

THE EFFECT OF AN EIGHT-WEEK WATER AEROBICS PROGRAM
ON SELECTED PHYSIOLOGICAL MEASUREMENTS
OF FEMALE PARTICIPANTS

By

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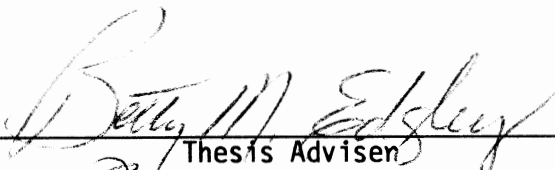
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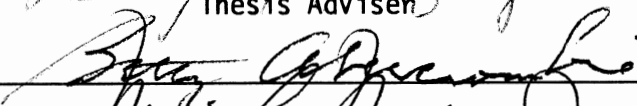
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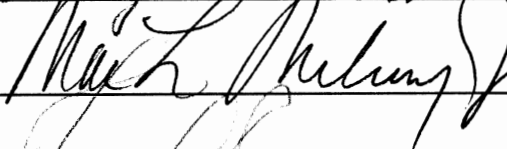
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CHAPTER I

INTRODUCTION

The emphasis on physical fitness has increased significantly over the past decade. Numerous factors demonstrate the magnitude of this growth; most noticeable are the increasing numbers of individuals participating in fitness activities and the media attention given to health and physical fitness. This increased emphasis on health and fitness has moved a larger percentage of the population from spectators to participants. The benefits of regular exercise are well documented; however, the "fitness craze" has not come without complications. There has been a high incidence of injuries that are directly related to the participation in fitness activities.

Several types of aerobic and nonaerobic exercises owe, in some respect, their origin to the high frequency of injuries associated with fitness-related activities, including water aerobics and low-impact aerobics. Water is a forgiving medium; it disallows movements that could provoke injury from excessive pounding or strain. Water aerobics is a relatively new concept in the world of fitness. It is a physical conditioning program consisting of rhythmic, vigorous movements performed in waist to chest deep water. The concept of water aerobics differs from that of water therapy. Water aerobics uses the water's resistance to achieve or maintain fitness. Water therapy, also known as hydrotherapy, is a medically supervised treatment that uses warm water and gentle motions to aid recovery from an injury or to correct a particular problem.

The growing popularity of water aerobics may be due to the buoyancy of the water, thus making it an ideal exercise medium for numerous populations. Individuals who have been unable to participate in traditional fitness activities, including those who are overweight, arthritic, elderly, sedentary, pregnant, or physically/medically disabled may be able to realize the benefits of exercise by participating in water aerobics programs.

The literature contains numerous studies in the area of physiological benefits of aerobic exercise. However, the research in the area concerning physiological benefits of water aerobics is limited. Publications which describe specific exercises and routines dominate the literature related to water aerobics. Although most articles implicate numerous benefits, the research to support these implied benefits is limited.

Vickery, Cureton, and Langstaff (1983), in a study of energy expenditure during aqua dynamics, found that water aerobics provided sufficient intensity to improve the participant's physical work capacity. An unpublished study by Beasley (cited in Vickery, Cureton, and Langstaff, 1983) found that individuals with low to average aerobic capacity would likely receive cardiovascular benefits. Daniel (1985) indicated that participation in water aerobics would promote weight loss; however, he suggested that it would probably be less than that produced through participation in weight-bearing activities.

Few studies were found that specifically studied the effect a water aerobics program had on loss of either weight or body fat in any age group, although it has been implied that a loss will result. Those that are available have studied an older population. This, coupled with the increased participation in water aerobics for fitness gains, warranted

the investigation of the effect water aerobics has on weight and body fat in young women.

Statement of the Problem

The purpose of this study was to determine the effect of an eight-week water aerobics program on selected physiological measurements of the female participants. Specifically investigated parameters included resting heart rate, resting blood pressure, body weight, and percentage of body fat.

Hypotheses

This study dealt specifically with the following hypotheses, and significance was accepted at the .05 level of confidence:

1. There will be no significant difference in the pre and post measurements of the resting heart rate.
2. There will be no significant difference in the pre and post measurements of the systolic resting blood pressure.
3. There will be no significant difference in the pre and post measurements of the diastolic resting blood pressure.
4. There will be no significant difference in the pre and post measurements in body weight.
5. There will be no significant difference in the pre and post measurements in percentage of body fat.

Limitations

This study was subject to the following limitations:

1. No attempt was made to control the dietary influences on the measured physiological variables.

2. Most exercise programs of any length will experience participant drop-out. No attempt was made to provide incentives to reduce or alleviate this problem.

3. Some sedentary individuals who begin exercise programs are often initially enthusiastic and may participate in additional exercise activities, which could affect the results of the study.

Delimitations

The delimitations of this study were:

1. The subjects were limited to 57 females between the ages of 18 and 25 who volunteered to participate in the study.

2. Physiological measurements were limited to resting heart rate, resting blood pressure, body weight, and percentage of body fat.

3. Only subjects who participated in the water aerobics program a minimum of 22 days were utilized in this study.

Assumptions

This study was based on the following assumptions:

1. It was assumed that the subjects were sedentary as defined.

2. It was assumed that the subjects participated to the desired level of intensity.

3. It was assumed that any change in the participants' diets was negligible.

Definition of Terms

The following are conceptual definitions which were used in this study:

Aerobic. Literally means "with oxygen."

Aerobic Exercise. Work which requires the heart to beat more rapidly, causing more oxygen to travel through the body and which must be accomplished in the presence of oxygen.

Exercise Intensity. The level at which a person trains, usually based on a percentage of the maximal oxygen consumption.

Maximal Oxygen Consumption. The maximum amount of oxygen a person is able to use while participating in maximal or exhaustive exercise.

Sedentary. An individual who has not regularly participated in an aerobic exercise program of any type (at least three times per week) for six months prior to beginning the water aerobics study.

Target Heart Rate Range. A calculated heart rate to indicate the minimal intensity of aerobic exercise necessary to achieve cardiovascular fitness [$220 - \text{age} - \text{resting heart rate} \times (.6 - .8) + \text{resting heart rate}$].

Water Aerobics. A physical conditioning program consisting of continuous rhythmic, vigorous movements performed in water for a prescribed length of time.

