

ABSTRACT

GASPARD, C. G. The effects of a seven-week Aqua Step aerobic training program on aerobic capacity of college-aged females. MS in Adult Fitness/Cardiac Rehabilitation, May 1995, 49pp. (J. Porcari)

Twenty-one apparently healthy females between the ages of 19 and 29 participated in the study. Subjects in the experimental group ($n = 12$) exercised 4 times per week for 7 weeks. Training heart rates progressed from 70-75% of HRmax during week 1 to 80-90% HRmax during week 7. Training heart rates during the aerobic portion of the class averaged 82% of HRmax. Subjects in the control group ($n = 9$) did not participate in a regular exercise program. Each subject performed a maximal treadmill test to volitional exhaustion prior to and upon completion of the study. The variables analyzed included body weight (kg), absolute $\text{VO}_{2\text{max}}$ (L/min), relative $\text{VO}_{2\text{max}}$ (ml/kg/min), HRmax (bpm), VE_{max} (BPTS) (L/min), RPE, and RERmax. The experimental group had increases in absolute $\text{VO}_{2\text{max}}$ (7.7%), relative $\text{VO}_{2\text{max}}$ (7.0%), and VE_{max} (11.7%) which were significantly greater than the control group from pre- to posttesting. No significant ($p > .05$) between-group changes were observed in body weight, HRmax, RPE, and RER from pre- to posttesting. It appears that participation in an Aqua Step aerobic training program is an effective way of improving aerobic capacity in college-aged females.

THE EFFECTS OF A SEVEN-WEEK AQUA STEP AEROBIC TRAINING
PROGRAM ON AEROBIC CAPACITY OF COLLEGE-AGED FEMALES

A MANUSCRIPT STYLE THESIS PRESENTED

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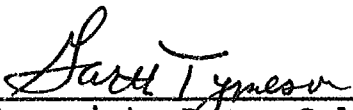


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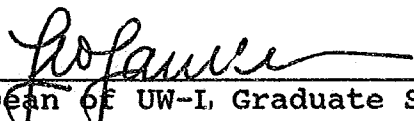
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INTRODUCTION

Water exercise has become increasingly popular as an accepted means of maintaining or enhancing cardiorespiratory fitness for a variety of populations in the fitness and rehabilitation industries. The buoyant properties of water facilitate movement, conditioning, and muscle strengthening in a nonimpact environment (Koszuta, 1989). Consequently, water's buoyant characteristic can accommodate for a variety of activities to be included in an individual's water workout.

Regular participation in water exercise stresses the cardiorespiratory system, producing similar metabolic demands on the cardiovascular system when compared to land exercise (Bishop, Frazier, Smith, & Jacobs, 1989; Herberlein, Perez, Wygand, & Connor, 1990; Hoeger, Spitzer-Gibson, Moore, & Hopkins, 1993; Town & Bradley, 1991). In addition to providing a challenge to the cardiorespiratory system, the buoyant properties of water permit a variety of activities to be included in an individual's workout. Activities such as walking, jogging, circuit training, aerobic dance, and muscle strengthening/toning can be performed in the low-impact water environment by individuals who cannot participate in a variety of land activities due to musculoskeletal limitations.

The most recent addition to water exercise is the Aqua Step. This new "twist" to water fitness can add variety to the water workout and possibly increase adherence to exercise programs. According to Brossman (1993), the traditional land-based step aerobic concepts cannot be directly transferred to the Aqua Step routine. It has been suggested that because the effect of gravity is reduced in water due to buoyancy, the benefits of aqua stepping may be less than land stepping (Brossman, 1993).

However, although the buoyant effect of water reduces the degree of impact during dynamic movement (Wilder, Brennan, & Schotte, 1993), this reduction in impact allows the addition of plyometric exercises to the Aqua Step routine. Plyometric-type activities performed during a land step routine can result in a tremendous amount of force the individual's joints must withstand (or tolerate). Nevertheless, plyometrics can enhance the intensity of the water workout without placing an excessive amount of stress on the weight bearing joints (Brossman, 1993).

In addition, the Aqua Step workout may provide an increased intensity to the workout due to the resistive properties of water. Resistance is a product of viscosity and drag forces which provide resistance that is proportional to the effort exerted in the water (Wilder et al., 1993). It has been suggested that water exercise

offers 12 times the resistance of land exercise (Sova, 1993).

Currently, there is no published research pertaining to the training effects of aqua stepping. However, aqua fitness professionals have accepted the challenge to adapt the land-based step aerobic class to water. Therefore, the purpose of this study was to determine if a 7-week Aqua Step aerobic training program can increase aerobic capacity (VO_{2max}) of college-aged females.

METHODS

This study was part of a larger project which also investigated the changes in body composition consequent to participation in the 7-week Aqua Step aerobic training program.

Twenty-one college-aged females volunteered to participate in this study. Twelve females, between the ages of 19 and 29, served as the experimental group for this study. This group of individuals were enrolled in a water fitness class at the University of Wisconsin-La Crosse (UW-L), Fall Semester, 1993. Nine females, between the ages of 19 and 20, served as the control group. This group would be enrolled in a similar water fitness class to be held the following semester. It was assumed that the physiological characteristics of the subjects in the control group would be similar to the experimental group at the beginning of the

study.

In accordance with the guidelines established by the University's Human Subjects Committee, each subject received a full explanation of all testing procedures. They signed an informed consent document which contained a written agreement stating that the subject would not modify their current level of activity or change their diet over the course of the study (see Appendix A). In addition, the subjects completed a Health History/Current Lifestyle Form (see Appendix B).

The testing and training entailed three phases: a pretesting phase, a training phase, and a posttesting phase. All testing took place at the UW-L Human Performance Laboratory. The training phase took place in the swimming pool at Wittich Hall on the UW-L campus.

