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ABSTRACT

Water aerobics is one mode of exercise that is gaining popularity. Water aerobics allows adults who participate in an exercise program to improve their cardiorespiratory fitness. The purpose of this study was to determine if water aerobic training is as effective as land dance aerobic training in improving cardiorespiratory fitness in sedentary healthy adults. Eighteen subjects participated in this study; nine in dance aerobics and nine in water aerobics. Before and after eight weeks of training, subjects performed a graded maximal exercise test on a Schwinn Air-Dyne while maximal oxygen uptake was measured via a Beckman Metabolic Cart. ANCOVA was used to analyze the data with mode, age, weight, and prior activity level as covariates. There was no significant difference found in the training effects between the water and land aerobics and both groups improved their maximal oxygen uptake significantly (p-value = 0.004). Therefore, water aerobics appears to be an effective means of improving cardiorespiratory fitness in sedentary healthy adults.

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PREFACE

Hypothesis

There will be no significant difference in improvements in VO2 max following eight weeks of dance aerobic training and eight weeks of water aerobic training in healthy sedentary adults.

Operational Definition of Terms

1. Low-impact aerobic dance: At least one foot is touching the floor throughout the aerobic portion of the workout, with non ballistic movements that consist of large upper body movements with a wide range of motion.
2. Sedentary: Individuals who do not engage in regular aerobic physical activity of 20 minutes or more duration greater than two times per week.
3. VO2 max: The largest rate of oxygen consumption achieved during exercise at sea level: expressed in liters per minute (L/min) or milliliters per kilogram of body weight per minute (ml/kg/min).
4. Water aerobics: Continuous rhythmic exercise routines in waist to chest deep water using various muscle groups.

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CHAPTER 1

INTRODUCTION

Exercise is an important component in physical therapy programs and in maintaining a healthy lifestyle. The conditioning effects gained from an exercise program enable an individual to perform daily activities at a higher functioning level. Physical therapists use a wide range of exercise modes to improve cardiorespiratory endurance. One mode that is gaining popularity is water aerobics. Water aerobics allows adults, who participate in an exercise program, to improve their cardiorespiratory fitness (Cassady and Nielsen, 1992; Vickery, Cureton, and Langstaff, 1983). This type of conditioning is an alternative for healthy adults who dislike land exercise, as well as some unhealthy adults who have poor tolerance for land exercise. Those who might avoid land exercises include individuals suffering from arthritis (Cassady & Nielsen, 1992; Koszuta, 1989; Weinstein, 1986), painful joints (Ruoti, Troup, & Berger, 1994; Weinstein, 1986; Whitley & Schoene, 1987), chronic back and knee problems (Cassady & Nielsen, 1992; Geim & Nicholas, 1989; Weinstein, 1986), cardiovascular disease (Fernhall, Manfredi, & Congdon, 1992; Harrison, Bruce, Brown, & Cochrane, 1980; McMurray, Fiesalman, Avory, & Sheps, 1988), weak leg musculature and musculoskeletal disabilities (Miller, 1990; Ruoti et al., 1994), and orthopedic dysfunction (Cassady & Nielsen, 1992). Water aerobics can facilitate movement, conditioning, and strength training in a non-impact environment and the likelihood of injury from overuse is thus reduced (Koszuta, 1986; Koszuta, 1989).

The most accurate measure of cardiorespiratory fitness in adults is maximal oxygen consumption (VO2 max) (Kaminsky, Wehrli, Mahon, Robbins, Powers, & Whaley, 1993). Maximal oxygen uptake defines the efficiency of the heart (Froelicher, Thompson, Davis, & Triebwasser, 1975; Naughton & Hellerstein, 1973). A review of literature revealed no studies that compared the training effects, as assessed by increases in VO2 max, of water aerobic training and dance aerobic training. Many studies, however, have found that dance aerobic training elicits a significant improvement in VO2 max (McCord, Nichols, & Patterson, 1989; Parker, Hurley, Hanlon, & Vaccaro, 1989; Williford, Blessing, Barksdale, & Smith, 1988; Blessing, Wilison, Puckett, & Ford, 1987; Dowdy, Cureton, DuVal, & Ouzts, 1985; Milburn & Butts, 1993; Vaccaro & Clinton, 1981), whereas few studies have examined the training effects of water aerobics. Research is needed to determine if water aerobic training can provide improvements in maximal oxygen consumption comparable to results achieved through dance aerobic training. Due to the lack of reliable data, health care providers do not have a basis for recommending water exercises and activities for their patients (Koszuta, 1989).

This study seeks to answer the question: Can a prescribed eight week water aerobics training program achieve similar improvements in VO2 max as does a dance aerobic training program? Thus, the purpose of this study is to determine if water aerobic training is as effective as land dance aerobic training in improving cardiorespiratory fitness in sedentary adults.

CHAPTER 2

LITERATURE REVIEW

Previous studies have investigated the training effects, as measured by increases in VO2 max, of dance aerobics (Blessing et al., 1987; Dowdy et al., 1985; McCord et al., 1989; Miller, 1990; Parker et al., 1989; Vaccaro & Clinton, 1981), water aerobics (Ruoti et al., 1994), swimming (Magel, Foglia, McArdle, Gutin, Pechar, & Katch, 1974; McArdle, Magel, Delio, Toner, & Chase, 1978; Oscai, Williams, & Hertag; 1968), cycle ergometry on land (Avellini, Shapiro, & Pandolf, 1983; Blumenthal, Emery, Madden, Coieman, Riddle, Schniebolk, Cobb, Sullivan, & Higginbotham, 1991; Sheldahl, Tristani, Clifford, Kalbfleisch, Smits, & Hughes, 1986), cycle ergometry in water (Avellini et al., 1983; Blumenthal et al., 1991; Sheldahl et al., 1986), and treadmill running (McArdle et al., 1978). This review of literature examined the properties of water, the heart rate and VO2 relationship, guidelines for exercise, land aerobic training and oxygen consumption, water exercise training and oxygen consumption, and measurement processes. These areas were reviewed as they relate to whether water aerobic training is as effective as land dance aerobic training in improving cardiovascular fitness in sedentary adults.

Properties of Water

The inherent properties of water include buoyancy, hydrostatic pressure, and viscosity (Johnson, Stromme, Adamczyk, & Tennot, 1977; McMurray et al., 1988). Buoyancy provides shock absorbing effects which significantly lessen weight bearing stresses, therefore minimizing the risk of injury (Gleim & Nicholas, 1989; Ruoti et al., 1994; Weinstein, 1986). In water, bodies weigh approximately ten percent of their dry-land weight (Koszuta, 1986; Mayse, 1991). Therefore, impact forces transmitted through the body are decreased, reducing stress on muscles and joints (Weinstein, 1986). In addition, patients with impact injuries or chronic joint pain may exercise in water without suffering from severe pain (Miller, 1990). Finally, buoyancy allows for less activity of the anti-gravity muscles making it easier for the patient to maintain proper body posture (Butts, Tucker, & Smith, 1991).

The property of external hydrostatic pressure causes a central shift in blood volume increasing central venous pressure. Increased central venous pressure subsequently causes an increase in stroke volume which may cause a decrease in heart rate with or without exercise (Butts et al., 1991; Cassady & Neilsen, 1992; Johnson et al., 1977; McArdle, Magel, Lesmes, & Pechar, 1976; Miller, 1990; Sheldahl et al., 1986; Svedenhag & Seger, 1992). Exercise at a lower heart rate lessens the stress on the heart which may be beneficial for cardiac patients. In addition, subjects may work at a higher physiological work load (Cassady & Nielsen, 1992).

The viscosity of water offers resistance to joint movement in all directions. Resistance allows exercise loading of various intensities on muscle groups, which produces greater muscular tension than that achieved for the same movements on land (Koszuta, 1986; Ruoti et al., 1994). The amount of resistance is determined by the speed the limbs are moved through the water and the surface area presented to the water. Implements such as web gloves, water bottles, and water exercise devices can also be used to increase resistance.

Heart Rate and VO2 Relationship

Cox (1991) defines oxygen uptake as the use of oxygen by the working tissues at any given rate of work. Absolute VO2 max, expressed as liters per minute (L/min.) or relative VO2 max expressed as milliliters per kilogram of body weight per minute (ml/kg/min.), is the body's ability to use oxygen maximally. The measurement of aerobic power reflects the ability to bring oxygen to the tissues, the extraction of oxygen by the muscles, and the oxygen use by aerobic metabolism (Cox, 1991). VO2 max is dependent on the cardiovascular and muscular systems (ACSM, 1988). An increase in VO2 max is correlated with an improvement in cardiovascular function as a result of training. Changes due to training have been reported to range from 5% to nearly 100%. However, increases above 20% are usually elicited in individuals with extremely low initial levels of cardiorespiratory fitness who undergo body mass decreases (Cox, 1991). Improvement in oxygen uptake is directly related to duration, intensity, and frequency of training (ACSM, 1990). Measurements of heart rate are conventionally used to assess work intensity. Heart rates may differ in water from those on land due to apprehension of water environment, hydrostatic pressure, and body position (Green, Cable, & Elms, 1990). Hydrostatic pressure causes a central shift and an increase in end diastolic volume leading to a decreased resting heart rate in water as compared to land. Target heart rate is the heart rate to be achieved and maintained during exercise, and is found to be ten percent lower in water than on land due to less gravitational pull secondary to buoyancy (Koszuta, 1989). The previous statement is especially true when an individual is supine in the water placing the heart in a horizontal position. Risch, Koubenec, Beckmann, Lange, & Gauer (1978) state that, as the water level is raised from the pubic symphysis to the xyphoid, the heart rate decreases approximately 15% as compared to the heart rate on land. Therefore, the heart rate in water is not only less when in the supine position, but also when one is upright during water aerobics.

