Original Paper

Biol. Sport 2010;27:95-98

EFFECTS OF A 24-WEEK DEEP WATER AEROBIC TRAINING PROGRAM ON CARDIOVASCULAR FITNESS

Accepted for publication 12.12.2006

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ABSTRACT: The purpose of this study was to determine the influence of prolonged deep water aerobic training on cardiovascular fitness. Two groups of women, each consisting of 19 women between the ages of 30-62 participated in this research. Group "A" (mean age of 49.2±8.7) participated in a 24-week deep water training program, exercising twice a week for 45 minutes. All 45 minute sessions were divided into three parts: the warm-up, the aerobic segment, and the cool-down including stretching elements. During the aerobic portion, the subjects were told to exercise at a moderate intensity which was established by used Karvonen's formula for water exercise and self-regulated by used of a Sport-tester Polar 800i. Subjects in group "A" were tested before and after 24 week program with the Bruce Protocol cardio-effort test when compared to the control group "B" (19 females with an average age of 48.7±8.1). Group "A" demonstrated significant improvement in aerobic capacity after deep water aerobic program (before=10.1±2.2 MET, after=11.1±2.0MET, $p<0.01$), also were demonstrated significant reduction of response systolic blood pressure and resting heart rate (before 84.5±14.3 bpm, after 75.8±10.0 bpm, $p<0.05$). The results of these study support the use deep water aerobic training as an alternative form of exercise to land-based training for unfit middle age participants.

KEY WORDS: deep water aerobic training, aerobic capacity, middle age women

INTRODUCTION

Looking for an "ideal" fitness activity, an ever increasing number of fitness participants are discovering water aerobics as a alternative to the traditional land-based programs. Since the nineties, water aerobics has become one of the most popular group exercise activities in the United States and Europe. Aquatic exercise is done in a vertical creating resistance and developing strength. The buoyant force of water results in a significant reduction of body weight in the water (approximately 90% of the weight of a person submerged to the neck). This dramatically decreases compression stress on weight-bearing joints, bones, and muscles. It can involve the upper and lower extremities through optimal ranges of motion while minimizing joint stress. Water is the optimal environment for providing full-body resistance. The density of water is approximately 800 times that of air, which is an important factor contributing to the energy expenditure of aquatic exercise. Thus, the water environment allows high levels of energy expenditure with relatively little strain to the body [13].

Two distinct forms of water aerobics have evolved – shallow and deep water training. Shallow water exercises (SW) are conducted in standing-depth water, whereas deep water exercises (DW) are performed with flotation devices to support the body in a suspended position in water that is over the exerciser's head.

Maximal Oxygen Consumption. Research investigating the lasting effects of shallow water aerobic exercise on VO2max improvements has been favorable. Various types of aquatic exercise have been tested including aqua aerobics, aqua step, shallow water running. Regardless of training mode, relative improvements have ranged from 5.6% to 18.9% [1,3,7,8,9,10,12,14,20,21] with only a single study reporting non-significant decrease (0.82%) in aerobic capacity [20]. As with other aerobic exercise modes, cardiovascular benefits of aqua training are not restricted by age [15,18,23]. Twenty females were divided into older (52.0±8.3 yr) and younger (28.0±6.5 yr) adults to assess the effects of age on improvements in cardiorespiratory fitness following a shallow water aerobics program [19]. Post-training submaximal treadmill tests (Astrand-Rhyming) revealed increases in aerobic capacity of 8.8% and 13.7% for both the older and younger women respectively. These findings support the use of shallow water exercise for cardiorespiratory improvements in an aging population.

The majority of research completed on deep water focused on running (DWR), has evaluated the ability to sustain or improve aerobic capacity following DWR in competitive runners [5,19,24,25]. The changes in VO2max after DWR training ranges from a 6.75% decrease [25] to a 10.6% relative increase [17,22]. One training study investigated the effects of DWR with older adults (mean age of controls 57.5±2.3yr, mean age of experimental group 63.1±1.6 yr). In this investigation Long [12] reported significant VO2max improvements in a group of 35 sedentary older women after a 10-week DWR program.