Water Therapy (Hydrotherapy). A medically supervised treatment that uses water and movement to aid recovery from an injury or to correct a specific problem.

CHAPTER II

REVIEW OF THE LITERATURE

Water aerobics, also called aquadynamics or water exercise, is a relatively new concept in the fitness domain and consequently the literature is somewhat limited. The most noticeable scarcity of research is on the physiological responses to water aerobics. This review of literature is an attempt to summarize the available information and research, concentrating on two related areas, including: (1) the fundamentals of water exercise programs and (2) the benefits of water aerobics.

Fundamentals of Water Exercise Programs

Aerobic exercise involves continuous, rhythmical activities which use large muscle groups, including activities such as walking, running, swimming, bicycling, and aerobic dance. For an aerobic exercise program to be effective it must include at least three sessions per week for 15 to 60 minutes. The intensity of the activity should be 60% to 90% of the individual's maximal heart rate. In most cases, a conditioning effect will result, which allows and necessitates the intensity or duration of the exercise to be increased, or some combination of the two (ACMS Guidelines, 1986).

A water aerobics program consists primarily of aquatic calisthenics performed in waist to chest deep water. The ability to swim is not necessary; however, some swimming-type movements are also used during the workout. Water aerobics programs generally include three components:

(1) a warm-up performed on the deck and in the water to prepare the body for more vigorous activities by using light conditioning and stretching exercises; (2) the aerobic workout, during which the heart rate is sustained at a minimum of 60% of its maximal capacity; and (3) a cool-down, using stretching exercises to provide a gradual decrease in the heart rate to the resting state. The pulse rate should be measured a minimum of four times during a workout: (1) prior to the warm-up, (2) five minutes into the aerobic workout; (3) five minutes before the aerobic workout is completed, and (4) after the cool-down.

According to Reed and Rose (1985), the intensity for specific movements or exercises in the water can be changed by modifying the speed at which the participant moves a body part. Slower movements in the water create less resistance, therefore reducing intensity. The surface area of the moving body part will also affect intensity. Body position can be altered to change the workload, such as vertical or horizontal hand positions with respect to the water's surface. This flexible resistance of the water allows participants of all levels to benefit from water exercise.

Water exercise books, manuals, and booklets, both published and unpublished, which describe specific exercises for the water, dominate the literature related to water exercise. Two primary approaches seem to be utilized. The more general approach describes and illustrates specific exercises, generally according to specific muscle groups or body parts. These texts generally provide the user with guidelines to exercise prescription related to frequency, duration, intensity, and time. The participants or exercise leaders can then build their own program from the described exercises to meet their specific needs (Conrad, 1973; Reed and Rose, 1985). The second approach designates specific routines

for various populations and fitness levels. Hydrorobics, aquadynamics, swimnastics, and aquacise are the most commonly seen published water exercise curricula. There is considerable variation in these programs with respect to exercise difficulty and the percentage of time devoted to calisthenic-type exercise versus the time devoted to water walking or jogging.

Benefits of Water Aerobics

The therapeutic value of water rehabilitation has long been documented. Its use for relaxation and treatment of joint disorders, range of motion problems, and pain is not new. Such treatment extends even to the rehabilitation of racehorses. The recognized value of such therapy gave rise to water aerobics. The potential benefit from this type of exercise may be twofold. The water reduces body weight in proportion to level of body immersion, thereby reducing the stress on the musculoskeletal system and improving the participants' levels of fitness. There is a lack of substantial research in documenting the purported benefits of water exercise; however, this is best explained by the relative infancy of the activity.

Nearly all of the authors of the literature related to water aerobics cited decreased stress on skeletal structure as the most significant benefit of participation in water aerobics. The body is lifted to some extent by the water, thereby decreasing the amount of stress on the weight-bearing joints and making it an ideal exercise medium for numerous populations, including those who are elderly, obese, pregnant, arthritic, and physically disabled or injured. The extent of buoyancy is dependent on the proportion of the body in the water versus the body portion out of the water, body size, and the percentage of body fat. An individual

immersed to the neck in water may experience an apparent weight loss of up to 90% of his body weight. Individuals can participate painlessly and with almost no risk of injury, yet can still improve or maintain cardiovascular, respiratory, and muscular fitness (Giles, 1988; Katz, 1985a; Ruoti, 1989).

The high incidence of injuries from land-based activities, such as running and rhythmic aerobics, has participants seeking less stressful exercise modalities. Water walking and water jogging have gained a significant following. Dr. Daniel Kuland heads a running-injury center in Virginia that allows the injured exerciser to maintain his fitness level by jogging in a specially designed pool. Jogging in deep water while wearing a specially designed vest will enhance or maintain cardiorespiratory fitness with significant stress reduction on the musculoskeletal system. The same things that attract the injured exercise participants to the water are attracting the noninjured (Barol and Cohn, 1985). According to Glenn McWaters (cited in Barol and Cohn, 1985), director of the Sports Medicine Fitness Institute at Samford University, water is 12 times more resistant than air; thus, water jogging provides a more efficient means of aerobics exercise. McWaters equates a water jog of 45 minutes to two hours of jogging on land.

Whitley and Schoene (1987) studied water walking to determine its effect on the heart rate response by comparing it to treadmill walking. The heart rates of 12 female college students were measured immediately after walking in waist deep water and on a treadmill at the same distance, duration, and speed (2.55, 2.77, 3.02, and 3.31 km/hr). The heart rates for water walking were significantly higher than for the treadmill walking at each speed. The authors concluded that water walking could serve as an effective exercise mode for the purpose of achieving

cardiorespiratory fitness, especially for those individual who are unable to perform weight-bearing exercise. They also implicated the potential benefit that water walking might possess for the rehabilitation of cardiac patients, especially those with body weight and lower body joint problems.

Evans, Cureton, and Purvis (1978) had six male subjects walk and jog at similar intensities in waist-deep water and on a treadmill. The investigators found that the heart rates and oxygen consumption increased linearly with greater speed in both the water exercise and with treadmill walking. No significant difference in the heart rates at any given level of oxygen consumption for either the water or land environment was found. They also found that only one third to one half of the treadmill speed was required in the water to achieve the same level of energy expenditure as that of any given speed on the treadmill.