Training Phase

The training program consisted of a 43-minute class which met 4 times per week for 7 weeks. The subjects were required to fully participate in at least 24 of the 28 training sessions to be included in the final analyses.

At the beginning of the 7-week training program, each subject was instructed how to take a 10-second pulse count (radial or carotid). Each subject was prescribed a training heart rate based upon their maximal treadmill test (American College of Sports Medicine (ACSM) (1990). Exercise

intensities were prescribed with the following guidelines: week 1 at 70-75% of HRmax, week 2 at 75-80% of HRmax, and weeks 3-7 at 80-90% of HRmax. In order to measure heart rate, each subject took their pulse at two intervals during the cardiorespiratory portion of the class, after minute 8 and again after minute 15. The second heart rate was recorded.

The height of the Speedo Aqua Step was 7 inches and subjects were submerged in the water to naval level while standing on the step. The tempo of music ranged from 125-147 beats per minute while exercising on the Aqua Step. Plyometric-propulsive type movements provided an increased intensity and comprised approximately 30-50% of the activity performed while aqua stepping. Refer to Table 1 for class format.

The instructor constantly encouraged the subjects to use full range of motion throughout each movement pattern, while demonstrating the full range and explosive motions as she instructed the class. It was important that the subjects kept their lower arms submerged in the water throughout the choreographed moves and that they use their hands in a webbed or cupped position. In the lowering phase of propulsive movements, subjects were instructed to bend the knees and lower themselves to shoulder-level in the

Table 1. Speedo Aqua Step class format

Time	Class Format	Duration
7:45	Warm-up and stretch, music tempo was 120-130 beats per minute, water walking, jogging, range of motion exercises.	5 minutes
7:50	Cardio warm-up, music tempo was 125-130 beats per minute, Aqua Step - short lever sweeps and smaller movements.	5 minutes
7:55	Cardio-training, music tempo was 125-135 beats per minute, Aqua Step - patterns that combine traveling, long lever sweeps, full range and plyometrics. HR taken at minute 8 and 15.	20 minutes
8:15	Toning and resistive training, music tempo was 100-120 beats per minute, Equipment usage: buoys, jugs, dumbbells, etc...	10 minutes
8:25	Final stretch - cool down plus range of motion stretching.	3 minutes

water, thus creating more resistance by the water when they began the next step-up movement. Music tempo was another critical factor to ensure proper heart rate intensities. The instructor selected music that had a definite beat that could easily be followed by all subjects and motivated the subjects to perform to the cadence of the music.

Testing Phase

Pre- and posttesting sessions involved the measurement

of body composition and aerobic capacity. Prior to testing, the subjects were required to participate in a practice session to become accustomed to exercise on the treadmill and to identify a self-selected speed at which to perform the treadmill test. Upon arrival for the practice session, the nature of the study and the risks involved were thoroughly explained by the investigator.

For both pre- and posttesting sessions, each subject reported to the Human Performance Laboratory well-rested and after abstaining from food, caffeinated beverages, drugs, alcohol, and tobacco for at least 4 hours prior to the testing session. Upon arrival, the subject's height and weight were measured, age was recorded, body composition determined by hydrostatic weighing, and aerobic capacity determined on the treadmill.

The subject's maximal oxygen consumption ($\text{VO}_{2\text{max}}$) and maximal heart rate (HR_{max}) were measured while performing a maximal treadmill test using a modified Balke protocol (ACSM, 1991). The treadmill test began with a 2 to 3-minute warm-up at a moderate intensity. Following the warm-up, the subject began the test at their previously self-selected speed while at 0% grade. The speed was held constant and the grade was increased 2.5% every 3 minutes until volitional exhaustion. All subjects received verbal encouragement from the investigator. Maximal oxygen

consumption was established as the highest 1-minute value attained for VO_2 during the test. All subjects achieved at least two out of three of the following criteria necessary for a "true" maximal test:

- 1) an RER value > 1.0 (Pollock & Wilmore, 1990),
- 2) a plateau in VO_2 despite an increase in workload, (McArdle, Katch, & Katch, 1991),
- 3) heart rate no less than 10 beats below predicted maximal values (McArdle et al., 1991).

Collection of Data

A Quinton Instruments motorized treadmill (Quinton Instruments Company, Seattle, WA) was used to conduct the maximal treadmill exercise test. The gas analysis measurements for the $\text{VO}_{2\text{max}}$ test were performed using a Quinton Q-Plex I metabolic cart (Quinton Instruments Company, Seattle, WA). Calibration of the analyzers was performed immediately before and after each $\text{VO}_{2\text{max}}$ test with calibrated gases of known concentrations of oxygen and carbon dioxide, previously determined by the Scholander technique. The gas meter was calibrated using a 3.002 liter syringe at varying flow rates. The following variables were obtained from the expired gas data: VE , VO_2 , VCO_2 , and $\text{P\ddot{E}R}$. Metabolic measurements were recorded every 30 seconds and at maximal exertion.

Each subject had their heart rate monitored continuously during the maximal exercise test using the Polar Vantage XL model heart rate monitor (Polar, USA, Inc.,

Stamford, CT). Heart rates were recorded every 30 seconds and at maximal exercise. Ratings of perceived exertion (RPE) were assessed using the 15 point Borg scale at the end of each stage and at maximal exercise (Borg, 1973).

Statistical Analyses

The data were summarized using standard descriptive statistics. A two-way analysis of variance (ANOVA) with repeated measures was used to determine if significant changes occurred between the experimental and control groups as a result of the training period. Paired t-tests were used to test for within group differences from pretest to posttest. Variables analyzed for change were VO_2max (L/min), VO_2max (ml/kg/min), VEmax (L/min), RERmax , RPE, and HRmax . The alpha level was set at .05 for all analyses.

