no significant ($p > .05$) difference between the effects of a water aerobics program and the effects of an aerobic dance program on cardiovascular fitness of women was retained. There was no significant ($p > .05$) difference in either absolute or relative oxygen consumption for either experimental group or for the control group at the post-test. This indicated a lack of improvement in cardiovascular fitness in spite of participation in water aerobics or aerobic dance. There was no significant ($p > .05$) difference in treadmill run time at T_2 for any group as a result of training. Run time did, however, increase by a slight degree for both training groups. This too was an indicator of lack of significant improvement in cardiovascular fitness.

There were no significant ($p > .05$) differences in maximal ventilation for either of the training groups or for the control group at the post-test. Max $\dot{V}E$ increased only slightly for the water aerobics and the aerobic dance groups. An increase in $\dot{V}E$ generally does occur with training. No significant ($p > .05$) differences in maximal heart rate were noted for any group at the post-test indicating that changes in this variable did not occur as a result of participation in water aerobics or aerobic dance. Changes in maximal heart rate may or may not

occur with training. The above findings all indicate that neither water aerobics nor aerobic dance resulted in improvements in cardiovascular fitness of subjects in this study.

Based on these findings, neither water aerobics nor aerobic dance could be considered adequate training modes to elicit improvements in cardiovascular fitness or in body composition when performed four times per week, 40 minutes per session for seven weeks. Though very few studies to determine training effects of water aerobics have been performed, a number of studies to determine training effects of aerobic dance have been reported in the literature. Researchers have generally found aerobic dance to significantly improve maximal performance data. The degree of improvement has varied depending on frequency, intensity, and duration of training. Also, initial fitness level of subjects is known to influence improvement with training. In the present study, an attempt was made to control initial fitness level of subjects by requiring that max $\dot{V}O_2$ not exceed 45 ml.kg.min.⁻¹ at the onset of the study. Those in the aerobic dance group had an average max $\dot{V}O_2$ value of 40.9 ml.kg.min.⁻¹ and those in the water aerobics group had an average value of 41.5 ml.kg.min.⁻¹. It is possible that an improvement in performance for these subjects would have been noted if they had been even less fit at the onset of the study. Also, this training study was of a relatively short duration (seven weeks) and only a small number of subjects was included in each group. These are important factors to consider in interpreting results of this research.

Variable results have been reported in the literature by researchers who have studied changes in body composition with training. Reasons

cited for lack of change in body composition have been: relatively short duration of a training period, lack of control of dietary intake, normal, or near normal, gross body weight and body composition prior to the onset of a study, and lack of adequate training stimulus to lead to significant changes in body weight or body composition. These reasons as well as the small number of subjects included in the present study, are possible explanations for lack of significant change in body composition.

Recommendations for Future Study

It is recommended that similar, future studies be done with more subjects included in each training group. This would greatly enhance the value of the data collected. At this time, little research has been done on cardiovascular training effects of water aerobics per se. Because this is a form of activity which is rapidly gaining in popularity, the need for such research does exist.

It is recommended that similar, future studies be done with a less fit population characterized by having lower, initial max $\dot{V}O_2$ values and higher percent body fat scores. Also, it is recommended that future research include subjects of a wide range of ages especially since water aerobics is an exercise mode in which many older and heavier individuals can participate.

An interesting question which has been raised by the present study is whether, though training at significantly lower heart rates, participants in water aerobics were exercising at similar intensities to those exercising on land. This may have been possible due to

physiologic adaptations to exercise in water. Research to determine and verify if a lower heart rate response to water aerobics should be expected would be of value to those developing exercise prescriptions for participants in water aerobics programs.

Finally, in addition to potentially being of cardiovascular benefit, participation in water aerobics may be of great value in increasing muscular strength and flexibility. Research to determine if such benefits of water aerobics exist would substantiate informal observations of such benefits made by individuals involved in water aerobics programs.