An unpublished study was cited by Koszuta (1986) in which a professor at the University of South Florida evaluated six aerobically fit male subjects to determine energy cost and total calorie expenditure during aquatic circuit training similar in design to land-based circuit training. The heart rates and mean oxygen uptake were maintained within the range for fit athletes as established by the American College of Sports Medicine to develop and maintain fitness. It was concluded that individuals with low to average aerobic capacity would most likely receive cardiovascular benefits from a water aerobics program.

Water aerobic programs that consist primarily of calisthenic-like movements have been questioned as to whether there is sufficient intensity to improve cardiovascular fitness. Most programs of this nature utilize water walking and/or water jogging, but these specific exercises constitute only a small percentage of the total exercise time.

Vickery, Cureton, and Langstaff (1983) conducted a study to determine the effects of Aqua Dynamics on heart rate and energy expenditure. Aqua Dynamics is a water exercise program consisting of aquatic calisthenics and modified lap swimming developed by the President's Council on Physical Fitness and Sports. Three subjects were tested using open-circuit spirometry to measure oxygen uptake and telemetry to measure heart rate response during each of the three outlined workouts categorized as low, middle, and high. They found heart rates of 70% to 77% and oxygen uptakes of 51% to 57% of maximal values. It was concluded that Aqua Dynamics does have sufficient intensity to improve the physical work capacity of people who are poorly conditioned, if performed regularly and with sufficient intensity.

Howell (1987) studied the effects of a 10 week land and water exercise program on selected physiological measures of an older population, ranging from 55 to 76 years. The land and water exercise progressive program consisted of calisthenics and aerobic exercise. The subjects were divided into three groups: a land exercise group, a water exercise group, and a control group. The specific parameters investigated included body composition, cardiorespiratory endurance, muscular strength and endurance, and flexibility. The posttest results showed significant improvement from the pretest results for both the land and water exercise groups in cardiorespiratory endurance, body fat percentage, flexibility, and muscular endurance. Only muscular strength did not show a significant improvement. The two exercise interventions differed from the control group on each of the selected variables. The investigator found no differences in the results between the two exercising groups.

Ruoti (1989) studied 20 older males and females, assigning them to either a control group or an experimental group. The 12 subjects in the

experimental group, with a mean age of 65.16, exercised three times per week for one hour for 12 weeks. The results showed significant improvement in resting heart rate, maximum oxygen consumption, and the onset of blood lactate accumulation. Both body weight and percentage of body fat decreased significantly. Like Howell (1987), Ruoti found a significant improvement of local muscular endurance with respect to the upper extremities. The HDL to total cholesterol ratio also showed a significant change; however, no change of significance was found in either total cholesterol, HDL, LDL, or triglycerides. It was concluded that calisthenic water exercise would provide a training effect for older individuals, given adequate intensity, frequency, and duration.

Green (1986), in an unpublished study, found significant reductions in diastolic blood pressure, body weight, and percentage of body fat in senior citizens after participation in a 16 week water aerobics program. No significant difference was found in resting heart rate or systolic blood pressure. His finding of no difference in heart rate was contradictory to most other research in this area.

A comparative study of females participating in water aerobics and high impact aerobics on land by Heberlein et al. (1987) found that exercise heart rates were 13% lower in water exercise when identical routines were performed. The average heart rate achieved during water exercise was equivalent to 80% of the predicted maximal heart rate during water aerobics, thus allowing Heberlein et al. to conclude that water exercise has sufficient intensity to provide cardiovascular benefits.

Daniel (1985), in a paper presented to the American Alliance for Health, Physical Education, Recreation, and Dance Convention, stated that water exercise helps in a weight reduction program, but he indicated that it may be less than that lost in the same amount of weight-bearing

activities. He implicated two factors for this phenomenon: (1) water exercise is not weight-bearing, so less work is done in the movement; and (2) the body seems to have a mechanism for retaining some fat as insulation against the cooler environment of the water.

Koszuta (1986), in an overview of water exercise, discussed the potential benefits of such exercise to special populations who, because of certain ailments or conditions, have generally been precluded from participation. Such populations include the overweight, pregnant, elderly, or sedentary. Kozuta emphasized how water exercise can provide benefits independent of the participants' health limitations, skill levels, or swimming ability.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to determine the effect of an eight-week water aerobics program on selected physiological measurements of the female participants. Specifically tested were the resting heart rate, resting blood pressure, body weight, and body fat percentage.

Water Aerobics Program

The water aerobics program consisted of rhythmic, vigorous aquatic exercises. The program lasted eight weeks, with the subjects participating three days per week. The workout duration progressed by increments of five minutes every two weeks from an initial 25 minutes. The exercises outlined in the President's Council on Physical Fitness and Sports' publication, Aqua Dynamics: Physical Conditioning Through Water Exercises, (1975) were used; however, the sequences and durations were modified. The exercises were grouped to create a traditional aerobic workout consisting of a warm-up phase, an aerobic phase, and a cool-down phase. Table I shows the specific exercises used, the workout sequence, and the time for each exercise for each week of the program. A description of each exercise may be found in Appendix A.

Each subject was asked to exercise at an intensity level that would achieve and maintain her predetermined target heart rate during the aerobic phase. Each subject checked her pulse rate four times during the exercise session. These specific times were: (1) prior to starting the

TABLE I
 WATER AEROBICS PROGRAM: EXERCISES,
 SEQUENCE, AND DURATION (sec)

Exercise	Week			
	1 & 2	3 & 4	5 & 6	7 & 8
Alternate toe touch	30	30	30	30
Side straddle hop	30	30	30	30
Stride hop	30	30	30	30
Standing crawl	30	30	30	30
Walking twists	30	45	60	60
Walking in place	30	60	60	60
Jogging in place	30	45	60	90
Front flutter kicking	60	75	90	90
Right side flutter kicking	60	75	90	90
Back flutter kicking	60	75	90	90
Front flutter kicking	30	45	60	90
Leg crosses	30	45	60	60
Climbing	30	30	45	60
Alternate leg rearward bobbing	60	75	90	120
Knees up, front	60	60	60	60
Knees up, back	60	60	60	60
Alternate leg sideward bobbing	60	75	90	90
Bunny hop bobbing	180	180	210	240
Reverse sides extension	60	60	60	60
Progressive alternate leg bobbing	90	120	150	180
Rub-a-dub-dub	90	90	90	120
Left leg raiser	15	15	30	30
Right leg raiser	15	15	30	30
Alternate leg raiser	30	45	45	60
Jogging in place	60	90	120	150
Walking--length of pool	<u>120</u>	<u>150</u>	<u>150</u>	<u>180</u>
Total Seconds	1500	1800	2100	2400
Total Minutes	25	30	35	40

warm-up phase, (2) five minutes after the start of the aerobic phase, (3) five minutes prior to the completion of the aerobic phase, and (4) immediately after the completion of the cool-down.