RESULTS

Initially 15 experimental and 11 control subjects were tested prior to the 7-week training period. However, only 12 experimental and 9 control subjects were included in the final statistical analyses. Two experimental subjects were eliminated from the training study because their attendance dropped below the required 24 out of the 28 sessions and one experimental subject was excluded due to technical difficulties. Two control group subjects were eliminated due to nonparticipation in the posttesting session.

Descriptive characteristics for the 21 subjects who

completed the study are presented in Table 2. There were no significant ($p > .05$) differences between the experimental and control groups for age, height, weight, $VO_2\text{max}$, or HRmax at the beginning of the study.

Table 2. Descriptive characteristics of the subjects
(N = 21)

Variable	Control (n = 9)	Experimental (n = 12)
Age (yrs)	19.2 \pm 0.44	21.1 \pm 2.68
Height (cm)	65.1 \pm 2.52	64.3 \pm 2.38
Weight (kg)	64.7 \pm 9.08	62.2 \pm 10.57

Note. All values represent mean \pm standard deviation

The pre-posttesting results are summarized in Table 3.

There was a significant ($p < .05$) interaction between the experimental and control groups for both absolute and relative $VO_2\text{max}$ values. The experimental group had a significant ($p < .05$) increase in $VO_2\text{max}$ from pre- to posttesting. Absolute VO_2 (L/min) increased 7.7% and relative VO_2 (ml/kg/min) increased 7.0% from pre- to posttesting. The control group showed no significant ($p > .05$) change in $VO_2\text{max}$ over time.

Maximal heart rate and RPE values for both groups were similar during the initial treadmill test and there were no significant ($p > .05$) changes over the training period.

At the beginning of the study, there were no significant ($p > .05$) differences in VEmax between the groups. However, the analysis found a significant ($p < .05$) ($p < .05$) interaction occurred over the course of the study.

Table 3. Results of the training study for the control ($n = 9$) and the experimental groups ($n = 12$).

Variable	Pretesting ($\bar{x} \pm SD$)	Posttesting ($\bar{x} \pm SD$)	Change (%)
VO ₂ (L/min)			
Control	2.53 \pm .368	2.51 \pm .420	-0.02 (0.8)
Experimental	2.47 \pm .373	2.66 \pm .392*	0.19 (7.7)#
VO ₂ (ml/kg/min)			
Control	39.1 \pm 3.93	39.2 \pm 2.94	0.1 (0.3)
Experimental	39.9 \pm 5.95	42.7 \pm 5.84*	2.8 (7.0)#
HRmax (bpm)			
Control	200 \pm 9.3	196 \pm 12.4	-4.0 (2.0)
Experimental	193 \pm 11.2	194 \pm 8.8	1.0 (0.5)
RPE			
Control	19.9 \pm 0.33	19.7 \pm 0.71	-0.2 (1.0)
Experimental	19.0 \pm 1.48	19.3 \pm 0.87	0.3 (1.6)
VEmax (L/min)			
Control	91.1 \pm 7.93	86.6 \pm 9.14*	-4.5 (5.8)
Experimental	89.8 \pm 9.08	100.3 \pm 10.14*	10.5 (11.7)#
RER			
Control	1.16 \pm .056	1.10 \pm .021*	-0.06 (5.7)
Experimental	1.16 \pm .067	1.11 \pm .048	-0.05 (4.3)

Note. All values represent mean \pm standard deviation.

* = Significant change from pre- to posttesting ($p < .05$)

= Significant change compared to the control group ($p < .05$)

The experimental group increased their VEmax significantly

($p < .05$) after the 7 weeks of training (11.7%), while the control group showed a significant ($p < .05$) decrease of 5.8%.

Results for RERmax indicate that there was not a significant ($p > .05$) interaction between the groups as result of training. Both groups had a lower RER posttraining, however, only the change for the control group was significant ($p < .05$).

DISCUSSION

VO₂max provides a good estimate of the potential of the cardiovascular system and is considered the best index of cardiorespiratory fitness (Fox, Bowers, & Foss, 1988). According to ACSM (1991), the accepted method of determining a person's cardiorespiratory fitness level is to directly measure VO₂max. Improvements in cardiorespiratory fitness levels are dependent upon the combination of intensity, frequency, and duration of physical activity. Other factors which may influence the magnitude of improvement are mode of training, age, initial fitness level, and performance level of the subjects (ACSM, 1991).

The American College of Sports Medicine recommends that individuals exercise at 50-85% of VO₂max or HRmax 3-5 times per week for 20-60 minutes per session for developing and maintaining cardiorespiratory fitness. The subjects in the experimental group trained according to ACSM guidelines.

In the present study, participating in a 7-week Aqua Step program resulted in a significant increase in $VO_2\text{max}$ expressed in both absolute (L/min) and relative (ml/kg/min) terms of 7.7 and 7.0%, respectively. The magnitude of change is in agreement with other training studies that have been conducted on land and in the water (Abraham, Szczerba, & Jackson, 1993; Brennan, Michaud, Wilder, & Sherman, 1992; Burke, 1977; Butts, Pein, & Stevenson, 1984; Eyestone, Fellingham, George, & Fischer, 1993; Hoeger et al., 1993; Kieres & Plowman, 1991; McCord, Nichols, & Patterson, 1989; Milburn & Butts, 1983; Parker, Hurley, Hanlon, & Vaccaro, 1989; Wilmore, Royce, Girandola, Katch, & Katch; Yeager & Brynteson, 1970). These training studies ranged from 6 to 12 weeks in duration with exercise sessions averaging 3 times per week for 30 minutes. Fox et al. (1988) stated that an average improvement in $VO_2\text{max}$ of 5 to 20% should be anticipated for college-aged women following 8 to 12 weeks of aerobic training.