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Appendix A

Subject Questionnaire

1. Name _____
Social Security Number _____
Phone _____ Major _____
2. Do you exercise regularly? _____
If yes, how many times each week? _____
How long does each exercise session last? _____

What type of exercise do you do? _____

3. Are you on any university athletic teams? _____
If yes, what team and when is your season? _____

4. Do you smoke? _____ If yes, approximately how many packs
per day? _____
5. Which do you consider yourself to be (check one):
____ a) poor physical condition (never exercise at all)
____ b) fair physical condition (rarely exercise)
____ c) good physical condition (occasionally exercise)
____ d) excellent physical condition (regularly exercise)
6. Are you interested in being in this study? _____

Appendix B

Subject Procedure List

Testing Information for Treadmill Test

- 1) Bring or wear shorts, a t-shirt, and gym shoes.
- 2) If you eat before your test - eat at least two hours prior to the test.
Your meal should be light.
- 3) Do not consume alcohol at least 3 hours before your test.
- 4) Do not engage in heavy physical exercise 24 hours prior to the test.
- 5) Testing location: The Human Performance Laboratory

225 Mitchell Hall

(upstairs on the southeast side of the building)

You are scheduled for your treadmill test on _____
at _____. Please keep this appointment. If you cannot,
please contact me, Charlotte Smith at 782-5907 (home) or 785-8685 (lab).
Please leave a message if you can't reach me.

Testing Information for Underwater Weighing

- 1) Do not eat 12 hours before your scheduled test.
- 2) Do not participate in any heavy physical activity 8 hours prior to the test.
- 3) Please bring a swimsuit and towel with you on the day of the test.
- 4) Testing location: The Human Performance Laboratory
225 Mitchell Hall
(upstairs on the southeast side of the building)

Your appointment for your underwater weighing test is _____
_____ at _____. Please keep this
appointment and be on time. If you cannot make the test for any reason,
please contact me, Charlotte Smith at 782-5907 (home) or 785-8685 (lab).
Leave a message if you can't reach me.

Appendix C
Subject Consent Form

INFORMED CONSENT FOR THE AEROBIC DANCE/WATER AEROBICS STUDY

In conjunction with my aerobic dance/water exercise class, I, _____, am willing to participate in the aerobic dance/water exercise training study being conducted by Charlotte Smith, a graduate student in the Adult Fitness/Cardiac Rehabilitation program at the University of Wisconsin - La Crosse. I understand that participation in this study requires regular attendance throughout the scheduled class as well as two or three visits to the Human Performance Laboratory at the University of Wisconsin - La Crosse for pre- and post- max VO_2 tests and hydrostatic weighing.

I understand that the treadmill test involves running to voluntary exhaustion on a motor-driven treadmill. After an initial warm-up of 3.5 mph at 2.5% grade, the speed of the treadmill will be increased to 6.0 mph and grade will be set at 0%; the grade will then be increased 2% every two minutes until exhaustion. During the test, heart rates will be monitored continuously with an electrocardiogram (ECG). This will involve the placement of 4 electrodes on the skin surface. Oxygen consumption will be monitored by the use of a Beckman Metabolic Cart. This involves breathing through a mouthpiece so that expired air can be controlled and analyzed. The increase in workload will continue until maximal oxygen consumption is reached or until I feel I cannot continue any longer. In any testing situation, some potential risk is involved. As with any exercise, the possibility of adverse reactions occurring does exist (i.e. dizziness, staggering, difficulty breathing, etc.) during the test. Also, I will feel tired at the end of the exercise. If any abnormal observations are noted, the test will be terminated immediately.

The hydrostatic weighing procedure involves being briefly submerged underwater. Potential risks of a water environment include infection, accident, and possible drowning. There have been no reports of infection or drowning as a result of hydrostatic weighing in the Human Performance Laboratory. I understand that I am free to stop any test or withdraw from the study at any time.

During my aerobic dance/water exercise class, I understand that I will be expected to work at a prescribed intensity based on results of my initial treadmill test. I understand that I will be expected to work at this intensity throughout the duration of the study.

In signing this consent form, I acknowledge that I have read and understand the foregoing; any questions which I may have had concerning my participation in the study have been satisfactorily answered. Potential risks of the study have been fully explained to me and I understand their implications. I hereby acknowledge that no representations, warranties, guarantees, or assurances of any kind

pertaining to the procedures have been made to me by the University of Wisconsin - La Crosse, the officers, administrators, employees, or by anyone acting on behalf of them. To my knowledge, I am not infected with any disease nor do I have any limiting physical condition or disability, especially with respect to my heart, that would prevent me from participation in strenuous exercise or would prevent me from being underwater weighed.