Selection of Subjects

The subjects were healthy female volunteers from the University of Tulsa or members of the Tulsa YWCA. The lack of male volunteers precipitated the use of only female subjects. They ranged in age from 18 to 25. Each subject was asked to complete a health and exercise history questionnaire to determine eligibility for this study (Appendix B). Only those individuals who were sedentary as defined and had no contraindications to exercise as defined by the American College of Sports Medicine's Guidelines for Graded Exercise Testing and Exercise Prescription (1986) were allowed to participate. The subjects were randomly divided into two groups of approximately equal number: the control group and the treatment (water aerobics) group.

Physiological Measurements

The following were the physiological measurements utilized in this study:

Body Composition. Each subject's body fat percentage was estimated by the sum of three skinfold measurements: suprailium, thigh, and triceps. Each site was measured by the researcher with a Lange caliper two times; a third measurement was taken if the variance of the first two was greater than one millimeter. The specific location and measurement of each site was as follows:

Suprailium. A diagonal fold above the crest of the ilium at the spot where an imaginary line would come down from the anterior axillary line.

Thigh. A vertical fold on the anterior aspect of the thigh midway between the hip and knee joint.

Tricep. A vertical fold on the posterior midline of the upper arm, halfway between the acromion and olecranon processes with the elbow extended.

Body density was calculated from the following formula:

$$\text{Body Density} = 1.0994921 - 0.0009929(X1) + 0.0000023(X1) - 0.0001392(X2), \text{ where } X1 = \text{sum of skinfolds} \\ \text{and } X2 = \text{age in years.}$$

$$\text{Percentage of Body Fat} = (495/\text{body density}) - 450.$$

Resting Heart Rate. Each subject was placed in a supine position. The subject was allowed to rest for five minutes. The resting heart rate was then taken using a 30-second count of the subject's pulse.

Resting Blood Pressure. Each subject's resting blood pressure was recorded in the supine position immediately after the recording of the resting heart rate. An appropriately sized blood pressure cuff was used and noted for reuse in the post-test. Blood pressures were recorded using a mercury sphygmomanometer.

Weight. Each subject's weight was measured without shoes in kilograms.

Test Procedure

All subjects participating in the study were administered a pretest, and eight weeks later were administered a posttest. The researcher administered all tests during the week prior to and the week after the eight-week water aerobics program.

The subjects were tested at the University of Tulsa's Mabee Gymnasium in Tulsa, Oklahoma. Each subject completed the health and exercise questionnaire (Appendix B) and was asked to read and sign the consent form (Appendix C). Any questions were answered at this time. The age and weight for each subject were then recorded.

The resting heart rate was recorded in a supine position following a five-minute rest. The resting blood pressure was recorded in the same position immediately after the resting heart rate.

The body fat percentage was estimated by measuring three skinfolds: the suprailium, thigh, and tricep. All measures were taken on the right side of the body, and each site was measured a minimum of two times. If the difference between the two measures was greater than one millimeter, a third measure was taken after the other sites were measured.

The subjects in the experimental group participated in a water aerobics program three days per week for eight weeks. Subjects in this group were instructed to avoid participation in any additional exercise during the eight-week study. Attendance was verified by the use of a sign-in sheet. Each subject in this group was examined by a physician to determine if any condition(s) existed that would contraindicate her participation in the exercise program.

The subjects were asked to exercise within their predetermined target heart rate range during the aerobic phase of the water exercise workout. The Karvonen method was used to determine target heart rate range using 60% and 80% as the range for intensity. The rationale for using these intensity percentages was twofold: (1) the subjects were sedentary and (2) research has shown exercise heart rates to be lower in water-related exercise than in land-based exercise. This range was calculated for and explained by the researcher to each subject prior to beginning

the exercise program. The subjects checked their heart rate four times during the exercise session by counting their pulses for a period of 10 seconds. The heart rate was checked: (1) prior to the warm-up, (2) five minutes into the aerobic workout, (3) five minutes before the aerobic workout was completed, and (4) immediately after the cool-down.

The posttest was administered to all the subjects, except for those subjects in the experimental group who participated in less than 22 exercise sessions. Those individuals who participated in less than 22 sessions were removed from the study. Each subject was tested at approximately the same time of day to account for any circadian differences that may have existed. Each subject's resting heart rate, resting blood pressure, weight, and body fat percentage were measured in the posttest.

The following hypotheses were then analyzed:

1. There will be no significant difference in the pre and post measurements of the resting heart rate.
2. There will be no significant difference in the pre and post measurements of the systolic resting blood pressure.
3. There will be no significant difference in the pre and post measurements of the diastolic resting blood pressure.
4. There will be no significant difference in the pre and post measurements in body weight.
5. There will be no significant difference in the pre and post measurements in percentage of body fat.

Analysis of Data

Using the statistical program described in the Statistical Package for the Social Sciences (SPSS), the data were subjected to an analysis of covariance design. The collected data were coded and submitted for

treatment and analysis at the University of Tulsa Computer Center. The adjusted posttest means of each of the five variables for the two groups were compared to determine if any significant differences occurred due to the treatment. Significance was accepted at the .05 level.

This study was approved by the Oklahoma State University Institutional Review Board for Human Subjects and the University of Tulsa IRB for Human Subjects. A copy of the approval may be found in Appendix E.

CHAPTER IV

RESULTS AND DISCUSSION

A total of 54 female students at the University of Tulsa and members of the Tulsa YWCA participated in the pre and posttests of the study to determine the effects of a water aerobics program on selected physiological measures. The subjects were randomly divided into two groups: a control group and an experimental group. Fifty-nine subjects were originally included in the study. Four subjects were eliminated from the experimental group for missing more than two exercise sessions, and one subject in the control group was unable to be posttested.