When looking specifically at water exercise training programs, several authors have reported favorable results. Abraham et al. (1993) reported a 5.6% increase in aerobic capacity (ml/kg/min) following an 11-week aqua aerobics training program. Brennan et al. (1992) found an increase in $VO_2\text{max}$ (ml/kg/min) of 19.6% following an 8-week aqua run training program. Eyestone et al. (1993) found that over a

6 week period, injured runners could maintain their aerobic capacity and 2-mile run time regardless of the individual's fitness level, provided he or she exercises with the same intensity, duration, and frequency during water running. An increase in aerobic capacity of approximately 20% was reported following an 8-week swimming and water calisthenic program (Kieres & Plowman, 1991). Hoeger et al. (1993) also reported a significant increase in VO_{2max} following a water aerobic exercise class performed for 20 minutes 3 times per week.

Greater gains in VO_{2max} can be expected in individuals with lower fitness levels as a result of endurance training (ACSM, 1991). According to the American Heart Association (1972), the average VO_{2max} value for college-aged females is 31 to 37 ml/kg/min. It should be noted that the subjects in this study had a mean pretraining VO_{2max} of 39.1 ml/kg/min, which is slightly above the average range of values. This could possibly explain, in part, the lower magnitude of improvement in the subjects participating in the present study.

In addition, the lower magnitude of improvement could be attributed to the length of the training period and the length of each training session. Subjects trained for only 7 weeks while the recommended training period range is 8-12 weeks (Fox et al., 1988). In addition, although each

training session was 43 minutes in length, the cardiorespiratory section was only 25 minutes. The American College of Sports Medicine (1991) recommends 20-60 minutes of cardiorespiratory training each session. Twenty-five minutes of cardiorespiratory training falls on the lower end of ACSM's recommended range.

In this study, training adaptations were also reflected by changes in VEmax. The increase in VEmax (11.7%) found in the experimental group is a common cardiorespiratory response following training and this increase can be partly attributed to a training effect on the respiratory muscles (Fox et al., 1988). Since respiratory muscles are skeletal muscles, both strength and endurance of the respiratory muscles can be significantly increased following training (Fox et al., 1988).

Maximal attainable heart rates are thought to remain unchanged or decrease slightly following aerobic training. There were no significant changes in HRmax between or within the groups which, according to Fox et al. (1988), is a common response.

Maximal heart rates vary greatly among individuals during exercise testing. Therefore, it is useful to evaluate RPE to assess whether or not the test is truly maximal and to assess if maximal exercise is being approached. Ratings of perceived exertion using the Borg

15-point category scale increases linearly as exercise intensity increases. When a subject has reached the subjective limit of fatigue, an RPE of 18 or 19 is often expressed (ACSM, 1991). The present study revealed no significant differences between or within groups for RPE from pre- to posttesting. Therefore, both groups subjectively exerted maximal efforts both pre- and posttesting.

In the present study, training heart rate accommodations for water-based factors such as body position, temperature, compression, and gravity were not made. The literature is inconclusive as to the physiological responses to water exertion, specifically heart rate. Therefore, the literature is also inconclusive as to the appropriate training heart rate prescription for water exercise in the vertical position required to elicit an appropriate training response. Factors thought to effect heart rate are water temperature, water depth, skill level of subject, and water activity.

Some investigators (Butts, Tucker, & Greening, 1991; Herberlein et al., 1987; Svedenhag & Seger, 1992; Town & Bradley, 1991) have found that heart rate is lower during water exercise than when working at a comparable VO_2 on land. Investigators have hypothesized reasons for the decreased heart rate during water exertion. The studies

listed above have included highly trained athletes as their subjects which may account for the lower heart rate levels in the water.

Butts et al. (1991) suggested that lower heart rates found at maximal exertion in water may be the result of hydrostatic forces facilitating venous return, maintaining an efficient cardiac output through an increased stroke volume. Herberlein et al. (1987) commented that although a lower heart rate was found when comparing water to land based exercise, suggesting an efficient cardiac output during water exertion, the metabolic data confirmed that a cardiovascular training stimulus can still be obtained.

In contrast to the reports of lower heart rates during water exertion, others (Arborelius, Balldin, Lilja, & Lundgren, 1972; Evans, Cureton, & Purvis, 1978; Gleim & Nicholas, 1989; Green, Cable, & Elms, 1990) found relatively no difference in heart rates at any given level of oxygen consumption when comparing land to water-based exercise in the vertical position. Although Bishop et al. (1989) found lower submaximal and maximal VO_2 values in water, similar heart rates and RPE's were reported compared to land.

Sheldahl et al. (1987) concluded that water exercise elicited a lower heart rate at intense or maximal exercise but not at submaximal workloads. Therefore, it would appear, based on the literature, that altering the

prescribed training heart rate for water-based exercise may not be necessary in the vertical position, especially since the subjects in this study exercised at submaximal intensities, not maximal intensities.

In addition, alterations in prescribed training heart rate were not made due to the level or depth of water used in the present study. Gleim and Nicholas (1989) reported that as water depth increased from chest to neck, a lower heart rate was reported. However, when subjects exercised at ankle depth, below knee, midthigh, and waist depth, their heart rates were higher when compared to land-based exercise. Since subjects in this study exercised in water depths ranging from the waist to the xiphoid process, no alterations were made in training heart rate based on the reported findings of Gleim and Nicholas (1989).