Studies confirm that water temperature has an influence on cardiovascular adjustments to exercise. McArdle et al. (1976) investigated the metabolic and cardiovascular adjustments to work in air and water at 18, 25, and 33 degrees Celsius. Six male subjects were tested at rest and during exercise using an arm-leg cycle ergometer. The researchers found there was no difference in the relationship of VO2 and heart rate between water and land activity when the water was 33 degrees Celsius. However, at 18 and 25 degrees Celsius, the average heart rates in water were, respectively, 15 and 10 beats per minute lower than on land. Svedenhag and Seger

(1992) found a similar heart rate reduction at 25 degrees Celsius (as did McArdle et al.) in their comparison study of ten trained male runners. Avellini et al. (1983) found that in 20 degree Celsius water, heart rates were 20 beats lower than on land and in water at 32 degrees Celsius. The authors conducted this study on 15 unconditioned young men who exercised on a cycle ergometer either on land or immersed to the neck in water.

A linear increase in heart rate and oxygen consumption has been shown during traditional aerobic exercise such as running, cycling, and swimming with increased work intensity (Eckerson & Anderson, 1992; Holmer & Astrand, 1972; Parker et al., 1989). The traditional use of heart rate to predict VO2 is based on this assumption of linearity. This linear relationship has not been well established for dance aerobics (Parker et al., 1989; Williford, Blessing, Olson & Smith, 1989). Berry, Cline, Berry & Davis (1992), compared dance aerobics where the arms were overhead, dance aerobics where arms were below shoulder level, and treadmill running with nine healthy females. The researchers found a linear relationship between heart rate and VO2 during the two forms of low intensity dance aerobics and running. Parker et al. (1989) performed a study to determine heart rate and VO2 relationship for 14 untrained females during one dance aerobic session. The researchers found that heart rates during dance aerobics represented a lower absolute VO2 (L/min.) than that of running. In addition, Thomsen and Ballor (1991) conducted a study to determine physiological responses of 27 healthy females during dance aerobics. They found that for high intensity work, defined as greater than 90% of maximum heart rate, there was not a linear relationship between heart rate and VO2. However, this would be expected since at greater than 90% of maximum heart rate, one would be working anaerobically.

Williford et al. (1989) discovered that a higher heart rate elicited during dance aerobics was not correlated with an increase in VO2 after investigating the relative energy expenditures of ten women performing four different dance aerobic routines. The lack of correlation may be due to the added stress of an individual's desire to keep up with the group, which may raise heart rate out of proportion to VO2. Also, the individual's involvement with the music may cause them to forget how hard they are working, and the vigorous overhead arm movements involved in dance aerobics may be a factor leading to a nonlinear relationship. Bell and Bassey (1994) assessed oxygen uptake and heart rate in various dance styles and in a step test of ten healthy women. They found the relationship between heart rate and oxygen uptake to be relatively linear. It is interesting to note that in their study there was no static work of the arms above shoulder level.

The location of the arms may be an important training variable. Bell and Bassey (1994) support this conclusion with their suggestion that static use of the arms may elevate heart rate at a different rate than VO2. These findings suggest that the use of a target heart rate to estimate VO2 may be inaccurate. Toner, Glickman, & McArdle (1990) investigated cardiovascular adjustments to arm-leg exercise. They concluded that, when 25% of total energy expenditure is due to arm work, elevations in heart rates are above those expected for energy expenditure. Berry et al. (1992) suggested that prolonged overhead arm work during dance aerobics increases the heart rate disproportionately due to an increase in sympathetic outflow. Astrand, Ekblom, Messin, Saltin, & Stenberg (1965) examined submaximal and maximal arm and leg exercise in 13 subjects comparing oxygen uptake and heart rate. They found that heart rate is usually higher in arm work than in leg work.

Sheldahl, Wann, Clifford, Tristani, Wolf, & Kalbfleisch (1984) concluded that at rest the heart rate-VO2 relationship did not differ between land and water. However, their results showed a significantly lower heart rate during high intensities of exercise in water than during the same exercise on land. The linear relationship of heart rate and oxygen uptake in water was not shown in a study by Eckerson and Anderson (1992).

They investigated heart rate and oxygen uptake of sixteen females prior to and following water aerobic training. These authors noted a greater heart rate response than VO2 response. The researchers concluded that when the arms are exercised above water there is an increase in vasoconstrictor tone, leading to a higher heart rate response. Therefore, the authors concluded that heart rate may not be an accurate index of exercise intensity during water aerobics.

In conclusion, heart rate may not be an accurate reflection of the level of maximal oxygen consumption at which one is exercising. This relationship is influenced by mode of exercise, position of arms in space, body position, and exercise medium.

Guidelines for Training

The American College of Sports Medicine (ACSM) recommends certain criteria for developing or maintaining cardiorespiratory fitness in the healthy adult. According to their recommendations, the frequency of training should be three to five days per week; the intensity of training should be at 60-90% of maximum heart rate or 50-85% of maximum oxygen uptake; the duration of training should consist of 20-60 minutes of continuous aerobic activity; and the mode of exercise can be any activity that continuously utilizes the large muscle groups of the body and is rhythmical and aerobic in nature (ACSM, 1990). According to Cox (1991), most participants involved in a properly designed fitness program will elicit a general training response within four to six weeks of the initiation of a program.

Training Effects of Land Aerobic Exercise on Oxygen Consumption

According to ACSM, dance aerobics has been shown to increase heart rates to levels above 55% of the maximum and, therefore, is considered a viable cardiovascular training mode (Bell & Bassey, 1994). Improvements in cardiorespiratory fitness as measured by VO2 max have ranged from 6% to 23% (Wiliford et al., 1989).

McCord et al. (1989) examined the training effects of a 12 week program of low-impact dance aerobics on 16 sedentary college-aged females. The program was held three times a week for 45 minutes. Results showed a significant 7.62% increase in relative VO2 max and a 5.2% increase in absolute VO2 max. It was concluded that low-impact dance aerobics is just as effective in producing cardiovascular improvements as high-impact dance. One disadvantage to this study was the use of a treadmill test (a form of leg exercise) to measure oxygen consumption when arms were used in dance aerobics.

In a study conducted by Parker et al. (1989), 14 untrained females were investigated to measure the intensity and training effects of a dance aerobics session held three days per week for eight weeks. Maximal oxygen uptake was evaluated prior to and after the training period on a continuous treadmill test. The eight weeks of training resulted in a 11% improvement in relative VO2 max. As in the previous study, arm activity was not taken into consideration when comparing the VO2-heart rate relationship as measured on the treadmill.

Williford et al. (1988) conducted a study of ten healthy untrained females with mean age of 23 to identify improvements in cardiopulmonary function resulting from dance aerobics training. The subjects completed a maximal treadmill test prior to and at the end of the program using a modified Bruce protocol. Relative VO2 max increased 4% while absolute VO2 max increased 12.28%.

In a study conducted by Blessing et al. (1987), 28 sedentary college-aged females were investigated to determine the physiological effects of eight weeks of aerobic dance with and without hand-held weights. VO2 max was determined prior to and after exercise using a progressive treadmill test. The exercise intensity for the dance aerobics was prescribed between 75-85% of age predicted maximal heart rate. The hand-held weight group showed increases of 16% in absolute VO2 max and 13% in relative VO2 max. The nonhand-held weight group increased 15% and 14% respectively.

In a study by Dowdy et al. (1985), 28 sedentary females age 25 to 44 participated in a ten week dance aerobic conditioning program. VO2 max was assessed prior to and following the program by a continuous grade-incremented walking treadmill test. The workouts were between 70-85% of heart rate reserve. Relative VO2 max increased by 5-7% in this study.

Millburn and Butts (1983) conducted a study that compared the cardiorespiratory changes that resulted from a dance aerobic program to a comparable jogging program in untrained college-aged females. Forty-six subjects were given maximal treadmill tests using the modified Astrand protocol prior to, and after, seven weeks of training. The joggers and dancers trained four days per week at an intensity that represented 83-84% of their maximum heart rates. The joggers increased their absolute and relative VO2 max by 8.2% and the dancers increased their absolute VO2 max by 9.1% and relative by 10.2%. Both experimental groups decreased their maximal heart rates. The researchers concluded that both dance aerobics and jogging were equally effective exercise activities for improving cardiorespiratory responses. A study by Vaccaro and Clinton (1981) showed a 22.9% increase in relative VO2 max in ten women ages 19 to 27 after a ten week dance aerobics training program. In conclusion, cardiorespiratory improvements can be achieved from land aerobic exercise training following ACSM guidelines.

Training Effects of Water Exercise on Oxygen Consumption

Swimming is an example of a form of exercise that may elicit a training effect as measured by oxygen uptake. A study by Magel et al. (1974) investigated swim training effects on 15 male recreational swimmers in a ten week training session following ACSM guidelines. Prior to training, the researchers found no significant differences in VO2 max measurements between the experimental group and the control group. After the ten week period, the experimental group showed significant improvements in VO2 max and a significant decrease in maximum heart rate. However, the experimental group demonstrated no significant improvement in VO2 max during a running test that followed the swim training program, thus demonstrating specificity of training (Cox, 1991).