Descriptive Data

The 54 female subjects ranged in age from 18 to 25 years. The means, standard deviations, and ranges for each of the variables (both pre and posttest) are shown in Table II by group.

Results

Any significance of participation in water aerobics on the selected physiological measurements was determined by using five separate measures of analysis of covariance (ANACOVA). The results of these procedures are found in Tables III-VII.

The first hypothesis stated that there would be no significant difference between the pre and post measurements of the resting heart rate. The posttest resting heart rate means for the control and experimental

TABLE II
 MEANS, STANDARD DEVIATIONS, AND RANGES OF
 THE VARIABLES FOR THE CONTROL AND
 EXPERIMENTAL GROUPS

Variable	Control (n=29)	Treatment (n=25)
Age (years)	20.48 (2.13) 18-25	21.08 (2.22) 18-25
Pretest weight (kg)	59.87 (5.10) 50.9-72.5	60.76 (5.06) 53.2-73.2
Posttest weight (kg)	59.69 (4.89) 50.7-69.5	60.60 (4.93) 53.2-74.3
Pretest heart rate (bts/min)	70.38 (5.49) 59-82	69.16 (4.97) 62-79
Posttest heart rate (bts/min)	69.97 (5.54) 60-81	67.16 (4.83) 60-81
Pretest systolic blood pressure	119.31 (8.49) 102-136	118.08 (8.38) 102-132
Posttest systolic blood pressure	118.28 (7.50) 96-132	116.80 (7.64) 102-134
Pretest diastolic blood pressure	70.14 (6.93) 56-84	68.48 (6.17) 58-84
Posttest diastolic blood pressure	68.62 (5.02) 58-80	68.00 (5.29) 60-80
Pretest fat percentage	25.51 (5.06) 18.4-35.1	24.75 (4.44) 17.4-37.7

TABLE II (Continued)

Variable	Control (n=29)	Treatment (n=25)
Posttest fat percentage	25.53 (5.01) 18.6-35.4	24.73 (4.67) 17.7-39.3

groups were compared, controlling and adjusting for the pretest resting heart rates. Table III shows the results of the analysis of covariance for resting heart rate. The F ratio of 5.409 was significant at the .05 level of confidence. Therefore, the null hypothesis of no significant difference between the pre and posttest resting heart rate was not accepted.

The results of the ANACOVA for the resting systolic blood pressure are shown in Table IV. Using the pretest systolic blood pressure as the covariate, the F ratio was 0.23. This value was not significant at the .05 level of confidence. Therefore, the hypothesis of no significant difference between the pre and posttest measurements of systolic blood pressure was accepted.

To test the hypothesis of no significant difference in pre and posttest diastolic blood pressure, an ANACOVA was performed using the pretest diastolic blood pressure as the covariate. The results for diastolic blood pressure are located in Table V. The F ratio of 0.263 was not significant at the .05 confidence level; consequently, the null hypothesis of no significant difference in pre and posttest diastolic blood pressure was accepted.

TABLE III
ANALYSIS OF COVARIANCE: COMPARISON OF
RESTING HEART RATE

	Sum of Squares	Degrees of Freedom	Mean Square	F	Prob. Level
Covariate pretest RHR	1088.20	1	1088.20		
Main effects group	41.79	1	41.79	5.409	0.024
Explained	1129.99	2	565.00		
Residual	394.01	51	7.73		
Total	1524.00	53	28.76		

TABLE IV
ANALYSIS OF COVARIANCE: COMPARISON OF
SYSTOLIC BLOOD PRESSURE

	Sum of Squares	Degrees of Freedom	Mean Square	F	Prob. Level
Covariate pretest SBP	2058.76	1	2058.76		
Main effects group	4.25	1	4.25	0.23	0.633
Explained	2063.01	2	1031.50		
Residual	940.03	51	18.43		
Total	3003.04	53	56.66		

TABLE V
ANALYSIS OF COVARIANCE: COMPARISON
OF DIASTOLIC BLOOD PRESSURE

	Sum of Squares	Degrees of Freedom	Mean Square	F	Prob. Level
Covariate pretest DBP	907.89	1	907.89		
Main effects group	2.43	1	2.43	0.263	0.610
Explained	910.31	2	455.16		
Residual	471.69	51	9.25		
Total	1382.00	53	26.00		

The information in Table VI deals with the analysis of covariance for body weight. The F ratio of 0.076 was found, with the pretest body weight used as the covariate. This value was not significant at the .05 level of confidence. The null hypothesis of any significant difference in body weight was accepted.

The data in Table VII illustrate the difference in pre and post percentage of body fat. The data analysis showed an F ratio of 0.04, with a probability of 0.843. The null hypothesis of no significant difference in pre and posttest fat percentage was accepted.

Discussion

The statistical analysis revealed only one significant difference in pre and posttest measurements of the five variables. Only minute changes, if any, were seen in the other four variables.

TABLE VI
ANALYSIS COVARIANCE: COMPARISON
OF BODY WEIGHT

	Sum of Squares	Degrees of Freedom	Mean Square	F	Prob. Level
Covariate pretest wt.	1205.48	1	1205.48		
Main effects group	0.09	1	0.09	0.076	0.784
Explained	1205.57	2	602.79		
Residual	59.47	51	1.17		
Total	1265.04	53	23.87		

TABLE VII
ANALYSIS OF COVARIANCE: COMPARISON OF
PERCENTAGE OF BODY FAT

	Sum of Squares	Degrees of Freedom	Mean Square	F	Prob. Level
Covariate pretest fat	1221.70	1	1221.70		
Main effects group	0.01	1	0.01	0.040	0.843
Explained	1221.71	2	610.86		
Residual	14.39	51	0.28		
Total	1236.09	53	23.32		

The significant difference was found in the pre and posttest resting heart rates. The unadjusted means for pre and posttest resting heart rate reflected a two beat per minute drop for the experimental group. This change implies that a conditioning effect occurred due to participation in the water aerobics program. The magnitude and direction of change in the resting heart rate found in this study corresponded to heart rate changes found in studies involving aerobic exercise of similar durations.