This investigator believed that a major factor in determining whether the target heart rate is achieved and maintained is the subject's exercise technique which ultimately is a function of the instructor's teaching techniques. Step exercise in the water is a challenge since subjects are stepping up and down against the resistive properties of water. Unlike land step, where gravity is only resisting the step-up movement and not the step-down movement. Cues are important from the instructor to aid in proper movement to maintain an efficient exercise intensity.

The instructor for the training study had previously attended an aqua step clinic sponsored by the National Fitness Association based in Minneapolis, MN. Her knowledge of hydrodynamics, as well as choreography, provided for a safe, fun, and effective aqua stepping experience for the subjects.

It would seem reasonable to conclude that training on the Aqua Step for improvements in cardiorespiratory fitness is justifiable based on the results of this study. The American College of Sports Medicine (1990) recommends that an apparently healthy individual exercises 3-5 days per week for 20-60 minutes at an intensity of 50-85% of VO_{2max} or HR_{max} as a guideline for developing and maintaining cardiorespiratory fitness.

Although this study was conducted for a short period of 7 weeks, the participants trained 4 days per week at intensities at the higher end of the recommended range suggested by ACSM. This elicited an increase in aerobic capacity which compares favorably to training studies found in the literature. Although this increase is small, it was significant and it is hypothesized that a greater increase in aerobic capacity would have resulted if the training period was extended beyond 7 weeks.

Suggestions for future research include determining the acute energy costs of a typical aqua stepping exercise

routine, increasing the duration of the training program from 7 to 12 weeks to determine if greater training responses would be elicited, and to increase the actual cardiorespiratory training session from 25 minutes to 35-45 minutes.

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APPENDIX A
INFORMED CONSENT

INFORMED CONSENT

Project Title: The effects of a 7-week Aqua Step aerobic training program on $VO_{2\max}$ and body composition of college-aged women.

Principle Investigators: John Porcari, Ph.D.
Gabrielle Gaspard and
Linda Schmal

I _____ volunteer to be a subject in a research study at the University of Wisconsin, La Crosse. This study will be conducted in conjunction with my water exercise class. I understand that participation in this study requires regular attendance during the scheduled water exercise class. The class will meet 4 days per week from 7:45 - 8:50 a.m., Monday - Thursday. I also understand that I will need to spend time in the Human Performance Laboratory on two or three occasions during the course of this study.

Participation in the study will require me to have my body composition determined by hydrostatic weighing and my maximal oxygen consumption measured on a treadmill test. This will be done both before and after the training period. I will also be required to keep a 3 day food intake record both pre- and posttraining.

I understand that during the training period I will be required to exercise at an intensity based on a percentage of my maximal heart rate determined by a treadmill test. I will also be asked to keep track of my exercise heart rate in a daily log book that will be provided.

If I am a subject in the control group, I will be required to undergo both testing procedures before and after the conclusion of the study.

The hydrostatic weighing procedure involves having my residual lung volume determined while breathing into a valve. Underwater weighing will also involve being submerged under water for a brief period. Potential risks of this procedure are infection, accident, and possible drowning.

I understand that the treadmill test consists of walking or running to voluntary exhaustion on a motor driven treadmill. The grade of the treadmill will follow a modified Balke protocol with a self-selected speed. Oxygen consumption will be monitored using the Quinton Q-Plex

through a mouthpiece so that expired air can be collected and measured. As with exercise, the possibility of adverse reactions exist, such as dizziness, shortness of breath, leg fatigue, chest pain, and even sudden death. I will feel tired at the end of the test. If any abnormal observations are noted, the test will be terminated. I am free to stop any of these tests, or withdraw from the study at any time.

I also agree not to modify my diet and/or change my exercise habits for the duration of the study.

I _____ consider myself to be in good health with no contagious disease or other physical conditions, especially with respect to my heart, that might limit my ability to participate in this study.

I have read the above document and have ben advised of the possible risk involved. I hereby acknowledge no guarantees, 0 warranties, or assurances of any kind have been made to me by the University of Wisconsin-La Crosse, the officers, administrators, employees, or by anyone acting on their behalf.

Signed _____ Date _____

Witness _____ Date _____

APPENDIX B

HEALTH HISTORY/CURRENT LIFESTYLE FORM

HEALTH HISTORY/CURRENT LIFESTYLE FORM
Aqua Step Research Project

Name _____ S.S. _____

Address _____
(Include street, city, state, and zip)

Phone _____ Age _____ Birth Date _____

Height _____ Weight _____

In case of emergency, please contact _____
phone _____

Check if you have or have had the following:

_____ Family History of coronary or other atherosclerotic
disease in self, parents or siblings prior to age 55.

_____ Shortness of breath _____ Heart arrhythmias

_____ Chest pain _____ Diabetes Mellitus

_____ Asthma _____ High cholesterol >240mg/dl

_____ Dizzy spells _____ High blood pressure >240mg/dl

_____ Seizures _____ Coughing up blood

_____ Hospitalization _____ Bone or joint injury

Do you currently smoke? _____

Physical Activity

I am currently participating in the following activities:

_____ None _____ Walking _____ Running

_____ Biking _____ Swimming _____ Strength training

_____ Aerobic dance _____ Water aerobics

How long do you exercise for?

_____ None _____ 15 minutes or less

_____ 16-30 minutes _____ 31-45 minutes

_____ 46-60 minutes _____ more than 60 minutes

How many days per week?

_____ None _____ One _____ Two _____ Three _____ Four

_____ Five _____ Six _____ Seven

I hereby certify that all the above statements provided by
me in this form are complete and true to the best of my
knowledge.

