

PHYSIOLOGICAL RESPONSES OF WATER TRAINING ON ATHLETES: A META-ANALYSIS

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ABSTRACT

The objective of this meta-analysis was to observe the trends in the research in reference to the effect of water exercises on the physiology of trained and untrained population and to establish the fact about the water exercise and its responses. Articles and abstract were reviewed and presented into two sections, responses on cardio respiratory system and on the body composition. Systematic reviews on research articles from the year 1992 to 2011 were reviewed and the conclusions were drawn on both of the objectives. The finding of the meta-analysis concluded that water is one of the medium in comparison to land that helps in improvement in abilities of the cardio-respiratory system and in the reduction of body fat and body mass index because of the control experiment protocol or due to the unique characteristics of the of the water that is viscosity and bouncy.

Keywords: Maximum oxygen consumption, respiratory muscle strength, body fat, land exercises, water exercises.

1. INTRODUCTION

Water has been used for healing and rituals since centuries. Our bodies are composed primarily of water. For many, water is a natural place for healing, rehabilitation and exercise (DeMaere, & Ruby, 1997). Aquatic history provides a foundation for understanding the current culture of water in exercise or in medicine (White, 1995). The long history of the use of aquatics therapy has history of the use of aquatic therapy has generated a number of terms that describe their activity, including hydrotherapy, water therapy, spa therapy, aqua therapy,

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water gymnastics, aqua aerobics and water exercises. Water was using for healing purpose as early as 2400 BC and its use for those reason even continues today. Water uses for the combat fever documented for back in 1500 BC. In Far East, prolonged submersion or continues running water was used for curative purpose. Some of the first school of medicine arose near the bath and spring in Greece. Hippocrates (460-375 BC) documented the use of water immersion to treat a variety of problems and improve the quality of life the Roman empire further expand the use of water immersion for the athletes, they made some pools on larger scale for the training of their athletes and solders and also provide the water base exercise to the normal population that they discover about the natural abilities of water that water provide natural resistance to improve the health status of humans by just mean of even full s immersion in the water. By AD 330, the primary purpose was to treated rheumatic disease, paralysis and injuries and mainly used to provide strength to weak people (Torres-Ronda, & Schelling-i-del-Alcázar, 2014).

For some, it is sensation of weightlessness and an easy way to perform the movement that result from buoyancy force of the water. This will give the stability and support from the pressure of the water and its viscosity. For the ability to continue a cardiovascular training program despite of any injury similarly athletes who are trying to get recover from any injury or working on their muscular strength or endurance need to limit their joint load are basically opt water training and they get result faster. People with variety of different goals are the water to optimize function. People who are participating in a strength or endurance program frequently find that water an ideal complement to a land based program. Cross training is very important for developing muscular balance. However sports that are primarily require strength in other side required to prevent injuries the water can be best environment to train. When people raise their heart rate and metabolic rate to burn calories in the water is the best part. Water is a fluid of living thing as a chemical that contain an oxygen and the two hydrogen atoms, water cover 71% of earth surface that make it the most important chemical of life. Its density is 800 times dense to the weight bearing exercises which are very stress full on the land based become a challenge to joint and to the soft tissue of the body (Casa, Stearns, Lopez, Ganio, McDermott, Yeargin,, & Maresh, 2010).

Water provide the iso-kinetic effect on the moving body part a uniform way to provide equal resistance during the movement to establish all the fact about the water exercise and its responses many articles and abstract were reviewed will be presented into three section, Responses on cardio respiratory system, body composition (Alberton, Cadore, Pinto, Tartaruga, da Silva, Martins, & Krueel, 2011).

2. METHODS AND MATERIALS

A comprehensive literature search of research articles from the year 1992 to 2011 (19 years period) using the google scholar and medline search strings, deepwater immersion, cardiovascular system, maximum oxygen consumption, respiratory muscle strength, body fat, land exercises, water exercises. Differences were observed, discussed and reported for the cardio-respiratory and body composition.