No change was found in the pre and posttest systolic blood pressure. This implies that participation in a water aerobics program would not significantly lower the systolic blood pressure. Perhaps the best explanation of this lack of change was related to the normalcy of the subjects' blood pressure. The unadjusted means for the control and experimental groups were 119.31 mm Hg and 118.08 mm Hg, respectively; the highest reading was 136 mm Hg. The literature related to the effect aerobic exercise has on systolic blood pressure indicated that "normal" pressures would not be significantly lowered with sufficient participation in an aerobic exercise program. The intensity of the water aerobics program appeared to be sufficient to cause a drop in resting heart rate; therefore, it can be assumed that the intensity would have been sufficient to lower systolic blood pressure.

The diastolic blood pressure, like the systolic, did not change significantly from the pre to posttest. The mean diastolic pressures for each group would be considered "normal," perhaps even a little below average for this age group. The same explanation as that offered for systolic pressure would be suggested for this lack of change in the diastolic pressure due to the water aerobics program.

The ANACOVA for body weight resulted in no significant difference among the two groups, which implied that a water aerobics program would not decrease body weight. There are several possible explanations for this lack of change. The first explanation may be that there was insufficient workout time to cause a significant drop in weight. The 780 minutes (13 hours) of the exercise participation over the eight-week period may need to be increased if the participant's primary desire or goal is weight loss.

Also critical to caloric expenditure and subsequent weight loss was a weight-bearing factor. The number of calories an individual burns during exercise is directly related to exercise intensity and body weight. The fact that an individual weighs less in water would reduce the total energy expenditure for any given intensity, compared to non-water aerobic exercise. It is unlikely that the intensity of the water aerobics would be considered a factor in insufficient energy expenditure and a subsequent weight loss since the changed resting heart rate implied adequate intensity.

Another factor that may be offered to explain the absence of any significant drop in body weight was the lack of control over the subjects' dietary intake. The subjects in the experimental group may have subconsciously increased their caloric intake, "knowing" that their participating in the water aerobics program would offset such an increase. Therefore, the subjects' body weight would not have markedly changed.

The final variable that did not change significantly due to participation in the water aerobics program was the percentage of body fat. One possible explanation of this lack of change, specifically a drop, could have been insufficient time with respect to the number of weeks of

participation. A second possibility lies in the fact that some evidence exists suggesting that the body retains fat when exercise is performed in a water medium (Daniel, 1985). Since the subjects in this study demonstrated no changes of significance in body fat, this concept must at least be considered as a possible explanation.

Summary of Results

The purpose of this study was to determine the effect of an eight-week water aerobics program on selected physiological variables, including: resting heart rate, resting systolic blood pressure, resting diastolic blood pressure, body weight, and percentage of body fat. Pre and posttest measurements were taken for two groups of subjects, including a control group and an experimental group of water aerobics program participants. An analysis of covariance was performed on the data to determine if there was any significant difference between the two groups on any of the five variables.

The results of this study, based on the stated null hypotheses, included:

1. There will be no significant difference in the pre and post measurements of the resting heart rate. The F ratio of 5.409 was significant at the .05 level of confidence; therefore, the null hypothesis was rejected.

2. There will be no significant difference in the pre and post measurements of the systolic resting blood pressure. This hypothesis was accepted since the F ratio of 0.23 was not significant at the .05 level.

3. There will be no significant difference in the pre and post measurements of the diastolic resting blood pressure. The F ratio of

0.263 was not significant; consequently, the null hypothesis was accepted.

4. There will be no significant difference in the pre and post measurements in body weight. The F ratio of 0.076 was not significant at the .05 level of confidence; therefore, the null hypothesis was accepted.

5. There will be no significant difference in the pre and post measurements in percentage of body fat. The F ratio of 0.04 was not significant; consequently, the null hypothesis was accepted.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Water aerobics is a relatively new phenomenon in the physical fitness realm. Water aerobics programs have adopted movements and exercises similar to those used in rhythmic aerobics programs, but have put them in the injury-forgiving medium of water. Many individuals who have experienced injuries from participation in other types of aerobic exercise and higher risk individuals are now exercising in a water environment. The benefits of regular participation in rhythmic aerobics with respect to improved cardiorespiratory endurance, decreased body fat, increased muscle strength and tone, and improved self-image are well documented. It has apparently been assumed that these same benefits would be derived by participation in water aerobics, but the change in exercise environment should preclude such a casual assumption. Little research exists that documents the purported benefits of water aerobics, particularly for a relatively young population.

It was the purpose of this study to determine the effect of participation in an eight-week water aerobics program on resting heart rate and blood pressure, body weight, and percentage of body fat of young females.

Conclusions

The results of this study showed a significant difference in resting heart rate between the control and experimental groups. No differences

were found in resting systolic or diastolic blood pressure, body weight, or body fat percentage.

Several conclusions can be drawn based upon the above results. It can be concluded that regular participation in a water aerobics program will decrease the resting heart rates of young, sedentary females, and that changes will occur within eight weeks. It can then be assumed, based on the supporting literature related to aerobic exercise and heart rate changes, that water aerobics programs can be of sufficient intensity to increase cardiorespiratory endurance for most any aged, sedentary individual, given adequate duration and frequency. The existing studies show similar conclusions, but most were based on an older, sedentary population.

It can also be concluded that participation in the water aerobics program, specifically aquadynamics, did not significantly reduce the resting blood pressure. Research has demonstrated that only modest, at best, reductions in normal blood pressures can be expected from participation in aerobic activities. The lack of a significant change in either systolic or diastolic blood pressure in this study is not surprising, given the normalcy of the subjects' pretest blood pressures.

Another conclusion drawn was that the eight-week water aerobics program (participating three times per week for a total exercise time of 780 minutes) did not significantly reduce body weight. This finding is somewhat contradictory to other findings in the literature; however, the other studies in which body weight was reduced involved older subjects of both sexes. The lack of dietary control could have been a factor in the absence of reduced body weight. Also, the duration of eight weeks may explain the lack of change; however, the total exercise minutes for this study was similar to 10-week studies in which body weight was lost.

Finally, it was concluded that the eight-week water aerobics program did not significantly lower body fat percentage. This finding does not differentiate from the results found in the existing research, although most of this research was performed on older subjects. In summary, the water aerobics program utilized in this study was of sufficient intensity, duration, and frequency to have a training effect on the subjects, but caused no significant reduction in blood pressure, body weight, nor percentage of body fat.