Signature _____ Date _____

Witness _____ Date _____

APPENDIX C
REVIEW OF LITERATURE

REVIEW OF LITERATURE

INTRODUCTION

Water exercise has become increasingly popular for individuals of varied fitness levels. Unfortunately, popularity of exercise in the water has exceeded conclusive research pertaining to the physiological and training effects of water exercise. Consequently, aqua fitness professionals are faced with uncertainties as to the physiological responses to exercise in the aqua environment, in particular the prescription of an appropriate training heart rate.

As fitness enthusiasts create new and productive ways to enhance exercise in the water, research is needed to understand the physiological responses to the new activity (i.e., energy costs and training effects). The newest arrival to the aqua exercise environment is the Speedo Aqua Step, a device which simulates the action of performing step aerobics on land.

There is no published research pertaining to the cardiorespiratory training effects of aqua stepping, therefore, the following review of literature will discuss the effects of training on VO_2max and the physiological effects of water immersion at rest and exercise. In addition, the responses to water exercise training programs and studies comparing land versus water exercise will be reviewed.

Effects of Physical Training on VO_{2max}

Physical training can elicit favorable physiological changes within the cardiorespiratory system. The frequency, duration, and intensity of training collectively influence the extent of cardiorespiratory gains. Additional factors which influence training are mode of exercise, initial fitness level, and age (American College of Sports Medicine (ACSM) (1991)).

The American College of Sports Medicine (1990) has published guidelines regarding the quantity and quality of exercise for developing and maintaining cardiorespiratory fitness levels in healthy adults. These guidelines recommend that an individual exercise at an intensity of 50-85% of VO_{2max} or 60-90% of HR_{max} 3-5 days per week for a duration of 20-60 minutes, excluding warm-up and cool-down. The American College of Sports Medicine (1990) also recommends individuals participate in activities which use large muscle groups, are rhythmic and aerobic in nature, and can be maintained for a prolonged period of time to enhance fitness levels. The rate of progression depends upon the conditioning effects occurring over each training session. It has been suggested that the total amount of work performed can be increased each session due to the conditioning effects. The most significant conditioning effects occur within the first 6 to 8 weeks of the exercise

program (ACSM, 1991).

Jogging, walking, swimming, cycling, and aerobic dance are popular forms of exercise which meet the ACSM requirements for enhancing cardiorespiratory fitness levels. Research has conclusively demonstrated the cardiorespiratory benefits of participating in exercise regularly. An increase in VO_2max has been achieved with all forms of exercise listed above (Abraham, Szczerba, & Jackson, 1993; Brennan, Michaud, Wilder, & Sherman, 1992; Burke, 1977; Butts, Pein, & Stevenson, 1984; Eyestone, Fellingham, George, & Fischer, 1993; Hoeger, Gibson, Moore, & Hopkins, 1993; McCord, Nichols, & Patterson, 1989; Milburn & Butts, 1983; Parker, Hurley, Hanlon, & Vaccaro, 1989; Wilmore, Royce, Girandola, Katch, & Katch; Yeager & Brynteson, 1970).

Milburn and Butts (1983) conducted a 7-week training program comparing the training effects of aerobic dance to jogging. Increases in VO_2max of 10 and 8% were found for the aerobic dance and jogging programs, respectively. Parker et al. (1989) found similar results following an aerobic dance program. Subjects increased their VO_2max (ml/kg/min) by 11% after training 3 times per week for 8 weeks. McCord et al. (1989) reported a 7.6 and 5.2% increase in VO_2max (ml/kg/min and L/min), respectively following a 12-week study. Subjects performed 30-35 minutes of low-impact aerobic dance 3 times per week at 75-85% of

their maximal heart rate reserve.

Burke (1977) found that an 8-week jogging program elicited a 24% increase in VO_2max (ml/kg/min) when subjects trained 3 times per week. Wilmore et al. (1970) reported that a 10-week jogging program conducted 3 times per week for 24 minutes increased VO_2max (ml/kg/min) by 5% in college-aged individuals. Yeager and Brynteson (1970) reported that a 6-week cycling program yielded significant increases in VO_2max of 5 ml/kg/min for subjects who exercised for both 10 and 20 minutes per session and 8 ml/kg/min for those who exercised for 30 minutes per session.

Swim training also elicits significant improvements in aerobic capacity (Butts et al., 1984). Fourteen women trained 5 days per week for 8 weeks at an exercise intensity of 80-85% VO_2max . Subjects improved their VO_2max by 8.7% and 9.7% (L/min and ml/kg/min), respectively.

Step aerobics, the forerunner of Aqua Step aerobics, has also been found to elicit positive cardiorespiratory changes. A study by Francis and Francis (1990) revealed that the energy expenditure of step training (3.49 ml/kg/min) was almost identical to running 7 miles per hour (3.29 ml/kg/min). Brown, Berg, and Latin (1993) found that the energy cost of step aerobics at bench heights of 4, 8, and 10 inches met the ACSM criteria for aerobic

conditioning. Olson, Williford, Blessing, and Greathouse (1991) concluded that the cardiovascular and metabolic effects of bench stepping exercise in females provided sufficient cardiorespiratory demands for enhancing aerobic fitness. Chapek (1993) found that bench stepping for 10 weeks improved VO_2max (ml/kg/min) by 11.5% in a group of college-aged females.

Physiological Effects of Water Immersion

Denison, Wagner, Kingaby, and West (1972) concluded that water immersion exposes the body to hydrostatic, viscous, inertial, and thermal conditions which could offer possible explanations to the altered cardiorespiratory responses to immersion at rest and during exertion. In addition, it was suggested that the cardiovascular effects of water immersion vary with posture (horizontal versus vertical), workload, type of limb movement, mean intrathoracic pressure, and water temperature (Denison et al., 1972).