2.1 Responses on Cardio-Respiratory System of Water Exercises

Most of the studies completed on deep water running have shown the ability to develop cardio-respiratory abilities (Bushman, Flynn, Andres, Lambert, Taylor, & Braun, 1997; Eyestone, Fellingham, Georgej, & Fisher, 1993; Quinn, Sedory, & Fisher, 1994; Wilber, Moffat, Scott, Belee, & Cucuzzo, 1996). The cardiovascular effect of water exercise vs. land based exercise is of particular to athletes or to those who wanting to reduce the exercise stress related with the exercise and significant effect. Studies conducted to utilize endurance training, in the water environment, subjects have found that deep water is successful in developing cardio-respiratory variables (Bushman, *et al.*, 1997; Hertler, Provost-Craig, & Sestili, 1992. Wilber, *et al.*, (1996) takes 16 trained male runners for to study the effects of a 6-week deep water running program on maximal O₂ consumption (VO₂ max), lactate threshold and running economy. Result shows VO₂ max “(pre = 58.7 ± 4.7”, post = 59.6 ± 5.4 ml/kg/min)” in the highly fit subjects. These similar results were also found in the study done by Bushman, found similar result in maximal “(pre = 63.4 ± 1.3, post = 67.2 ± 1.3 ml/kg/min)” and sub maximal VO₂ responses (pre = 44.8 ± 1.2, post = 45.3 ± 1.5 ml/kg/min) after four weeks of Deep Water Running in eleven runners. Hertler, *et al.* (1992) study the effect of thirteen young runners in water training vs. treadmill exercises (aged 18-26 yrs.). Athletes trained on land 3 days a week for 4 weeks and then half of the subjects began a water training program while rest continued to exercise on land. Post training treadmill test shows no change occurred in maximum Oxygen consumption between the treadmill and deep water running group. The result indicates that water exercise is effective in maintaining VO₂ max. (Michaud, Brennan, Wilder, Sharman, 1995) had 10 volunteers’ complete maximal treadmill and DWE for an eight-week aerobic DWR program. Improvements in maximum oxygen consumption of 10.7% and 20.1% for deep water running and treadmill were detected. Treatment given 3 times a week. Workout heart rates ranging from 63% to 83% of maximal treadmill heart rate (Michaud, Brennan, Wilder, & Sherman, 1995) shows a large increases result from a mixture of the high-intensity exercise, unfit subjects, specific training and testing involved in the study. The results of the study support the utilization of deep water training as an

alternative way of training to land based training for the maintenance of aerobic ability in athletes as well as the improvement of maximum oxygen consumption in unfit subjects. Hoyer, Hopkins, Barber, and Gibsons, (1992) examined the effects of training by identical aerobics program performed on land and in water. 49 untrained women (water n = 20; land n= 15; control n = 14) actively participated in the eight-week program as three days a week for 20min in duration with the intensity between 70-80% of HRR. Result shows the significant increase in maximum oxygen consumption in both the groups (land and shallow water aerobics). In agreement with (Hoyer, *et al.*, 1992). A similar significant 5.6% increase in $VO_2\text{max}$ “(34.8 ± 4.1 to 36.7 ± 5.2 ml/kg/min)” and an enriched run time to enervation “(pre = 15.8 ± 3.7 min, post = 19.4 ± 5.0 min)” was also saw by Abraham, Szezerba, and Jackson, (1994) who conducted a study on 11 weeks of shallow water aerobics on twenty women (40 ± 13.99 yrs.) Were separated into young (28 ± 6.5 yrs.) and older (52 ± 8.3 yrs.). The result shows a significant gain in cardiovascular efficiency through shallow water training program (Sander, 1993). Completed eight-week training that involves shallow and deep water exercise with a heart rate between 74%-84% of intensity during exercise. Submaximal treadmill test shows increase in a cardiovascular improvement in aging population. Simpson (1995) tested the effect of DWA program on 18 adult women with age ranging from 22-39 yrs were buoyed in the water by using foam waist or ankle cuffs. All women trained for 50 minutes per session for 3 days a week using aquatic movement. The exercise in DW significantly improved estimated maximum oxygen consumption “(pre = 29.5 ± 1.8, post = 35.1 ± 1.9 ml/kg/min)”. Barbara, Shapiro, and Pandolf, (1993) follow a one week of water training and same on land on a cycle ergometer in water immersed to the neck. physical training consist of one hour daily exercise, 5 time/wk. with an hrs of 75% $VO_2\text{max}$. The result shows physical training produce similar adaptation as does training on land and increase in 16% of $VO_2\text{max}$. Ide, Belini, and Caromano, (2005) in their investigation found a significant result in the improvement of respiratory power due the water exercise program of ten weeks on the elderly population. Involve 81 volunteers age ranging between 60 to 65 yrs.