The training effects resulting from deep water exercise programs described only Simpson and Lemon study [21]. Eighteen adult females (22-39 years old) were held up in the water by using foam waist belts or ankle cuffs. All subjects trained a minimum of 3 days per week for 50 minutes per session using various aqua aerobics movements. The exercise program in deep water significantly improved estimated VO2max (pre=29.5±1,8; post=35.1±1.9 ml/kg/min) in both groups as assessed from an Astrand-Rhyming submaximal treadmill test.

Resting Heart Rate. Physiological adaptation to regular cardiovascular exercise is a reduction in heart rate at rest. However, little research has been conducted to support this decrease following shallow water exercise. Hoeger [10] and Simpson [21] have observed reductions in resting heart rate after prolonged shallow water exercise. An 8 week training study by Hoeger compared the heart rate responses following an identical shallow water and land-based aerobics program. Both shallow water and land-based aerobics programs led to similar decreases in resting heart: water pre=77.0±9.3 bpm, post=70.0±7.5 bpm, land= 6.0±10.8 bpm, post= 0±7.7 bpm). Simpson found resting heart rates were reduced by 11 bpm (before=77.7±2.4 bpm, after=66.3±1.7 bpm; p<0.01) upon completion of an 8 week aerobic training program.

Changes in resting heart rate through DW exercise has yet to become an important training variable of study. This is because the subject population for the majority of the current investigations has been aerobically trained athletes with the focus on performance training outcomes. Additionally, through land-based training, these fit subjects have achieved very low resting heart rates.

In the light of this fact it seems worth examination effects of the deep water aerobic training on participated middle age women. Thus resulting problem was captured in the following investigative question: If, and to what extend does deep water aerobic training influence cardiovascular efficiency and the adaptation to the effort performed.

MATERIALS AND METHODS

Subjects. This project investigated the effects of a 24-week deep water aerobic training program on cardiovascular fitness. There were 2 groups of women between 30-62 years participating in this study: group "A" consisting of 19 females subjects (mean age: 49.2±8.7 yr), participated in the deep water training program at the AWF swimming pool. Group "B" (the control group), consisting of 19 females subjects (mean age: 48.7±8.1 yr), did not engage in organized physical activity at in official setting). Subjects "A" were pre- and post-tested with Bruce Protocol cardio-effort test and pre-test compared with control group.

Deep Water Aerobic Program. The training program commenced for a total of 24 weeks (two 12 weeks cycles). The experimental group worked regularly twice a week with the same instructor (the researcher) throughout the period. The water in the pool used for the study was 27-28°C, in depth 140-360cm. The sessions were conducted with strict adherence to safety principles and to AEA guidelines and American College of Sports Medicine guidelines for working with adults [2].

All exercise sessions were divided into three parts; the warm-up, aerobic and a cool-down with stretching. They began with a 10-minute warm up period consisting of a succession of moderate stretching and flexibility exercises involving all the joints and muscles. The aerobic portion was lengthened gradually from 20 minutes in the beginning in first week to 30 minutes in 12th week. During the aerobic portion, all subjects were told to exercise at a target intensity which was established by used Karvonen's Formula for water exercise and self-regulated by the use of Sport-tester Polar 800i. The aerobic portion of the classes was done in a continuous, interval and circuit format. Equipment used in the training program included: rubber gloves, hand bars, ankle cuffs, "noodles" (water-resistant sponges 1.5 m long), kick boards and hand paddles. This study used equipment developed to increase the resistance of movement in water, and increase the force needed for the movement, thereby increasing the intensity and strengthening and toning of muscles. Each deep water aerobic training ended with cool-down period that included balancing and coordination, stretching and relaxation movements.

Statistical analysis. The Statistica 6.0.(StatSoft) was used as for the result analysis. The results obtained were evaluated statistically using the T- test for dependent samples - to opinion of differences between average in group, and T-test for independent samples - to opinion of differences between average for independent groups, Data are presented as means ±SD. Differences at the level of *p<0.05 and **p<0.01 were accepted as significant.

RESULTS

The subjects were similar in terms of age, height, weight and body composition (Table 1).