Few studies investigated the training effects as measured by oxygen uptake in water aerobics. Ruoti et al. (1994) conducted a study to determine the effects of water aerobic training on maximal oxygen uptake. Twelve subjects, with a mean age of 65 years, participated in an exercise program for 12 weeks. ACSM guidelines state that VO2 max decreases with age in sedentary adults over the age of 25 at a nine percent reduction per decade (ACSM, 1990). The results showed a 15% increase in VO2 max after training. The researchers concluded that water aerobics is an effective mode of exercise to improve cardiovascular fitness. A problem with this study was that maximum oxygen consumption was measured indirectly by a Gould 2900 Energy Measurement Module. An indirect technique may not be as accurate in assessing maximum oxygen consumption as a direct technique. Also, use of the treadmill test neglects the use of arm activity in water aerobics. Eckerson and Anderson (1992) assessed the energy demand during a water aerobics class. Sixteen college-aged females participated in the study. A continuous graded exercise test completed on the treadmill was performed prior to the training period. The VO2 measured during water aerobics was 48% of relative VO2 max. Although this measurement was slightly lower than the standards recommended by the ACSM for training, a heart rate response of 82% of maximal heart rate was achieved which met the ACSM standards. This study measured VO2 max during rather than after the training period, therefore training effects of VO2 max were not assessed.

Training Effects of Land Exercise Versus Water Exercise on Oxygen Consumption

A few studies compared the training response of land versus water exercise. Twenty-two healthy subjects participated in a study by Sheldahl et al. (1986). The authors attempted to determine the effects of exercise training with head-out immersion using a cycle ergometer in water versus on land. Relative VO2 max increased significantly in both groups (16% increase on land and 14% increase in water). Avellini et al. (1983) conducted a study of fifteen unconditioned men who trained using a cycle ergometer on land and in water. Training elicited an increase in absolute VO2 max of 16% on land and 13% and 15% in water at 32 degrees Celsius and 20 degrees Celsius respectively. McArdle et al. (1978) evaluated the specificity of ten weeks of run training on land by measuring VO2 max and heart rate changes during treadmill running and tethered swimming tests. The subjects consisted of 19 college-aged male recreational swimmers and one volunteer from the laboratory staff. VO2 max significantly improved when measured during treadmill running whereas VO2 max did not improve during tethered swimming. These findings support the concept of specificity of cardiovascular response to aerobic training and the authors suggested that local adaptations in skeletal muscles contribute to improvement of VO2 max.

Schwinn Air-Dyne Ergometer

The Schwinn Air-Dyne ergometer (SAE) is a stationary cycle that incorporates both arm and leg work. It utilizes the resistance of air on wind vanes set perpendicular on the fly-wheel. It provides workloads ranging from 25W to 500W (Fernandez & Pitetti, 1993; Pitetti & Tan, 1991). According to Fernandez and Pitetti (1993) and Pitetti and Tan (1991), the SAE is a valid exercise tool for assessing cardiopulmonary fitness, and has been shown to be a safe and reliable method for disabled populations. The traditional mode of stress testing is the treadmill and few researchers have utilized the SAE in this manner. Due to the fact that dance aerobics and water aerobics incorporate the use of both upper and lower extremities, and the SAE uses upper and lower extremities through leg pedaling and arm push/pull work, the SAE is our choice for stress testing. According to Cox (1991), directly measuring expired gases while the subject performs an exhaustive bout of exercise while utilizing the large muscle groups of the body is the most effective way to measure VO2 max. In a study by Pitetti and Tan (1990), 12 physically healthy and moderately retarded adults were recruited to participate in a study to determine their maximal physiological responses during incremental exercise using the SAE compared to their responses with treadmill exercise. The researchers found no significant difference between the two forms of exercise testing for maximal VO2 and heart rate.

Summary

Maximal oxygen uptake (VO2 max) has been widely used to represent cardiovascular responses resulting from aerobic training. Some researchers have estimated VO2 max by measuring heart rate, thus assuming a linear relationship between the two variables. However, other researchers have found that this relationship is not necessarily a linear one. This relationship depends on the type of exercise performed, and the position of arms in space. In order to develop cardiorespiratory fitness, the ACSM states that the training program should be three to five days per week, at 60-90% of maximum heart rate or 50-85% of maximum oxygen uptake, with each bout 20-60 minutes long. Previous studies that have researched training effects gained from aerobic activities (including swimming, running, and cycle ergometry) have found significant increases in VO2 max. Training studies of dance aerobics have shown increases in VO2 max. Very few studies have been conducted to identify the training effects of water aerobics on VO2 max. However, significant improvements in maximal oxygen uptake have been reported. No previous research was found that compared training effects as measured by oxygen uptake between dance aerobics and water aerobics. It is hypothesized that improvements in cardiovascular fitness in sedentary healthy adults, as measured by maximal oxygen consumption following eight weeks of training, will be similar between individuals trained by water aerobics and dance aerobics.

CHAPTER 3

METHODOLOGY

Design

This investigation was a quasi-experimental study consisting of two treatment groups. The independent variable was the mode of exercise, and consisted of two subsets: dance aerobic training and water aerobic training. The dependent variable was maximal oxygen consumption. Maximal oxygen uptake was measured prior to and after training to determine if training effects occurred.

Subjects

Thirty-three healthy sedentary subjects from Grand Valley State University (GVSU) and the surrounding community were recruited on the basis that they were not currently aerobically exercising more than two times per week. Participants completed a self-report health screen form (see Appendix A). This form evaluated the physical condition of each participant, and is the standard medical-health history questionnaire utilized by the Grand Valley State University Staff/Student Health and Physical Exercise Program. To be eligible for inclusion in this study, participants were: (1) able to read and write English, (2) 18 to 40 years old if male, (3) 18 to 50 years old if female, (4) not exercising in a regular aerobic program more than two times per week, (5) "apparently healthy" as defined by ACSM guidelines (see Appendix B), (6) able to successfully complete the pretest with no adverse effects according to the ACSM guidelines for exercise termination (Appendix C), (7) free of contraindications of exercise testing according to the ACSM guidelines (see Appendix D). The "apparently healthy" and sedentary population with age restrictions were chosen in order to avoid the necessity of a physician being present during exercise testing as well as to show the greatest training effects possible. Participants were given the choice of attending an evening or morning aerobic class. After their choice was made, they were informed that the morning class was the water aerobics and the evening class was the dance aerobics. Participants were given the opportunity to voice any questions or concerns that they had regarding the research study. Following this, they were provided with an informed consent form (see Appendix E) to read and sign. The testing was conducted in the Human Performance Laboratory in the Field House, GVSU. The exercise programs were conducted in the pool and the dance studio in the Field House. The subjects were allowed only three absences during the training program.

Instruments

To reduce the time spent completing tests, and to improve the accuracy and reliability, the scientific community developed computer technology resulting in the development of the Beckman MMC (Wilmore, Davis, & Norton, 1976). Maximal oxygen consumption was measured by means of the Beckman MMC. This device is a complete and mobile system designed to provide a totally automated assessment of metabolic, respiratory, and ventilatory parameters both at rest and during exercise. The MMC contains analyzers and sensors for analyzing and measuring expired air. The gas collection system consists of a Hans-Rudolph nonrebreathing valve, low resistance tubing, and a high velocity volume transducer. Expired air is pulled through a drying column and into a Beckman OM-11 O2 analyzer and a LB-2 CO2 analyzer. The analyzers' response time is less than one second and consists of a resolution of 0.01% and an accuracy of +/- 1.0%. Oxygen consumption (VO2) can be measured as often as every 30 seconds in liters/minute (L/min) and milliliters/kilogram of body weight/minute (ml/kg/min). The gas volume measurements are calibrated before and after each exercise test.

Procedures

A full review of the study was conducted and approved by the Grand Valley State University Human Subjects Review Board prior to the recruitment of subjects. The study consisted of a pretraining graded maximal exercise test; eight weeks of either submaximal dance aerobic training or water aerobic training; a midpoint measurement of oxygen consumption of one subject during the performance of the water aerobic and dance aerobic routines; and a post training maximal graded exercise test. Prior to the pretest, subjects were acquainted with the testing equipment. Both the pretraining and post training exercise tests were performed on an air-braked Schwinn ergometer utilizing the ACSM Air-Dyne Bike Maximal Test protocol (see Appendix F). During the pretest and posttest, each participant exercised until volitional exhaustion. Heart rates and rhythms were monitored continuously by means of a five lead electrocardiogram (EKG). Blood pressure and ratings of perceived exertion (RPE) were measured and recorded every two minutes. Each participant's maximal oxygen consumption, carbon dioxide production and minute ventilation were measured by the Beckman MMC. The Beckman MMC analyzed expired air and reported it every minute. Criteria for obtaining VO2 max was when a plateau was reached or a decline was noted in VO2 with an increase in workload. The Beckman MMC was calibrated prior to and following each graded exercise test.

Four weeks into the aerobic classes, one participant from each class volunteered to perform the aerobic routine while their maximal oxygen consumption was measured directly by the Beckman MMC. The purpose of this procedure was to ensure that the mean percentage of VO2 max achieved during the water and dance aerobic classes met the training standards of the ACSM. This allowed the principal investigators to evaluate the intensity level of both routines.

All data obtained from the study remained confidential and was stored and identified by a code number. Confidentiality was maintained by a master key kept separately from the collected data.