2.2 Effect of Water Exercise on Body Composition

Review literature revealed the fact of reduction in body fat due to land-based exercise. The researcher also effort to substantiate similar body composition change due to water exercise program. Additionally, nine studies were conducted on water exercises have used. One of such study conducted by Michaud, *et al.*, (1995) shows that eight weeks of deep water running program in 10 untrained subjects' provided a significant body fat reduction. Subject trained for eight weeks in three days per week with 63%-83% intensity of HRR. The result of

skinfold measurement shows 2.6% decrease in body fat (Simpson, 1995) used bioelectrical impedance to assess body fat percentage shows a 2.7% decrease in body fat after 8 weeks of DWA training that shows Significant decreases in body fat have been observed in several studies conducted on DWA and SWA Athletes trained for 3 days a week for 50min a session for eleven week training program completed by sedentary decrease in body fat (Abraham, Szezerba & Jackson, 1994). Result of Hoger, *et al.*, (1992) study shows decrease in body fat in sedentary women exercising three days per week for eight weeks with the 70-80% of HRR. A 7.5% change in percent fat “(pre = 26.4 ±7.4%, post = 24.4 ±6.7%)” as measured by skinfold thickness were similar to the 5% decreases seen in the land-based. Aerobics group (pre-test = 21.8 ±5.0%, post-test = 20.7 ±4.5 %;). Sander, (1994) observed the shallow and deep water exercise effect on body fat of young (28 ±6.5 yrs.) and older (52 ±8.3 yrs.) female. The result shows the significant reduction in body fat following an eight-week community-based program with a decrease of 11.9% for young and 5.8% for the older subject. Nuttamon, Warakul, Amatyakal, and Suksom, (2012) examined the twelve-week aerobic exercise program effect on physiological adaptation and glycemic control in an older subject with T2DM. 40 subjects with T2DM were assigned either to the Aerobic Exercise group (n=20) or the non-exercise control group (n=20).The Aerobic Exercise group executed Exercise in the swimming pool for three days a week at 70% of maximum heart rate for 30 min. A significant reduction in body weight, a percentage of body fat. Triglyceride and insulin reduction observe in aerobic exercise group. (Nagle, Robertson, Otto, Ranalli, & Chiapetta, 2007) Investigate the effects of the non-weight-bearing method of aquatic exercise as a modality for weight loss. The duration of training was 14 week. 44 obese women were selected and divided into water and aerobics, both groups were required to complete 3 sessions a week. In the AE group, slightly greater non-significant losses in body weight, improvements in flexibility. These observations suggest that aquatic exercise in combination with walking can serve as an alternative to walking exercise alone for overweight women during periods of weight loss. Similarly Min-Sun, Soo-Keun, Yong-Kwon, Hee-Jung, and Nam-Cho, (2011) examined the effect of water exercise program on BMI, skeletal muscle mass, body fat percentage and physical fitness by applying SFT and depression in elderly women. They take 59 elderly female. Aquatics exercise program was performed 3 days a week for 12 weeks using rating of perceived exertion and BMI, BFP,SMM and depression were tested before and after the exercise program. BMI (p=.002) and BFP (p=.021)” were significantly down after the AEP. It is suggested that aquatic exercise program may play a significant role in decreasing body fat in elderly. In a similar study done by Jones, Meredith-Jones, and Legge, (2009) investigate the response of twelve-week aquatic based circuit training program on glucose depletion in the obese female with impaired and

normal G6H12O6 tolerance. 15 obese female ([BMI] > 25 kg/m²) with normal glucose tolerance (Normal Glucose Tolerance: n=7) or impaired glucose tolerance (Impaired glucose tolerance: n=8) were selected for this study. All women completed a 12-week training program on combination of aerobic and resistance exercises in a water environment, 3 days a week and 60 min per session at 70–75% of optimum heart rate. 12-week period, fasting insulin levels had down by 44% and 2-h glucose by 30.4percentage in the group with impaired glucose tolerance. WC had reduced by 5.3 percent in this group at the end of the experiment. Only WC and waist-to-hip ratio (WHR) decreased (6.0% and 5.5%, respectively) intermediate intensity, WBC-type exercises appear to be an effective exercise modality to improve glucose and insulin response to a glucose challenge in overweight women with IGT.