TABLE 1. SUBJECT'S ANTHROPOMETRICS DATA

	A (n=19)	B (n=19)
Age (years)	49.2±8.7	48.7±8.1
Height (cm)	163.3±5.8	163.6±5.8
Weight (kg)	69.2±9.0	69.6±10.4
BMI (kg/m^2)	25.6±3.6	25.7±3.4

TABLE 2. AVERAGE VALUES OF SBP AND DBP AT FOLLOWING EFFORT STAGES DURING BRUCE'S TEST IN GROUP A IN 1ST AND 2ND (BEFORE AND AFTER) EXAMINATION AND FOR GROUP B IN THE 1ST EXAMINATION

	A (n=19)				B (n=19)	
	before training		after training		before training	
	SBP(mmHg)	DBP(mmHg)	SBP(mmHg)	DBP(mmHg)	SBP(mmHg)	DBP(mmHg)
Pre-test	124.2±15.3	80.0±5.6	119.5±6.7	80.0±0.0	125.8±11.5	80.5±2.2
Stage 1	137.7±12.0	81.5±3.7	133.5±8.1	80.0±1.8	140.5±8.9	82.0±4.1
Stage 2	156.3±14.4	85.5±6.0	147.0±8.6**	81.5±3.0**	155.4±13.8	88.0±5.2
Stage 3	171.8±12.8	88.4±3.7	161.4±11.4*	87.2±1.0	171.1±9.6	90.0±0.0
Stage 4	185.0±7.1	90.0±7.1	173.5±9.4**	88.5±1.0	174.5±5.2†	90.0±0.0
Stage 5	180.0±1.0	86.7±4.8	176.7±3.1	86.7±1.0		
recovery	124.3±9.9	81.5±3.7	124.0±5.0	80.0±0.4	130.3±9.8	84.5±6.0

Legend: * - p<0.05; ** - p<0.01; † - p<0.05 between groups

TABLE 3. AVERAGE VALUES OF HR AT FOLLOWING EFFORT STAGES DURING BRUCE'S TEST IN GROUP A IN 1ST AND 2ND (BEFORE AND AFTER) EXAMINATION AND FOR GROUP B IN THE 1ST EXAMINATION

	A (n=19)		B (n=19)
	before training	after training	before
	HR [beats·min^{-1}]		
pre-test	84.5±14.3	75.8±10.0*	83.9±9.9
stage 1	116.5±14.4	104.5±9.3**	119.8±18.0
stage 2	136.1±16.3	123.0±13.8**	138.1±20.5
stage 3	155.1±12.7	142.4±14.1**	153.5±17.6
stage 4	167.2±8.9	153.8±10.0**	152.8±15.9†
stage 5	167.0±4.0	163.0±1.0	
peak ex	165.2±10.1	155.5±13.7**	158.3±14.6
recovery	113.5±11.7	107.3±11.5	119.8±15.4

Legend: * - p<0.05; ** - p<0.01; † - p<0.05 between groups

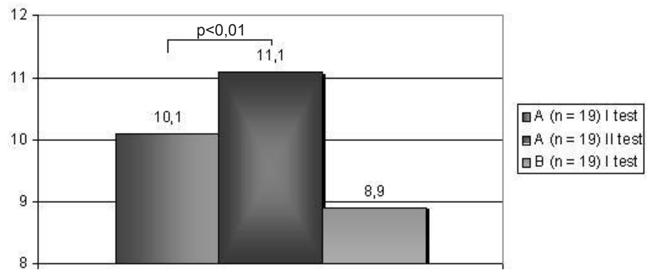

FIG. 1. AVERAGE VALUES OF MAXIMAL EFFORT DURING THE BRUCE TEST IN 1ST AND 2ND (BEFORE AND AFTER) EXAMINATION IN GROUP A AND FOR GROUP B IN THE 1ST EXAMINATION

The first pre-training test effort for the DW aerobics was completed by all the examined women from group "A" and "B". They achieved a correct result (negative test). The average level of aerobic capacity was 10.1 MET's , (Fig. 1). The lowest level 7 MET's was achieved by the three women whereas the highest level of 15 MET was achieved only by one woman.