Physiological Changes at Rest

A central shift of blood volume causes several cardiorespiratory adjustments with water immersion at rest. Adjustments include an increase in cardiac output, an increase in stroke volume, and no change or a small decrease in heart rate (Arborelius, Balldin, Lilja, & Lundgren, 1972; Farhi & Linnarsson, 1977; Haffor, Mohler, & Harrison, 1991;

Sheldahl, Tristani, Clifford, Hughes, Bobocinski, & Morris, 1987).

Arborelius et al. (1972) found that at rest, water immersion increased cardiac output by 32% and stroke volume by 35% while heart rate remained almost unchanged. It was suggested that the increase in cardiac output upon water immersion could possibly be due to the blood redistribution into the thorax. The increased water pressure forces blood from the periphery into the thorax (Arborelius et al., 1972).

Physiological Changes During Exercise

During immersion exercise, a higher stroke volume, an unchanged or higher cardiac output, and lower heart rates were found during intense but not moderate workloads versus nonimmersion exercise (Sheldahl et al., 1987). Haffor et al. (1991) studied the effects of water immersion on cardiac output during rest and exercise. They concluded that cardiac output increased with resting water immersion. During water exercise, it was concluded that cardiac output was significantly higher than during land exercise. It was suggested that the blood volume shift that occurs with immersion caused an increased preload and thus an increase in stroke volume. The heart rate response indicated that as the level of water immersion increased, heart rate decreased when compared to land exercise at the same VO_2 (Haffor et al., 1991).

Effect of Water Immersion on Exercise Prescription

The controversy over the appropriate heart rate prescription for water exercise still remains a challenge to exercise physiologists. Butts, Tucker, and Greening (1991) concluded that deep water running produced lower VO_{2max} values and heart rates than treadmill running. It was suggested that lower heart rates may be a result of the hydrostatic forces facilitating venous return, thereby maintaining an efficient cardiac output through an increased stroke volume (Butts et al., 1991).

As suggested earlier, the heart rate response decreased as the level of water immersion increased (Haffor et al., 1991). It is possible that the increased depth of water required for deep water running in the Butts et al. (1991) study elicited the lower heart rates.

In addition, Sheldahl et al. (1987) reported lower heart rate values at maximal exertion only, not at submaximal levels. Butts et al. (1991) reported lower heart rate values at maximal exertion.

Town and Bradley (1991) also compared land versus water running and reported similar results. Treadmill running produced higher VO_{2max} and HR_{max} values versus deep and shallow water running. Since the authors reported maximal exertion values only, this may have accounted for the lower reported heart rates, as well as the depth of water the

subjects were exercising at for deep water running. But, it was also concluded that shallow water running elicited higher metabolic responses than deep water running and was capable of producing similar heart rates as treadmill running.

In contrast, Bishop, Frazier, Smith, and Jacobs (1989) concluded that although water running elicited a significantly lower VO_2max than treadmill running, heart rate was not significantly different between the two forms of exercise. However, VO_2 and heart rate values were measured at submaximal levels instead of maximal exertion. This provides a possible explanation as to why the heart rate values reported were not significantly different on land versus water mediums. It was also reported that two of the athletes with relatively high VO_2 values were able to achieve the same exercise intensity in water as on land, producing similar VO_2max values (Bishop et al., 1989). This finding suggests that it is possible to achieve the same exercise heart rate in water as on land as long as exertion is submaximal, whereas other authors have cautioned against exercising at a heart rate prescribed from land-based maximal tests due to the reported decreased heart rate values in the water.

Yamaji, Greenley, Northey, and Hughson (1990) concluded that there is a linear relationship between HR and VO_2 for

both land and water exercise, reporting no significant differences between water versus treadmill running for HR and VO_2 . If HR for a given VO_2 during water running was lower, it was hypothesized that the nonsignificant decrease was greatly influenced by the skill of the athlete in the water running activity.

Investigators have reported similar training effects comparing land versus water exercise, thus it has been suggested that training in the water may be more efficient than training on land since the heart rate is lower during water exercise. Avellini, Shapiro, and Pandolf (1983) reported that similar training effects were achieved with individuals working at lower heart rates in water than on land. Herberlein, Perez, Wygand, and Connor (1987) compared high impact land aerobics to water aerobics and also suggested that a cardiovascular training stimulus can be attained despite the lower heart rate response.

Elder and Campbell (1990) emphasized the importance of instructing individuals who are exercising in the water to focus on technique instead of an appropriate heart rate intensity to elicit a training response. The data indicate that water exercise can produce metabolic adaptations similar to those of land exercise. Therefore, the most important determinant of training effectiveness is proper exercise technique, followed by maintaining an intensity for a sufficient amount of time.

Effect of Body Position, Water Depth, and Water Temperature on Heart Rate and VO_2

Body position (horizontal versus vertical), water depth, and water temperature have all been found to influence the cardiorespiratory responses to water exercise, specifically heart rate. The horizontal position in water exercise has been found to produce lower heart rate values versus exercising in the vertical position. McArdle, Magel, Lesmes, and Pechar (1976) suggested that the horizontal position may account for lower heart rates because the head becomes wet and a bradycardic reflex is stimulated. The ACSM (1991) suggests that in the supine position, or horizontal position, an increased venous return or preload is accompanied by a lower rate in comparison to an upright position. However, this suggestion is applicable to a land-based position, but may be transferred to water-based exercise. Exercise in the vertical position, however, has produced varied heart rate responses in the water. This variation is dependant upon many factors, such as water depth.