Treatment consisted of eight weeks of submaximal training. Each treatment session consisted of 25 minutes of conditioning exercise. During this time participants monitored their heart rates by taking a six second carotid pulse approximately every five minutes and were able to maintain an intensity equal to 70% to 90% of their maximal heart rate. Prior to training, each participant was informed of their target heart rate range at 70% and 90% of maximum and was instructed to maintain this range throughout the conditioning phase. The 25 minute conditioning period was preceded by a ten minute warm-up and followed by a ten minute cool-down. This training occurred three times per week for an eight week period based on ACSM guidelines (ACSM, 1991). The conditioning exercises for both aerobic dance and water aerobic treatment groups included low-impact, high intensity exercise routines taught by the principle investigators. Similar music was used during the conditioning phase for both exercise classes. In addition, both exercise routines were performed consecutively without rest and included concurrent alternating arm movements such as punching, scissoring, and circling above and below shoulder level to the tempo of the music. Hand-held water bottles were used in the water aerobic routine after three weeks in order to increase work load and maintain target heart rate level. The lower extremity exercises in the water included jogging in place, straight leg kicking, high knee raising, and various forms of jumping; whereas the land exercises included marching in place, lunging, braiding, and forward/backward and sideways stepping. The average water temperature during the study was 28.3 degrees Celsius.

Potential risks were minimized to participants in the study by screening the health and fitness of potential participants. Careful observations of heart rate, blood pressure, and ratings of perceived exertion were made during all testing and trained personnel and emergency equipment were present.

Statistical Design

All data were analyzed using the SAS software package on IBM personal compatible computers. The data was statistically compared using ANCOVA. The variable representing the difference between the pretest score and the posttest score for VO2 max (ml/kg/min) was the dependent variable. Age, preweight, prior activity level, and exercise mode were the independent variables. ANCOVA determined whether each independent variable was explaining a significant variation in the dependent variable. If the p-value exceeded 0.05, the null hypothesis would be rejected. Therefore, we would have to conclude that there was no statistical evidence explaining a significant amount of variation in VO2 max. A correlated Sign Test and a t-test were used to test the differences in VO2 consumption prior to and following training in both groups.

CHAPTER 4

RESULTS

Subjects

Thirty-three subjects were recruited to participate in the study. Three subjects did not meet the inclusion criteria. Of these three who did not meet the criteria, two exceeded the age limit, and one had a history of cardiac problems.

Thirty remaining candidates participated in the study. Ten subjects dropped out during the training programs or exceeded three absences. Two additional subjects were excluded secondary to equipment malfunction during testing.

The data of the eighteen remaining subjects was examined. Each group consisted of eight females and one male. The mean age of the subjects in the land program was 28 years old and the mean height was 66 inches. The subjects in the water program had a mean age of 33 years and a mean height of 64 inches. Activity level of the subjects, prior to the study, was examined. Five subjects in the land group and six subjects in the water group reported participating in some recreational activities.

Table 1 summarizes statistical data including pretest and postest measurements for weight, relative VO2 max, absolute VO2 max, and maximum heart rate (MHR) for all subjects. There was a mean decrease in weight of 0.08 kg. or 0.1% and in MHR of 5.89 beats per minute or 3.2%. Mean relative VO2 max increased by 3.03 ml/kg/min. or 11.7% and mean absolute VO2 max increased by 0.2 L/min. or 11.6%. Figure 1 compares the relative VO2 max results between pretest and posttest trials for the entire group and displays a range of data. In order to look at the land and water groups separately, summary statistics were calculated for each group. Table 2 shows the statistics for the subjects who participated in the land program.

Table 1

Summary Statistics for Entire Sample

	Pre		Post		% Difference
	Mean	S.D.	Mean	S.D.	
Weight	67.73	14.90	67.65	14.74	0.1
RVO2 max	25.82	4.28	28.85*	5.62	11.7
AVO2 max	1.73	0.41	1.93	0.53	11.6
MHR	188.11	9.21	182.22	11.30	3.2

* indicates a significant difference ($p \leq 0.001$) in pre and post tests.

Note. Weight measured in kilograms; RVO2 max = Relative VO2 max (ml/kg/min); AVO2 max = Absolute VO2 max (L/min); MHR = Maximum Heart Rate (beats/min).

Overall, the land group showed a mean increase in weight (0.61 kg or 0.9%), relative VO2 max (3.34 ml/kg/min or 13.0%), and absolute VO2 max (0.22 L/min or 12.9%). The land group also showed a decrease in mean MHR (5.56 beats/min or 3.0%). Table 3 shows the statistics for the subjects who participated in the water program. The water group showed a mean increase in relative VO2 max (2.72 ml/kg/min or 10.6%) and absolute VO2 max (0.18 L/min or 10.3%). The water group showed a decrease in mean weight (0.76 kg or 1.1%) and MHR (6.22 beats/min or 3.4%). In addition, both groups showed a 2.4% decrease in ratings of perceived exertion. Figure 2 compares relative VO2 max pretest and posttest results between the land and water groups displaying the mean and the range from low to high values.

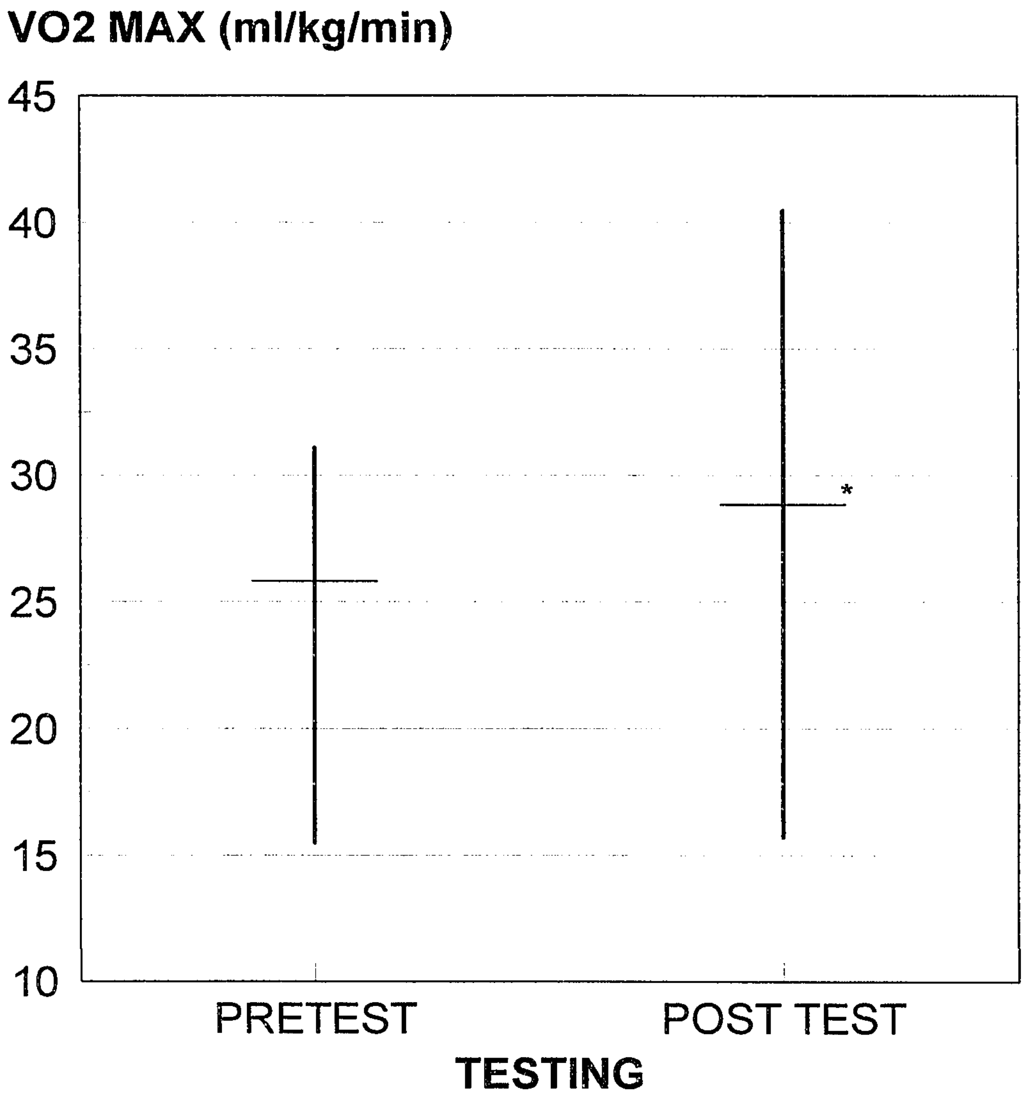

FIGURE 1. The range and mean of VO2 max of pre and post tests for all subjects. (* indicates a significant difference ($p \leq 0.001$) in pre and post tests.)

Table 2

Summary Statistics for the Land Program

	Pre		Post		% Difference
	Mean	S.D.	Mean	S.D.	
Weight	66.41	10.58	67.02	11.00	0.9
RVO2 max	25.79	3.79	29.13*	4.56	13.0
AVO2 max	1.71	0.35	1.93	0.29	12.9
MHR	188.11	7.25	182.56	9.45	3.0

* indicates a significant difference ($p \leq 0.01$) in pre and post tests.

Note. Weight measured in kilograms; RVO2 max = Relative VO2 max (ml/kg/min); AVO2 max = Absolute VO2 max (L/min); MHR = Maximum Heart Rate (beats/min).