After 24 weeks of DW training the average level of aerobic capacity for group "A" increased to 11.1 MET's and was significantly higher when compared to the results of the pre-test (p<0.01). 55% of the subjects improved their level of aerobic capacity, 43% did not change. Three women had 13 MET's and one woman had 15 MET's. In the control group, the average level of aerobic capacity was 8.9 MET's and did not differ much from the level for group "A".

After the end of 24 week training cycle in group "A" systolic blood pressure (SBP) decreased significantly at the 2nd and 4th stages (p<0.01) and at 3rd stage (p<0.05) during Bruce Test. Diastolic blood pressure (DBP) in the 1st test did not show any differences between group "A" and "B". After the DW training program, a significant decrease of DBP was noticed at stage 2 (p<0.01). In group "B", the recovery phase occurred after stage 4, and in group "A" after stage 5.

Average heart rate (HR) values during the effort tests are presented in Table 3. A significant heart rate increase in the 4th stage was observed in group "A" when compared to group "B" (p<0.05). In group "A", HR was lower at the beginning of the test and the average HR at further stages was significantly decreased (p<0.01). The participants demonstrated significant lower resting HR after deep water exercise (p<0.05).

DISCUSSION

The majority of cases presented to date in literature deal with recreational exercises conducted in water of 120-140 cm in depth. Only a few cases of DW training were included in the research but all of them were performed in water with the participant's feet touching the bottom of the pool. The research examined the training programs which offered three one hour sessions per week. The experiment being discussed in this article was based on the DW aerobic training which offered two 45 minutes session per week. The above amount of time is recommended by health and fitness specialists as a minimum period of physical activity for the beginners [4].

The average attendance of DW aerobic training included in this research reached 91.3%, in the first 12 week cycle and then decreased to 78.9% in the second cycle due to a conflict in one of the participants work schedule. It should be stressed that the amount of physical effort required by systematic training may be a real challenge for beginners or individuals leading a non-active, sedentary lifestyle. Increasing the frequency of the classes might influence the post training effects but at the same time might cause frustration and the necessity of making a choice between the duties of everyday life and the continuation of the training. In this context the physical exercises might not be considered a priority. Literature provides numerous examples which confirm the fact, that the increase of health benefits is directly proportional to the increase of physical activity and fitness. However, the statement "less physical exercise is better than no activity at all, and comparatively more exercise is better than less" [4] is very true for beginners starting a regular training program. This would be especially true for the population of Polish women who, according to the research conducted by of Kaleta and Jegier [11] and Charzewska [6], are least active between the ages of 45-54.

The effectiveness of training in the water is in direct correlation with the duration and the intensity of the exercises. On the basis of these observations it seems that a 45 minute session was the optimal time for the majority of the subjects as it allowed enough concentration to do the exercises correctly and keeping the right body temperature, and consequently the proper intensity with the final effect of pleasure and relaxation.

The DW aerobic program used in our experiment resulted 10.99% increase of aerobic capacity (11.1±2.0 MET's) in group "A", which is evidence of good cardiovascular capacity. Another effect of the training was the decrease of HR values at rest (bradycardia). Group "A" demonstrated a significant decrease of HR at rest. The values of 8.7 bpm were reported in post training tests.

The findings of this investigation creates an opportunity to broaden our knowledge on defining the influence of aqua aerobics, as a new form of health and fitness training, for middle and menopausal age women, as well as to create a database of physiological data related to this activity.

CONCLUSIONS

1. DW aerobic training had a positive affect on the level of cardiovascular capacity which manifested in higher values of METs for the work done.
2. The physiological changes resulting from participation in the 24-week deep water aerobic program were demonstrated in a significant reduction of response systolic blood pressure and resting heart rate.