Recommendations

The following are recommendations for future study related to a water aerobics program:

1. A water aerobics study of an extended duration (16 weeks) examining the same physiological variables as this study.
2. A water aerobics study using both men and women who are hypertensive.
3. A study to determine the effect of water aerobics on body weight with control of the subjects' dietary intake.
4. A study using subjects who are defined as obese by AMA standards.
5. A study to assess strength gains in selected major muscle groups, as well as changes in the girth of selected body parts.
6. A study using a geriatric population to determine the effect water aerobics has on energy expenditure, body weight, and percentage of body fat.
7. A study using subjects with low functional capacity to determine the effect water aerobics has on increasing maximum oxygen consumption.

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APPENDIXES

APPENDIX A

DESCRIPTION OF WATER EXERCISES

Alternate Leg Rearward Bobbing. Standing in shallow water, take a breath, submerge in water with left leg in squatting position with left foot on the pool bottom and right leg extended rearward, shove up off bottom, reversing position of legs.

Alternate Leg Sideward Bobbing. Standing in waist-to-chest deep water, take a breath, submerge with left leg in full squatting position, left foot on pool bottom and right leg extended sideward, shove up off bottom, reversing position of legs, inhaling when head is out of water. Submerge with right leg in full squatting position.

Alternate Leg Raisers. Starting from back-lying position, scull continuously, bringing left knee to chest until thigh is nearly perpendicular to surface of water, straighten left leg to perpendicular to water surface, return to left knee to chest position, return to back-lying position, bring right knee to chest until thigh is nearly perpendicular to surface of water, return to right knee to chest position, return to back-lying position. Repeat.

Alternate Toe Touch. Standing in waist-to-chest deep water, raise left leg, bringing right hand toward left foot, looking back and left hand extended rearward.

Back Flutter Kicking. Lying in a supine position and holding on to sides of pool with hand, kick flutter style.

Bunny Hop Bobbing. Standing, take a breath, submerge in a tuck or full squatting position with feet on pool bottom, push up and forward off bottom of pool, repeat, pushing forward the length of the pool or specified distance.

Climbing. Hands in pool gutter, facing pool side and feet flat against side and approximately 16 inches apart, walk up side by approximately six short steps. Walk down wall.

Front and Back Extensions. Starting from a vertical position, scull, drawing knees up to chest, shoving legs forward, coming up to a back-lying position, scull, drawing knees up to chest, shoving legs backward, coming to a front-lying position. Repeat.

Front Flutter Kicking. Lying in a prone position and holding on to side of pool with hands, kick flutter style.

Jogging in Place. Standing with arms bent in running position, jog in place.

Knees Up, Front. Starting from a front-lying position, scull, drawing knees up to chest, scull, shoving legs backward, returning to front-lying position. Repeat.

Knees Up, Back. Starting from a back-lying position, scull, drawing knees up to chest, scull, shoving legs forward, returning to a back-lying position. Repeat.

Leg Crosses. Supine, holding on to pool gutter with legs extended, swing legs far apart, bring legs together, crossing left leg over right, swing legs far apart, bring legs together, crossing right leg over left leg. Repeat.

Left Leg Raiser. Starting from a back-lying position, scull continuously, bringing left knee to chest until knee is nearly parallel to the surface of the water, scull, straightening left leg so that it is perpendicular to the water surface, return to left knee to chest position, return to back-lying position. Repeat.

Left Side Flutter Kicking. Lying on a side position, holding on to side of pool with right hand, and with left hand braced on pool wall, kick flutter style.

Progressive Alternate Leg Bobbing. Perform action described in alternate leg rearward bobbing, moving forward the length of pool or specified distance.

Reverse Sides Extension. Starting from a vertical position, scull, drawing knees up to chest, shoving legs to left side, causing body to be in a right side stroke position, scull vigorously, drawing knees up to chest and reversing position, shoving legs to the right side, shifting body to a left side stroke position. Repeat.

Right Leg Raiser. Starting from a back-lying position, perform like left leg raiser, using the right leg.

Right Side Flutter Kicking. Lying on right side position, holding on to side of pool with left hand braced on pool wall, kick flutter style.

Rub-A-Dub-Dub. Starting from a back-lying position, bring knees to chest with knees and toes together, spin in a circle by using an opposite sculling motion of hands. After one full turn, reverse action. Repeat.

Side Straddle Hop. Standing in waist-to-chest deep water with hands on hips, jump sideward to position with feet approximately two feet apart. Recover. Repeat.

Stride Hop. Standing in waist-to-chest deep water with hands on hips, jump, with left leg forward and right leg back, then jump, changing to right leg forward and left leg back. Repeat.

Standing Crawl. Standing in waist-to-chest deep water, simulate overhand crawl stroke by reaching out with left hand, pressing downward and pulling, bringing left hand through to thigh, reaching out with right hand. Repeat.

Walking in Place. Standing with arms bent in a walking position, walk in place, bringing legs up high.

Walking Twists. Standing in waist-to-chest deep water, with fingers laced behind neck, walk forward, bringing up alternate legs, twisting body to touch knee with opposite elbow.

APPENDIX B

HEALTH AND EXERCISE HISTORY

Name _____ Age _____

Address _____

Telephone Number (Home) _____ (Work) _____

Prescription Drugs _____

Allergies _____

Smoking: Cigarettes Y N # of cigarettes per day _____
 Pipe Y N # per day _____
 Cigar Y N # per day _____

Indicate any of the following you now have or have had:

- cardiovascular disease
- arrhythmia or dysrhythmia
- angina or chest pain
- shortness of breath
- hypertension (elevated blood pressure)
- hypercholesterolemia (elevated cholesterol)
- respiratory disease
- cancer
- severe anemia
- diabetes
- asthma
- marked obesity
- mitral valve prolapse (MVP)
- physical or orthopedic disabilities
- other (explain): _____

Aerobic Exercise History:

- never exercise
- have been on a regular exercise program before, but not within last six months
- currently exercising regularly (minimum three days/week)
- type: _____
- length of time: _____
- infrequent exercise
- (explain): _____

Additional information that may affect your participation in this study:

APPENDIX C

CONSENT TO EXERCISE FORM

OKLAHOMA STATE UNIVERSITY

Individual's Consent for Participation
in a Research Project

I, _____, voluntarily agree to participate in this study entitled "The Effect of An Eight-Week Water Aerobics Program on Selected Physiological Measurements of Female Participants" conducted by Judith Lee Grayston.