Statistical Techniques

ANCOVA is based on the following four assumptions: (1) the groups being compared come from a normal distribution, (2) the groups have equal variances, (3) all the data is independent, and (4) parallelism exists. To assess the normality assumption, a normality value was calculated for the land group and for the water group. The hypotheses for this test are as follows: Ho: The distribution is normal and Ha: The distribution is not normal. For the land group, the p-value was 0.0543, whereas, the water group had a p-value of 0.0008. Since these p-values are small, for both groups, we would reject the null hypothesis and conclude that the two groups do not come from a normal distribution. Thus, the normality assumption was not met. Since the other three

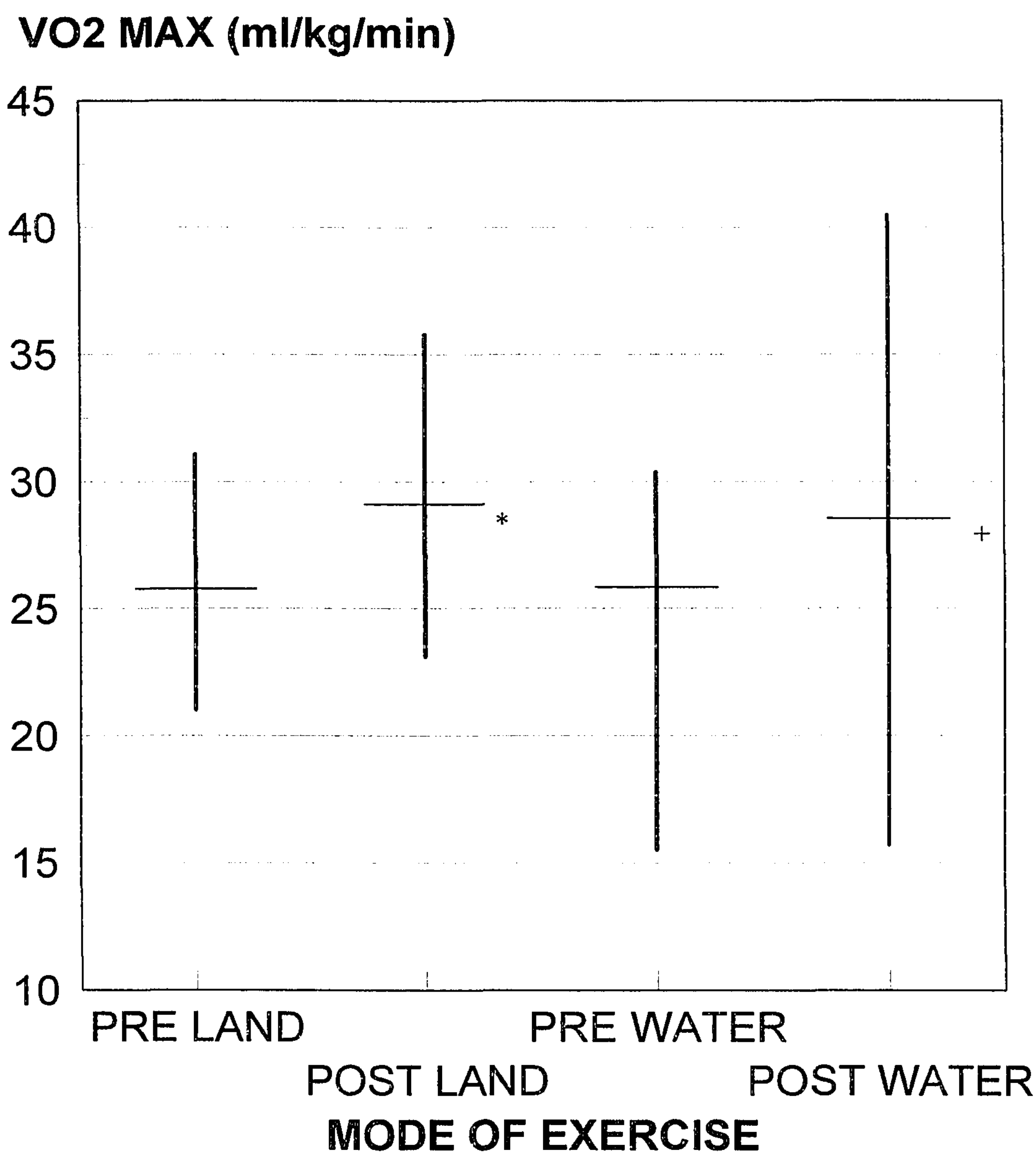

Figure 2. The range and mean of VO2 max of pre and post tests for land and water aerobic subjects. (* indicates a significant difference ($p \leq 0.01$) in pre and post tests of the land subjects; + indicates a significant difference ($p \leq 0.05$) in pre and post tests of the water subjects.)

Table 3

Summary Statistics for the Water Program

	Pre		Post		% Difference
	Mean	S.D.	Mean	S.D.	
Weight	69.04	18.87	68.28	18.44	1.1
RVO2 max	25.84	4.95	28.57*	6.79	10.6
AVO2 max	1.75	0.49	1.93	0.71	10.3
MHR	188.11	11.30	181.89	13.48	3.4

* indicates a significant difference ($p \leq 0.05$) in pre and post tests.

Note. Weight measured in kilograms; RVO2 max = Relative VO2 max (ml/kg/min); AVO2 max = Absolute VO2 max (L/min); MHR = Maximum Heart Rate (beats/min).

assumptions were met, the ANCOVA analysis was valid. The most straight forward way to analyze non-normal data is to use a distribution-free procedure such as the Sign Test.

The Sign Test is a nonparametric test used to determine if changes occurred within each group between the pretest and posttest. By counting how many of the differences are positive and looking up the number on a table, a p-value is obtained. Each group had nine different scores. For the land group, each group was positive, meaning that each person improved. From the table, the p-value was 0.004. The same results occurred for the water group. Thus, both the land and the water group resulted in significant differences in VO2 consumption.

In addition to the Sign Test, a t-test was performed to analyze the significance of the differences in VO2 max in all subjects and within each group. Significant improvements (p-value = 0.0004), as measured by an increase in relative VO2 max, of all subjects was noted. The land group and water group resulted in significant improvements at a p-value of 0.008 and 0.034 respectively.

Table 4 displays the p-values of the independent variables. The p-value of the age variable was considerably less than the preweight, activity, and exercise mode variables. Thus, a second ANCOVA was performed which excluded preweight and activity. The results of this ANCOVA procedure (summarized in Table 5) showed that age was a factor in explaining variation in relative VO2 max. However, differences in modes of exercise did not explain any of the variation in relative VO2 max. Therefore, there is no significant difference in the two modes of exercise, thus supporting the null hypothesis.

Table 4

First ANCOVA Procedure

Dependent Variable: Relative VO2 max Difference

Source	P Value
Exercise Mode	0.89
Activity	0.37
Preweight	0.73
Age	0.08

Table 5

Second ANCOVA Procedure

Dependent Variable: Relative VO2 max Difference

Source	P Value
Exercise Mode	0.93
Age	0.07

CHAPTER 5

DISCUSSION AND IMPLICATIONS

The results of this study support the hypothesis that no significant difference exists in improvements in VO2 max following eight weeks of dance aerobic training and eight weeks of water aerobic training in healthy, sedentary adults. In this study the dance aerobic group and water aerobic group both demonstrated significant improvement in relative VO2 max of 13.0% and 10.6%, respectively. The absolute VO2 max improvements of 12.9% for dance aerobics and 10.3% for water aerobics were similar to those results found for relative VO2 max. Therefore, the absolute VO2 max was not statistically analyzed for significance based on the emphasis previous literature placed on relative VO2 max.

Previous literature, as shown in Table 6, supports the use of dance aerobics in achieving a training effect as measured by relative VO2 max. The 13.0% improvement in VO2 max in this study is comparable to a 12.0% average improvement determined from the seven cited studies in Table 6. ACSM guidelines state improvements in VO2 max may range from 5% to 30% depending on the quantity and quality of training (ACSM, 1990). The VO2 max improvements noted from the supporting studies ranged from 5.6% to 22.9%. It is interesting to note that subjects in the present study had a pretest VO2 max value which was 5.32 to 12.59 ml/kg/min lower than that found in the aforementioned studies. According to ACSM guidelines, individuals with a low initial level of fitness, such as the subjects in the present study, will have a lower initial VO2 max (ACSM, 1990).

The literature review revealed one study which assessed the training effects of water aerobics as noted in Table 7. This study performed by Ruoti et al. (1994) showed an improvement of 15.3% as compared to a 10.6% gain in the current study. However,

Table 6

Comparison of land study to literature

Study	N	Age (yrs)	Frequency (days/wk)	Length (wks)	PreVO2max (ml/kg/min)	PostVO2max (ml/kg/min)	Difference (%)
Present (1996)	9	28	3	8	25.79	29.13	13.0
McCord et al. (1989)	16	17-29	3	12	38.38	41.30	7.6
Parker et al. (1989)	14	18-21	3	8	34.40	38.10	10.8
Blessing et al. (1987)	14	20	3	8	36.50	41.90	14.8
Williford et al. (1986)	10	23	3	10	34.68	38.94	12.28
Dowdy et al. (1985)	18	32	3	10	33.80	35.70	5.62
Milburn & Butts (1984)	15	21	4	7	35.40	39.00	10.17
Vaccaro & Clinton (1981)	10	21	3	10	31.11	38.24	22.90

Table 7

Comparison of water study to literature

Study	N	Age (yrs)	Frequency (days/wk)	Length (wks)	PreVO2max (ml/kg/min)	PostVO2max (ml/kg/min)	Difference (%)
Present (1996)	9	33	3	8	25.84	28.57	10.6
Ruoti et al. (1994)	12	65	3	12	23.37	26.95	15.3

the mean age of the subjects in Ruoti et al. (1994) was 65 years old. ACSM guidelines state that VO2 max decreases with age in sedentary adults over age 25 at a 9% reduction per decade (ACSM, 1990). In addition, the subjects had a lower initial VO2 max and trained four weeks longer than the present study, which may also explain the larger training improvement. Ruoti et al. (1994) and the present study support the use of water aerobic training in improving cardiovascular fitness to a comparable level as that achieved with dance aerobics.