3. RESULTS

Table 1: Pre and post effect of water training on Vo₂ max

S.N.	Authors of study	Subject length	Pre in VO ₂	Post in VO ₂	Change in %
1	Hertler, <i>et al.</i> , (1992)	13			increase
2	Hoeger, <i>et al.</i> , (1992)	49	31 ± 6.8	35.6 ± 7.0	5.6%
3	Sanders, (1993)	20			13.7%
4	Avellini, <i>et al.</i> , (1993)	15			16%
5	Abraham, <i>et al.</i> , (1994)	20	34.8 ± 4.1	36.7 ± 5.2	2.0%
6	Simpson, (1995)	18	29.5 ± 1.8	35.1 ± 1.9	6.4%
7	Michaud <i>et al.</i> , (1995)	10	29.3±8.23	2.8±8.0	10.6%
8	Wilber <i>et al.</i> , (1996)	16	58.4±2.3	60.1±3.6	3%
9	Ide, <i>et al.</i> , (2005)	81	92±36.5	100±34.3	8.0%

Table 2: Pre and post effect of water training on body composition

S. N.	Author	No of subject	duration	pre	post	Change in %
1	Hoeger, <i>et al.</i> , (1992)	49 F	8 wk	26±7.4	24.4±6.7	-7.5%
2	Abraham, <i>et al.</i> , (1994)	14 F	11 wk	24.2±3.3	22.8±3.0	-5.8%
3	Sander, (1994)	20 F	8 wk	25.1±1.2	22.1±1.1	-11.9%
4	Michaud <i>et al.</i> , (1995)	8 F	8 wk	30.0±7.4	29.2±7.2	-2.6%

5	Simpson (1995)		8 wk	-2.7%
6	Nagle, <i>et al.</i> , (2007)	44 F	16 wk	Decrease (ns)
7	Jones, <i>et al.</i> , (2009)	15 F	12 wk	HWR (-6.0%)
8	Songmin, (2011)	59 F	12 wk	BMI= dec (p=.621) (S)
9	Nuttamon, <i>et al.</i> , (2012)	40 F	16 wk	Decrease (Ns)

4. DISCUSSION

Research articles analysis the effects of aquatic training on VO₂ max improvements, five establish a significant increase in maximum oxygen consumption after water training with four of the researches shows a significant increases and maintenance of VO₂ max in Table 1. However, the increase should be due to proper manipulation of training variables. 10.6% relative rise in a study by Michaud, *et al.*, (1995). Water training still remains a smart way compared to land aerobic training. Shallow water training shows significant increases in maximum o₂ consumption but the effect on cardiovascular due to land based and water based exercise are same. Presently there is a strong need of conducting research studies on physiological effect to water exercises with proper control and good standard are recommend.

The impact of water workouts on changes in body fat percentage. Research findings revealed that an 11.9% decrease in body fat in studies lasting in 7-16 weeks. A trend of body fat percentage decreases was observed in training programs lasting 8 weeks or greater. All studies recorded decreases in body fat in water training show a significant decrease (Abraham, *et al.*, 1994; Hoeger, *et al.*, 1992; Michaud, *et al.*, 1995; Sanders, 1993; Min-Sun, *et al.*, 2011; Jones, *et al.*, 2009; Nuttamon, *et al.*, 2012). This supports the view that training effects are attained in studies 8 weeks or greater in length. Furthermore, experiments without dietary control will necessitate lengthier exercise training before notable changes in body fat are attained. And water effect is also responsible for controlling body fat.

5. CONCLUSIONS

The finding of the meta-analysis concluded that water is one of the other medium in comparison to land that helps in improvement in abilities of the cardio-respiratory system and in the reduction of body fat and body mass index because

of the control experiment protocol or due to the unique characteristics of the of the water. It is also concluded that water exercise are equally and more effective than the land exercises for untrained athletes .So on the bases of these researches, recommended that water exercise programs are equal effective in the development of cardiovascular fitness or in the reduction of fat.

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