In the vertical position, Haffor et al. (1991) found that as the level of water immersion increased, heart rate decreased compared to land exercise at a comparable VO_2 . Gleim and Nicholas (1989) conducted a study to determine how water depth and temperature changed the linear relationship

of VO_2 and heart rate. It was concluded that walking and jogging in water at speeds between 2 and 5 mph at ankle depth, below knee, midhigh, and waist depth significantly elevated VO_2 and heart rate above land treadmill walking. At speeds greater than 5 mph, the VO_2 of waist depth jogging was not significantly greater than jogging on land.

Gleim and Nicholas (1989) reported that exercising at waist depth in water at 30.5°C produced an increase in heart rate as VO_2 increased. As the temperature increased from 30.5°C at waist depth, the heart rate also increased in response to an increase in VO_2 or workload. Overall, as temperature increased, a higher heart rate response indicated that an increased cardiac demand occurred regardless of body position.

Choukroun and Varene (1990) also determined the effects of water temperature on heart rate. The water temperatures included a cold bath at 25°C , a thermoneutral bath at 34°C , and a hot bath at 40°C . Based on the results, it was concluded that hot water immersion at rest caused a heat-induced cutaneous vasodilation which caused a marked increase in heart rate as well as cardiac output. Immersion in a thermoneutral temperature caused a decrease in heart rate due to the large rise in stroke volume accommodating for the increase in cardiac output. This change in heart rate was attributed to a baroreflex induced by the increase

in blood pressure related to the rise in cardiac output. Cold water immersion caused a baroreceptor mediated decrease in heart rate due to the rise in blood pressure as a consequent of vasoconstriction. Cardiac output was not altered.

Avellini et al. (1983) reported lower heart rates compared to land exercise when subjects exercised in lower water temperatures of 20°C. Throughout the training period, heart rates of individuals exercising in 20°C water averaged 20 beats per minute less than those individuals exercising on land and 10 beats per minute less than those exercising in 32°C water although work was performed at an equivalent VO_{2max} percentage.

Responses to Water Exercise Training Programs

Several authors have reported that water exercise elicits gains in aerobic capacity (Abraham et al., 1993; Brennan et al., 1992; Eyestone, Fellingham, George, & Fischer 1993; Hertler, Provost-Craig, Sestili, Hove, & Fees, 1992) Brennan et al. (1992) studied the gains in aerobic capacity after 8 weeks of aqua run training. These authors reported that individuals increased their VO_{2max} (ml/kg/min) values by 19.6% as a result of training. The subjects trained 3 days per week for 8 weeks at 63-82% of VO_{2max} . No accommodations were made to alter heart rate prescription based on the maximal treadmill test.

Another training study examined the effects of a 11-week aqua aerobic program and found a 5.6% increase in aerobic capacity (Abraham et al., 1993). The subjects trained for 3 days per week for 50 minutes at an average training heart rate of 79% of HRmax. Eyestone et al. (1993) found that over a 6 week period, injured runners could maintain aerobic capacity and a 2-mile run time provided he or she exercised with the same intensity, duration, and frequency during water running as they were accustomed to on land.

Hertler et al. (1992) conducted a study to determine the training effects of water running on the maintenance of VO_{2max} in runners. For 4 weeks, the subjects trained by deep water running. It was concluded that the subjects were able to maintain their aerobic capacity over a 4 week period.

Studies Comparing Land Versus Water Exercise

Training studies comparing land to water exercise are sparse, but conclude that similar training effects do occur. Avellini et al. (1983) trained individuals on a Monarch cycle in land or water at 75% of pretraining VO_{2max} 5 times per week for 4 weeks. It was found that training on land elicited a 16% increase in VO_{2max} . A 13% increase was reported for those exercising in 32°C water and a 15% increase in VO_{2max} was reported for those exercising in 20°C

water.

Bufalino, Moore, Sloninger, Johnson, and Andres (1993) compared the physiological responses to bench stepping in water and on land. The bench height was 30 cm, water temperature was between 28 and 30°C, and water depth was 107 cm. Although a lower VO_2 and HR was found while stepping in water, it was concluded that a cardiorespiratory training stimulus can occur. In addition, the subjects perceived water and land trials to be equally strenuous. Similarly, a higher RPE was noted in a study comparing deep water running to land running when related to both VO_2 and percent $\text{VO}_{2\text{max}}$ (Svedenhag & Seger, 1992).

An additional training study comparing water aerobics to low-impact land aerobics found similar increases in $\text{VO}_{2\text{max}}$ for both activities (Hoeger et al., 1993). Subjects trained 3 days per week for 8 weeks, performing 20 minutes of aerobic activity and 20 minutes of strength and conditioning per session. In addition, it was found that greater strength development occurred with water aerobics.

Kieres and Plowman (1991) reported a 20% increase in cardiorespiratory fitness as a result of either swim-land exercises or swim-water exercises. Subjects trained performing 20 minutes of swimming and then either 15 minutes of calisthenics were performed on land or in water 3 times per week for 8 weeks.

Conclusion

Water immersion at rest and exercise produces different cardiorespiratory responses compared to land conditions. The literature has consistently reported an increase in central and cardiac blood volume during immersion causing an increase in cardiac output and stroke volume with a small decrease or no change in heart rate at rest. If heart rate drops, perhaps it is due to a baroreflexively-mediated response from the increased blood pressure found with immersion at rest.

Inconsistencies arise in the metabolic and cardiovascular responses to immersion exertion, specifically heart rate. Some authors have reported little or no change in heart rate while other investigators have reported a significant decrease in heart rate compared to land exercise values. It appears this decrease may occur only at maximal exertion and in deep water. A lower heart rate is also found with cold water temperatures and is more common in the horizontal position.

Numerous training studies have reported increases in aerobic capacity following water exercise training programs. Water exercise produces cardiovascular training changes, such as an increase in aerobic capacity, that are similar to cardiovascular changes on land.

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