Traditional aerobic exercises such as running and swimming have demonstrated a linear relationship between heart rate and VO2 max. This linear relationship has not been well established for dance aerobics (Parker et al., 1989; Williford et al., 1989) or water aerobics. Heart rates were monitored during the exercise routines in the present study to ensure that the intensity of the routine was adequate to obtain training effects. However, because this linear relationship has not been well established for dance aerobics or water aerobics, the pilot study was conducted to examine the intensity of the aerobic routines based on the percentage of VO2 max. The pilot study ensured that the subjects were achieving 50% to 85% of their VO2 max, which is the recommended percentage for training effects by the ACSM (1990).

Limitations

Limitations of this study include small sample size and convenience placement of subjects into exercise groups. Test results may have been influenced by participant motivation levels during testing procedures, ineffective measurements due to discomfort of the testing equipment, and specificity of training as it relates to maximum exercise testing on the SAE as compared to conditioning with either land or water aerobics.

Conclusion

In conclusion, water aerobic training may be as effective as land dance aerobic training in improving cardiovascular fitness in healthy sedentary adults. Significant improvements in VO2 max can be achieved from water aerobics and dance aerobics. Either mode of exercise is beneficial but water aerobics may be preferable for those suffering from painful joints (Ruoti et al., 1994; Weinstein, 1986; Whitley & Schoene, 1987), arthritis (Cassady & Nielsen, 1992; Koszuta, 1989; Weinstein, 1986), weak leg musculature and musculoskeletal disabilities (Miller, 1990; Ruoti et al, 1994), chronic back and knee problems (Cassady & Nielsen, 1992; Gleim & Nicholas, 1989; Weinstein, 1986), cardiovascular disease (Fernhall et al., 1992; Harrison et al., 1980; McMurray et al., 1988), or orthopedic dysfunction (Cassady & Nielsen, 1992). Therefore, individuals can benefit from the advantages of exercising in water and achieve similar cardiovascular improvements as with land exercise. These advantages include minimizing the risk of injury through lessened weight bearing stresses (Gleim & Nicholas, 1989; Ruoti et al., 1994; Weinstein, 1986), a lower energy requirement for maintaining posture due to a reduction in anti-gravity musculature use (Ruoti et al., 1994), and a resultant reduction of pain due to less force on the joints (Miller, 1990).

Due to the lack of previous research of the effects of water aerobic training, clinicians may find it difficult to prescribe water aerobics as a treatment mode for improving cardiovascular fitness in their patients. The present study has important clinical implications because it has demonstrated that water aerobic training may be as effective in achieving improvements in VO2 max as land aerobic training. Outcomes of this study indicate a need for further research to be performed on healthy individuals with a larger sample size, and with unhealthy and disabled populations.

References

American College of Sports Medicine (1990). The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adults. Medicine and Science in Sports and Exercise. 22(2), 265-274.

American College of Sports Medicine (1991). Guidelines for exercise testing and prescription. Philadelphia: Lea and Febiger.

American College of Sports Medicine (1988). Resource manual for guidelines for exercise testing and prescription. Philadelphia: Lea and Febiger.

Astrand, P., Ekblom, B., Messin, R., Saltin, B., & Stenberg, J. (1965). Intra-arterial blood pressure during exercise with different muscle groups. Journal of Applied Physiology, 20(2), 253-256.

Avellini, B. A., Shapiro, Y., & Pandolf, K. B. (1983). Cardio-respiratory physical training in water and on land. European Journal of Applied Physiology and Occupational Physiology, 50, 255-263.

Bell, J. M. & Bassey, E. J. (1994). A comparison of the relation between oxygen uptake and heart rate during different styles of aerobic dance and a traditional step test in women. European Journal of Applied Physiology and Occupational Physiology, 68, 20-24.

Berry, M. J., Cline, C. C., Berry, C. B., & Davis, M. (1992). A comparison between two forms of aerobic dance and treadmill running. Medicine and Science in Sports and Exercise, 24(8), 946-951.

Blessing, D. L., Wilison, G. D., Puckett, J. R., & Ford, H. T. (1987). The physiologic effects of eight weeks of aerobic dance with and without hand-held weights. The American Journal of Sports Medicine, 15(5), 508-510.

Blumenthal, J. A., Emery, C. F., Madden, D. J., Coleman, R. E., Riddle, M. W., Schneibolk, S., Cobb, F. R., Sullivan, M. J., & Higginbotham, M. B. (1991). Effects of exercise training on cardiorespiratory function in men and women > 60 years of age. The American Journal of Cardiology, 67, 633-639.

Butts, N. K., Tucker, M., & Smith, R. (1991). The maximal responses to treadmill and deep water running in high school female cross country runners. Research Quarterly for Exercise and Sport, 62(2), 236-239.

Cassady, S. L. & Nielsen, D. H. (1992). Cardiorespiratory responses of healthy subjects to calisthenics performed on land versus in water. Physical Therapy, 72(7), 532-538.

Cox, M. H. (1991). Exercise training programs and cardiorespiratory adaptation. Clinics in Sports Medicine, 10(1), 19-32.

Dowdy, D. B., Cureton, K. J., DuVal, H. P., & Ouzts, H. G. (1985). Effects of aerobic dance on physical work capacity, cardiovascular function and body composition of middle-aged women. Research Quarterly for Exercise and Sport, 56(3), 227-233.

Eckerson, J. & Anderson, T. (1992). Physiological response to water aerobics. The Journal of Sports Medicine and Physical Fitness, 32(3), 255-261.

Fernandez, J. E. & Pitetti, K. H. (1993). Training of ambulatory individuals with cerebral palsy. Archives of Physical Medicine and Rehabilitation, 74, 468-472.

Fernhall, B., Manfredi, T. G., & Congdon, K. (1992). Prescribing water-based exercise from treadmill and arm ergometry in cardiac patients. Medicine and Science in Sports and Exercise, 24(1), 139-143.

Froelicher, V. F., Thompson, A. J., Davis, G., & Triebwasser, J. H. (1975). Prediction of maximal oxygen consumption: Comparison of the Bruce and Balke treadmill protocols. Chest, 68(3), 331-336.

Gleim, G. W. & Nicholas, J. A. (1989). Metabolic costs and heart rate responses to treadmill walking in water at different depths and temperatures. The American Journal of Sports Medicine, 17(2), 248-252.

Green, J. H., Cable, N. T., & Elms, N. (1990). Heart rate and oxygen consumption during walking on land and deep water. Journal of Sports Medicine and Physical Fitness, 30(1), 49-52.

Harrison, M. H., Bruce, D. L., Brown, G. A., & Cochrane, L. A. (1980). A comparison of some indirect methods for predicting maximal oxygen uptake. Aviation, Space, and Environmental Medicine, 51(10), 1128-1133.

Holmer, I. & Astrand, P. (1972). Swimming training and maximal oxygen uptake. Journal of Applied physiology, 33(4), 510-513.

Johnson, B. L., Stromme, S. B., Adamczyk, J. W., & Tennot, K. O. (1977). Comparison of oxygen uptake and heart rate during exercises on land and in water. Physical Therapy, 57(3), 273-278.

Kaminsky, L. A., Wehrli, K. W., Mahon, A. D., Robbins, G. C., Powers, D. L., & Whaley, M. H. (1993). Evaluation of shallow water running test for the estimation of peak aerobic power. Medicine and Science in Sports and Exercise, 25(11), 1287-1292.

Koszuta, L. E. (1986). Water exercise causes ripples. The Physician and Sportsmedicine, 14(10), 163-167.

Koszuta, L. E. (1989). From sweats to swimsuits: Is water exercise the wave of the future? The Physician and Sportsmedicine, 17(4), 203-206.

Magel, J. R., Foglia, G. F., McArdle, W. D., Gutin, B., Pechar, G. S., & Katch, F. I. (1974). Specificity of swim training on maximum oxygen uptake. Journal of Applied Physiology, 38(1), 151-155.

Mayse, J. S. (1991). Aquacise and aquafitness for adapted aquatics. Palaestra, 54-56.

McArdle, W. D., Magel, J. R., Delio, D. J., Toner, M., & Chase, J. M. (1978). Specificity of run training on VO2 max and heart rate changes during running and swimming. Medicine and Science in Sports, 10(1), 16-20.

McArdle, W. D., Magel, J. R., Lesmes, G. R., & Pechar, G. S. (1976). Metabolic and cardiovascular adjustment to work in air and water at 18, 25, and 33 degrees Celsius. Journal of Applied Physiology, 40(1), 85-90.