The purpose of this study is to determine the effect of an eight-week water aerobics program on body weight, body composition, resting heart rate, and resting blood pressure of the female participants.

I understand that I will be assigned to one of two groups which are the control group and the treatment (water aerobics) group, and that the group I have been assigned to is selected at random, by chance. I will be given a pretest to determine my resting heart rate, resting blood pressure, body weight, and percentage of body fat. My body fat percentage will be estimated by the measurement of three skinfolds: suprailium, thigh, and tricep. I will be given a posttest identical to that of the pretest. If I am assigned to the treatment group, I will participate in the water aerobics class three days per week for eight weeks. I understand that the exercises, primarily calisthenic-type, are performed at a predetermined heart rate in waist-to-chest deep water and that swimming ability is not a prerequisite.

As a participant in this study, I may realize the following benefits: an increase in physical work capacity, a decrease in body weight, a decrease in percentage of body fat, and a normalization of blood pressure.

I recognize that the potential risks include ear infection (swimmer's ear) and the remote possibility of drowning. Swimmer's ear protection will be made available to me, if necessary, and a certified Water Safety Instructor will be present during each exercise session to minimize the risk of drowning.

By signing this consent form, I acknowledge that my participation in this study is voluntary. I also acknowledge that I have not waived any of my legal rights or released this institution from liability for negligence.

I may revoke my consent and withdraw from this study at any time without penalty or loss of benefits. My treatment by, and relations with, the staff at Oklahoma State University, now and in the future, will not be affected in any way if I refuse to participate, or if I enter the program and withdraw later.

Records of this study will be kept confidential with respect to any written or verbal reports, making it impossible to identify me individually.

If I have any questions or need to report an adverse effect about the research procedures, I will contact the principal investigator, Judith Lee Grayston, by calling the number made available to me.

If I have any questions about my rights as a research subject, I may take them to the Office of University Research Services at Oklahoma State University.

I have read this informed consent document. I understand its contents and I freely consent to participate in this study under the conditions described in this document. I understand that I will receive a copy of this signed consent form.

Date

Signature of Research Subject

Date

Signature of Witness

Date

Signature of Principal Investigator

APPENDIX D

DATA COLLECTION SHEET

DATA SHEET

NAME _____ AGE _____ HT _____ WT _____
 POST WT _____

	PRETEST	POSTTEST
RHR	_____	_____
RBP	_____	_____
BODY COMPOSITION		
SUPRAILIUM	_____	_____
TRICEP	_____	_____
THIGH	_____	_____

FAT PERCENT _____

X1 = sum of skinfolds
 X2 = age (yrs)

$$Db = 1.0994921 - 0.0009929 (X1) + 0.0000023 (X1) - 0.0001392 (X2)$$

$$\text{Fat \%} = 495/Db - 450$$

TARGET HEART RATE $220 - \text{age} - \text{RHR} \times (.60) + \text{RHR} =$ _____

$220 - \text{age} - \text{RHR} \times (.80) + \text{RHR} =$ _____

ATTENDANCE

1 _____	7 _____	13 _____	19 _____
2 _____	8 _____	14 _____	20 _____
3 _____	9 _____	15 _____	21 _____
4 _____	10 _____	16 _____	22 _____
5 _____	11 _____	17 _____	23 _____
6 _____	12 _____	18 _____	24 _____

APPENDIX E
INSTITUTIONAL REVIEW BOARD FOR HUMAN
SUBJECTS APPROVAL FORM

INSTITUTIONAL REVIEW BOARD
FOR HUMAN SUBJECTS
OKLAHOMA STATE UNIVERSITY

Proposal Title: The effect of an eight week water aerobics
program on selected physiological measurements of female
participants

Principle Investigator: Judith Lee Grayston

Date: December 17, 1987

This application has been reviewed by the IRB and

Processed as: Exempt [] Expedite [X] Full Board Review []
Renewal or Continuation [] Amendment []

Approval Status: Approved [x]

Disapproved []

Conditional []

Deferred []

Comments, Modifications/Conditions for Approval or Reason for
Disapproval:

A physician must certify that each subject is healthy to
participate.

Signature: Margaret J. Weber Date: 3-10-88
Chair of University Board

cc: David Francko
Betty Abercombie
Betty Edgley

APPENDIX F

PHYSICIAN RELEASE TO EXERCISE FORM

PHYSICIAN RELEASE TO EXERCISE

Subject's name: _____

Age: _____

Medications: _____

Cardiovascular: _____

Respiratory: _____

Orthopedic: _____

Other: _____

(Physician signature)

This subject appears to have no contraindications to preclude her participation in this research study.

(Physician signature)

This subject may have contraindications which preclude her from participation in this research study.

VITA

Judith Lee Grayston

Candidate for the Degree of

Doctor of Education

Thesis: THE EFFECT OF AN EIGHT-WEEK WATER AEROBICS PROGRAM ON SELECTED PHYSIOLOGICAL MEASUREMENTS OF FEMALE PARTICIPANTS

Major Field: Higher Education

Minor Field: Health, Physical Education and Recreation

Biographical:

Personal Data: Born in Sedalia, Missouri, December 19, 1955, the daughter of Mr. and Mrs. Judson M. Grayston.

Education: Attended elementary school in Sedalia, Missouri, Grand Forks, North Dakota, and Joplin, Missouri; attended junior high school in Joplin, Missouri; graduated from Parkwood High School, Joplin, Missouri, in 1974; received Bachelor of Science in Education degree from the University of Tulsa, Tulsa, Oklahoma, in May, 1978; received Master of Education degree from the University of Arkansas, Fayetteville, Arkansas, in 1980; completed requirements for the Doctor of Education degree at Oklahoma State University in May, 1990.

Professional Experience: Physical Education Teacher, Joplin Public Schools, August, 1979-May, 1981; Visiting Instructor in Physical Education Department, University of Tulsa, August, 1982-May, 1983; Exercise Physiologist at St. Francis Hospital, Tulsa, Oklahoma, October, 1983-January, 1987; Assistant Professor, University of Tulsa, Tulsa, Oklahoma, August, 1987 to present.