REFERENCES

1. Abraham A., Szczerba J.E., Jackson M.L. The effects of an eleven week aqua aerobic program on relatively inactive college age women. Med. Sci. Sports Exerc. 1994;26(Suppl. 5):S103.
2. American College of Sports Medicine. The recommended quantity and quality of exercise for developing and maintaining cardio respiratory and muscular fitness, and flexibility in health adults. Med. Sci. Sports Exerc. 1998;30:975-991.
3. Bailey C., Finch S., Harlan S., Stiff P. A study to investigate the effects of a 10 week Aquarobic programme on cardiorespiratory fitness, flexibility and general well being. AKWA 1997;June/July:7
4. Blair S.N., Connelly J.C. How much physical activity should we do? The case for moderate amounts and intensities of physical activity. Res. Q. Exerc. Sport 1996;67:193-205.
5. Bushman B., Flynn F., Andres C. et. al. Effect of 4 weeks of deep water run training performance. Med. Sci. Sports Exerc.1997;29:694-699.
6. Charzewska J., Danielczuk I., Sołowiej D., Figurska K. Stopień aktywności fizycznej kobiet z Warszawy. Wych. Fiz. Sport 1998;32:69-78 (in Polish, English abstract).
7. Evans B., Cureton K. Metabolic, circulatory and perceptual responses to bench stepping in water. Med. Sci. Sports Exerc. 1996;28(Suppl. 5):S210.
8. Gaspard C.G. The Effects of a Seven Week Aqua Step Aerobic Program on Aerobic Capacity of College-Aged Females. In: AKWA 1997, February/March, 10
9. Hered W.K., Darby L.A., Yaekle G.C. Comparison of physiological responses to comparable land and water exercise. Med. Sci. Sports Exerc. 1997;29(Suppl. 5):S162.
10. Hoeger W.K., Gibson T., Moore J., Hopkins D. A comparison of selected training responses to water aerobics and low impact aerobic dance. Nat. Aquatic J. 1992;Winter:13-16.
11. Kaleta D., Jegier A. Które grupy wiekowe dorosłych osób należy najsilniej motywować do zwiększenia poziomu rekreacyjnej aktywności ruchowej. Med. Sportiva 2004;8(Suppl. 2):S67 (in Polish).
12. Knecht S. Physical and psychological changes accompanying a 10 week aquatic exercise program. AKWA Lett. 1992;Feb.
13. Kravitz L., Mayo J. The Physiological Effects of Aquatic Exercise: A Brie Review. Aquatic Exercise Association. 2004:22-23.
14. Lindle J. Comparison of heart rate and VO_2 responses on land and in the water. AKWA 2002/2003;Dec/Jan,19-20.
15. Long K.A., Lee E.J., Swank S.A. Effects of deep water exercise on aerobic capacity in older women. Med. Sci. Sports Exerc. 1994;26:118-123.
16. McInnis K.J., Balady G.J. Comparison of submaximal exercise responses using the Bruce vs. modified Bruce protocols. Med. Sci. Sports Exerc. 1994;26:103-107.
17. Michaud T.J., Brennan D.K., Wilder R.P., Sherman N.W. Aquarunning and gains in cardiorespiratory fitness. J. Strength Cond. Res. 1995;9:78-84.
18. Routi G., Troup J., Berger R. The effects of non swimming water exercise on older adults. J. Sport Phys. Ther. 1994;19:140-145.
19. Sanders M.E. Selected physiological training adaptations during a water fitness program called wave aerobics. Thesis, University of Nevada, In: The Physiological Effects of Aquatic Exercise, 2004:10-11.
20. Seefeldt L.R., Abraham A. The effects of on an eleven week aqustep program on relatively inactive college age female. In: The Physiological Effects of Aquatic Exercise, 2004:22-23.
21. Simpson A., Lemon P. Effects of an eight deep water vertical exercise training program in adult women. AKWA Letter 1995;21-23.
22. Svedenhag J., Seger J. Runing on land and in water: comparative exercise physiology. Med Sci. Sports Exerc. 1992;24:1155-1160.
23. Wigglesworth J., Edwards J., Mikesky A., Evenbeck E. The effect of water exercise on various parameters of physical fitness. AKWA Lett. 1990;Sep./Oct.,5-17.
24. Wilber R., Moffatt B., Scott D. Influence of water run training on the maintenance of aerobic performance, Med. Sci. Sports Exerc. 1996;28:1056-1062.
25. Quinn T., Sedory D., Fisher B. Physiological effects of deep water running following a land-based training program. Res. Q. Exerc. Sport 1994;65:386-389.