Signed: _____

Date: _____

Witness: _____

Date: _____

Appendix D

Music for Dance Routines

Music for Aerobic Dance Routine

Celebration

Freak

Perfect

Beer Barrel Polka

Rubber Dolly

The Heat is On

Troika (folk)

Workin' on the Highway

New Attitude

Rock Around the Clock

Still Rock & Roll to Me

Celebrate Me Home

Music for Water Aerobics Routine**Little Darling****I Believe****Hell on Wheels****Fun Fun****Dance Dance****Breaking My Heart****Catch a Wave****Angel in a Centerfold****Heart****Witter Park**

Appendix E

Heart Rate Recording Form

Class: _____

Date: _____

Teacher: _____

Student

HR

HR

HR

123

1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____
5.	_____	_____	_____
6.	_____	_____	_____
7.	_____	_____	_____
8.	_____	_____	_____
9.	_____	_____	_____
10.	_____	_____	_____
11.	_____	_____	_____
12.	_____	_____	_____
13.	_____	_____	_____
14.	_____	_____	_____
15.	_____	_____	_____

Appendix F

Training Heart Rates

Heart Rates for Water Aerobics

<u>11/3</u>	<u>11/4</u>	<u>11/5</u>	<u>11/6</u>	<u>11/10</u>	<u>11/11</u>
24	25	24	25	24	24
29	28	25	28	24	25
22	21	20	21	22	19
26	25	23	25	25	23
<u>11/12</u>	<u>11/13</u>	<u>11/17</u>	<u>11/18</u>	<u>11/19</u>	<u>11/20</u>
23	25	26	24	27	24
24	25	27	23	23	24
19	--	27	23	23	24
22	26	25	22	23	24
<u>11/24</u>	<u>11/25</u>	<u>11/26</u>	<u>12/1</u>	<u>12/2</u>	<u>12/3</u>
24	24	25	24	25	26
25	27	23	27	25	23
22	--	21	21	21	22
20	25	25	26	23	23
<u>12/4</u>	<u>12/8</u>	<u>12/9</u>	<u>12/10</u>	<u>12/11</u>	<u>12/15</u>
25	25	24	23	26	24
22	27	21	18	26	24
--	24	20	17	24	22
23	26	22	--	26	24

Heart Rates for Aerobic Dance

<u>11/3</u>	<u>11/4</u>	<u>11/5</u>	<u>11/6</u>	<u>11/10</u>	<u>11/11</u>
26	30	27	30	27	25
25	--	26	24	24	25
25	--	26	27	27	27
--	28	30	28	28	26
<u>11/12</u>	<u>11/13</u>	<u>11/17</u>	<u>11/18</u>	<u>11/19</u>	<u>11/20</u>
29	27	30	29	27	29
25	25	26	25	24	--
--	27	27	27	26	26
28	26	27	28	27	28
<u>11/24</u>	<u>11/25</u>	<u>12/1</u>	<u>12/2</u>	<u>12/3</u>	<u>12/4</u>
27	27	30	28	29	28
25	26	26	25	24	25
26	25	27	26	27	26
27	22	29	26	27	25
<u>12/8</u>	<u>12/9</u>	<u>12/10</u>	<u>12/11</u>	<u>12/15</u>	
28	27	27	30	29	
24	25	24	24	25	
25	26	26	26	--	
25	--	27	25	--	

Appendix G

R Values Attained

R Values Attained

	T_1	T_2
<u>Aerobic Dance</u>		
Subject #1	1.02	1.10
#2	1.08	1.06
#3	.95a	1.05
#4	1.08	1.15
<u>Water Aerobics</u>		
Subject #1	1.04	1.16
#2	.97b	1.09
#3	1.00	1.11
#4	1.03	1.02
<u>Control</u>		
Subject #1	1.10	1.09
#2	1.04	1.04
#3	1.07	1.03

a: age predicted maximal heart rate = 198

HR achieved = 210

b: age predicted maximal heart rate = 201

HR max achieved = 200