McCord, P., Nichols, J., & Patterson, P. (1989). The effect of low impact dance training on aerobic capacity, submaximal heart rates and body composition of college-aged females. The Journal of Sports Medicine and Physical Fitness, 29(2), 184-188.

McMurray, R. G., Fieselman, C. C., Avory, K. E., & Sheps, D. S. (1988). Exercise hemodynamics in water and on land in patients with coronary artery disease. Journal of Cardiopulmonary Rehabilitation, 8(2), 69-75.

Milburn, S. & Butts, N. K. (1983). A comparison of the training responses to aerobic dance and jogging in college females. Medicine and Science in Sports and Exercise, 15(6), 510-513.

Miller, K. A. (1990). The cardiovascular and metabolic responses of men with cardio-vascular disease to aqua dynamic exercise. Unpublished master's thesis. University of North Carolina, Chapel Hill, NC.

Naughton, J. & Hellerstein, H. K. (1973). Exercise testing and exercise training in coronary heart disease. New York: Academic Press.

Oscai, L. B., Williams, B. T., & Hertag, B. A. (1968). Effect of exercise on blood volume. Journal of Applied Physiology, 24(5), 622-624.

Parker, S. B., Hurley, B. F., Hanlon, D. P., & Vaccarro, P. (1989). Failure of target heart rate to accurately monitor intensity during aerobic dance. Medicine and Science in Sports and Exercise, 21(2), 230-234.

Pitetti, K. H. & Tan, D. M. (1991). Effects of a minimally supervised exercise program for mentally retarded adults. Medicine and Science in Sports and Exercise, 23(5), 594-601.

Pitetti, K. H. & Tan, D. M. (1990). Cardiorespiratory responses of mentally retarded adults to air-brake ergometry and treadmill exercise. Archives of Physical Medicine and Rehabilitation, 71, 318-321.

Risch, W. D., Koubenec, H. J., Beckmann, U., Lange, S., & Gauer, O. H. (1978). The effect of graded immersion on heart volume, central venous pressure, pulmonary blood distribution, and heart rate in man. Pflueger Archives, 374, 115-118.

Ruoti, R. G., Troup, J. T., & Berger, R. A. (1994). The effects of nonswimming water exercises on older adults. Journal of Orthopedic Sports Physical Therapy, 9(3), 140-145.

Sheldahl, L. M., Wann, L. S., Clifford, P. S., Kalbfleisch, J. H., Smits, G., & Hughes, C. V. (1986). Effect of head-out water immersion on response to exercise training. Journal of Applied Physiology, 60(6), 1878-1881.

Sheldahl, L. M., Wann, L. S., Clifford, P. S., Tristani, F. E., Wolf, L. G., & Kalbfleisch, J. H. (1984). Effect of central hypervolemia on cardiac performance during exercise. Journal of Applied Physiology: Respiratory, Environmental, Exercise Physiology, 57(6), 1662-1667.

Svedenhag, J. & Seger, J. (1992). Running on land and in water: Comparative exercise physiology. Medicine and Science in Sports and Exercise, 24(10), 1155-1160.

Thomsen, D. & Ballor, D. L. (1991). Physiological responses during aerobic dance of individuals grouped by aerobic capacity and dance experience. Research Quarterly for Exercise and Sport, 62(1), 68-72.

Toner, M. M., Glickman, E. L., & McArdle, W. D. (1990). Cardiovascular adjustments to exercise distributed between the upper and lower body. Medicine and Science in Sports and Exercise, 22(6), 773-778.

Vaccaro, P. & Clinton, M. (1981). The effects of aerobic dance conditioning on the body composition and maximal oxygen uptake of college women. Journal of Sports Medicine, 21, 291-294.

Vickery, S. R., Cureton, K. J., & Langstaff, J. L. (1983). Heart rate and energy expenditure during aquadynamics. The Physician and Sportsmedicine, 11(3), 67-72.

Weinstein, L. (1986). The benefits of aquatic activity. Journal of Gerontological Nursing, 12(2), 7-11.

Whitley, J. D. & Schoene, L. L. (1987). Comparison of heart rate responses: Water walking versus treadmill walking. Physical Therapy, 67(10), 1501-1504.

Wilmore, J. H., Davis, J. A., & Norton, A. C. (1976). An automated system for assessing metabolic and respiratory responses during exercise. Journal of Applied Physiology, 40(4), 619-624.

Williford, H. N., Blessing, D. L., Barksdale, J. M., & Smith F. H. (1988). The effects of aerobic dance training on serum lipids, lipoproteins, and cardiopulmonary function. The Journal of Sports Medicine and Physical Fitness, 28(2), 151-157.

Williford, H. N., Blessing, D. L., Olson, M. S., & Smith, F. H. (1989). Is low-impact aerobic dance an effective cardiovascular workout? The Physician and Sportsmedicine, 17(3), 95-109.

Appendix A

Medical - Health History Questionnaire

GVSU Staff Health and Physical Exercise Program

All information in your medical - health history form will be kept confidential. As this data will be used in the evaluation of your health, you will want to make it as accurate and complete as possible, yet free of meaningless detail. Please fill out this form carefully and thoroughly. Then check it over to be sure that you have not left out anything.

Purpose: The information solicited on this form is necessary to evaluate the physical condition of each participant of the Grand Valley State Fitness Program and to prepare an exercise prescription for each participant.

A. PERSONAL DATA

Name__________________________ Date________ Date of Birth___________

Address________________________City/State/Zip________________________

Phone # ________________________Date of Last Physical Exam ____________

1. Do you have a specific personal medical alert? (Example: Allergic to Penicillin) If yes, please explain.______________________________________

   Medical Alert Identification: Bracelet (__) Neck Chain (__) Wallet Card (__)

   Not openly identified (__)

2. Do you wear contacts? Yes(__) No(__) If yes, please explain. ___________

3. What was/is your weight at: age 20__ age 30__ age 40__ age 50__

   present weight__

B. HEALTH AND MEDICAL INFORMATION

1. Do you have or have you experienced any of the following on a recurring basis?

	At Rest	During Exertion
a. Shortness of Breath?	Yes__No__	Yes__No__
b. Heart Murmers?	Yes__No__	Yes__No__
c. Daily Coughing?	Yes__No__	Yes__No__
d. Chest Pressure?	Yes__No__	Yes__No__
e. Chest Pain?	Yes__No__	Yes__No__
f. Dizziness/Fainting	Yes__No__	Yes__No__
g. Joint Soreness?	Yes__No__	Yes__No__
h. Chronic Muscular Soreness?	Yes__No__	Yes__No__
i. Joint Swelling?	Yes__No__	Yes__No__

If you have answered yes to any of the above questions, please explain.__________

____

2. Skeletal/Muscular History:
   a. Any bone or joint injuries? Yes__No__ If yes, when?_____________
      Please explain____
   b. Any cartilage or ligament injuries? Yes__No__ If yes, when?_______
      Please explain____
   c. Any major or chronic muscular injuries? Yes__No__ If yes, when?__
      Please explain____
   d. Any congenital muscular or structural disorders? Yes__No__ If yes, when?__________ Please explain_____________________________
   e. Are you taking any medications? Yes__No__ If yes, please list._____

      ____

3. Check the blanks below in front of those questions to which your answer is yes.

__Rheumatic Fever
__Phlebitis
__Scarlet Fever
__Infectious Mononucleosis
__Asthma
__Jaundice or Gallbladder Problems
__Major Surgery
__Any Nervous or Emotional Problems
__Urinary Tract Infections, Kidney Stones or Prostate Problems
__Varicose Veins
__Epilepsy
__Anemia
__Pneumonia
__Lung Disease
__Other Chronic Illness
__Hernias
__Allergies
__Arthritis of Legs or Arms
__Diptherias
__Thyroid Problems
__Abnormal Chest X-Rays

4. Circle the number within the box that best describes your experience with that topic.

Gout	No symptoms Negative Family History	Family History	Elevated Uric Acid 18% * No symptoms	New Onset Gout. Early Detected	Repeated Chronic Attacks	Gout with Renal and Osteo Complications	Score
	0	1	2	3	7	9	
Diabetes	No symptoms Negative Family History	Latent Positive Family History	Chemical	Mild Dietary Control	Moderate Oral Rx Control	Severe Insulin Control	Score
	0	1	3	5	5	8	

Heredity of CVD: Parents & Siblings	No Family History History of Cardiovascular Disease (CVD)	One with CVD Over 60 Years	Two with CVD Over 60 Years or One with CVD under 60	One Death from CVD under 60 years	Two Deaths from CVD under 60 years	Three Deaths from CVD under 60 years	Score
	1	2	3	4	6	7	
Present CVD Symptoms *	None	Occasional Fast Pulse and/or Irregular	Frequent Fast Pulse and/or Irregular	Dizziness or Chest Pain on Exertion	Occasional Chest Pain	Frequent Chest Pain	Score
	0	2	4	6	8	10	
Past Personal History	Completely Benign	CVD Symptoms * Not M.D. Confirmed	History of CVD Symptoms Examined by M.D.	Mild CVD No Present Treatment	CVD under Treatment	Hospitalized for CVD	Score
	0	4	5	6	8	10	
Tobacco Smoking	Nonuser		Cigarettes 10 or Less Per Day	Cigarettes 11-20 Per Day	Cigarettes 21-30 Per Day	Cigarettes Over 31 Per Day	Score
	0	1	2	4	6	10	
Stress	No Stress	Occasional Mild Stress	Frequent Mild Stress	Frequent Moderate Stress	Frequent High stress	Constant High Stress	Score
	1	2	3	4	5	7	

Exercise	Intensive job and Recreational Exertion 0	Moderate Job and Recreational Exertion 1	Sedentary Job and Intensive Recreation 2	Sedentary Job and Moderate Recreation 4	Sedentary and Light Recreation 6	Sedentary No Special Exercise 8	Score
Systolic Blood Pressure	<110 mm Hg 0	111-130 mm Hg 1	131-140 mm Hg 2	141-160 mm Hg 3	161-180 mm Hg 5	>180 mm Hg 7	Score
Diastolic Blood Pressure	<80 mm Hg 0	80-85 mm Hg 1	86-90 mm Hg 2	91-95 mm Hg 4	96-100 mm Hg 7	>100 mm Hg 9	Score
Cholesterol HDL___ LDL___	<180 mg % Diet Contains No Animals or Solid Fats 1	181-205 mg % 10% Animal or Solid Fats 2	206-230 mg % 20% Animal or Solid Fats 3	231-255 mg % 30% Animal or Solid Fats 4	256-280 mg % 40% Animal or Solid Fats 5	281-300 mg % 50% Animal or Solid Fats 7	Score

C. LIFESTYLE INVENTORY

1. What physical and recreational activities do you participate in and how often? (Please answer under both columns.)

   ACTIVITY (jogging, golf, skiing, etc.)   FREQUENCY (daily, weekly, monthly, etc.)

   ______________________________   ______________________________

   ______________________________   ______________________________

2. On the average, how many hours per day and week do you spend at work?

   Per day?_______ Per week?_______

3. On the average, how many days per month are you traveling on business?____

   ____

4. Have you followed any special diet within the last year? Yes__No__ If yes, please explain.____

   ____

Appendix B

"Apparently Healthy Characteristics"

Participating individuals are asymptomatic, apparently healthy, and do not have more than one of the following risk factors as reported by each participant:

(1) Diagnosed hypertension or blood pressure greater than or equal to 160/90 mmHg on at least two separate occasions or on antihypertensive medication.

(2) Serum cholesterol greater than or equal to 6.20 mmol/L (greater than or equal to 240 mg/dl).

(3) Cigarette smoking.

(4) Diabetes mellitus. Persons with insulin dependent diabetes mellitus (IDDM) who are over 30 years of age, or have had IDDM for more than 15 years, and persons with noninsulin dependent diabetes mellitus who are over 35 years of age are not classified as apparently healthy.

(5) Family history of coronary or other atherosclerotic disease in parents or siblings prior to age 55.

American college of Sports Medicine (1991). Guidelines for exercise testing and prescription. Philadelphia: Lea and Febiger.

Appendix C

ACSM Indications for Stopping an Exercise Test

(1) Progressive angina (stop at 3+ level or earlier on a scale of 1+ to 4+).

(2) Ventricular tachycardia.

(3) Any significant drop (20 mmHg) of systolic blood pressure or a failure of the systolic blood pressure to rise with an increase in exercise load.

(4) Lightheadedness, confusion, ataxia, pallor, cyanosis, nausea, or signs of severe peripheral circulatory insufficiency.

(5) Early onset deep (greater than 4 mm) horizontal or downsloping ST depression or elevation.

(6) Onset of second-or third-degree A-V block.

(7) Increase in ventricular ectopy, multiform PVCs, or R on T PVCs.

(8) Excessive rise in blood pressure: systolic pressure > 250 mmHg; diastolic pressure > 120 mmHg.

(9) Chronotropic impairment: increase in heart that is < 25 beats/minute below age-predicted normal value (in the absence of beta blockade).

(10) Sustained supraventricular tachycardia.

(11) Exercise-induced left bundle branch block.

(12) Subject requests to stop.

(13) Failure of the monitoring system.

American College of Sports Medicine (1991). Guidelines for exercise testing and prescription. Philadelphia: Lea and Febiger.

Appendix D

<u>Contraindications to Exercise Testing and for Entry into Exercise Programs</u>

(1) Unstable angina.

(2) Resting systolic blood pressure > 200 mmHg or resting diastolic blood pressure > 100 mmHg.

(3) Orthostatic blood pressure drop of greater than or equal to 200 mmHg.

(4) Moderate to severe aortic stenosis.

(5) Acute systemic illness or fever.

(6) Uncontrolled atrial or ventricular dysarhythmias.

(7) Uncontrolled sinus tachycardia (> 120 beats/minute).

(8) Uncontrolled congestive heart failure.

(9) Third degree A-V heart block.

(10) Active pericarditis or myocarditis.

(11) Recent embolism.

(12) Thrombophlebitis or intracardiac thrombi.

(13) Resting ST displacement (> 3 mm).

(14) Uncontrolled metabolic disease (e.g., diabetes, hyperthyroidism, or myxedema).

(15) Neuromuscular, musculoskeletal, or rheumatoid disorders that are excerbated by exercise.

American College of Sports Medicine (1991). <u>Guidelines for exercise testing and prescription</u>. Philadelphia: Lea and Febiger.

Appendix E

Informed Consent Form

TITLE

Comparison of Eight Weeks of Aerobic Dance and Water Aerobic Training on Maximal Oxygen Consumption

FACILITY

Grand Valley State University Human Performance Lab, Pool, and Dance Studio
Allendale, MI 49401

COMMITTEE MEMBERS

James Scott, P.E.S. (chairperson), Brian Curry, PhD, and Karen Ozga, M.M.Sc., P.T.

INVESTIGATORS

Terri L. Bedford, BS, SPT, Tamara A. Dusterwinkle, BS, SPT, and Darcy J. Hoppman, BS, SPT.

PURPOSE OF STUDY

This study seeks to determine if water aerobic training is as effective as is land aerobic dance training in improving cardiovascular fitness in sedentary adults.

PROCEDURE

I understand that there will be 30 participants in this study. The research procedures will consist of an equipment familiarization session; a pretraining maximal graded exercise test; eight weeks of either submaximal aerobic dance or aerobic water training; and a post training maximal graded exercise test. Prior to the familiarization session, I will complete the informed consent and the health screen forms. During the familiarization session, I will acquaint myself with the testing equipment and will ask questions regarding the procedures of this study as necessary. I will perform the pretest and post training exercise tests on a Schwinn Air-Dyne Ergometer until volitional exhaustion. I understand that my heart rate and rhythm will be monitored continuously by a five lead electrocardiogram. I also understand that my oxygen consumption will be measured during the testing procedures. If I agree to participate, I will be expected to attend classes three times a week for 45 minutes per session for eight weeks. All tests will take place in the Human Performance Lab during assigned times which are convenient to the participant. I also understand I am responsible for my own transportation.

CHANGES

I understand that I will be informed of any changes in the nature of this study prior to their occurrence.

RISKS AND DISCOMFORT

I understand that there exists the possibility of certain changes with this test. These changes may include blood pressure variations, fainting, heart beat irregularity, and in remote cases, heart attack, stroke and death. The above are minimal risk factors and recent surveys of more than 2,000 clinical labs where more than 600,000 tests were performed, and show a death rate of approximately 0.5 per 10,000 tested. The principle investigators will make every attempt to decrease these risks by screening regarding you health and fitness, continuous monitoring of your vital signs and by closely observing your exercise response throughout the course of this study. Trained personnel and emergency equipment are present in the event of an emergency situation.

BENEFITS

I understand that my participation in this study may result in the following: a free fitness assessment which includes maximal oxygen consumption, carbon dioxide production, minute ventilation, and a pulmonary function; pretest screen; musculoskeletal, cardiovascular, and cardiorespiratory conditioning; toning; possible weight loss; and opportunity for socializing.

REFUSAL OR WITHDRAWAL OF PARTICIPATION

I understand that my participation is voluntary and that I may refuse to participate or may withdrawal consent and discontinue participation in the study at any time with no adverse reactions from the principal investigators.

PHYSICAL INJURY

In the event of physical injury, immediate and appropriate measures will be taken. I understand that GVSU and the investigators are not liable in case of personal injury.

CONFIDENTIALITY

I understand that all results obtained from this study will remain confidential and will be stored and identified as a code number. The key to code numbers will be stored separately. If the data is published, no names will be identified. Photos and videos will be only be permitted for use with my permission.

REQUEST FOR MORE INFORMATION

I understand that I may ask questions about the study at any time. Paul Huizenga at 895-2472 is available to answer my questions or concerns. A copy of this consent form will be given to me for careful rereading. I acknowledge that I have read and understand the preceding information, and I am in agreement to participate in this study.

SIGNATURES

____________________	____________________
Witness	Participant
____________________	____________________
Date	Date

Appendix F
ACSM Airdyne Bike Maximal Test
Data Collection Sheet

Code number:
Age:
Maximal heart rate:
Height:
Weight:

	Workload	Time	HR	BP	RPE
Rest			___	___	___
Stage I	0.25 kp	2 min.	___	___	___
Stage II	0.50 kp	2 min.	___	___	___
Stage III	0.75 kp	2 min.	___	___	___
Stage IV	1.00 kp	2 min.	___	___	___
Stage V	1.50 kp	2 min.	___	___	___
Stage VI	2.00 kp	2 min.	___	___	___
Stage VII	2.50 kp	2 min.	___	___	___
Stage VIII	3.00 kp	2 min.	___	___	___
Stage IX	3.50 kp	2 min.	___	___	___
Stage X	4.00 kp	2 min.	___	___	___