Effect of Underwater Treadmill Training on Cardiovascular Responses In Normal And Overweight Individuals

Gaurang Baxi*, Tushar Palekar, Monisha Nair***, Soumik Basu*, Divya Gohil******

*Associate Professor, **Principal, ***Post-Graduate Resident, ****Assistant Professor,
Dr. D. Y. Patil College of Physiotherapy, Dr. D. Y. Patil Vidyapeeth, Pimpri, Pune, India

Abstract: Background: Obesity is an established risk factor for various cardiac conditions. Though the health advantages of aerobic exercise training are well established, there is also an increased risk of musculoskeletal injury with ongoing modes of exercises like sprinting and running. Various researchers have reported the positive effects of aquatic exercises on circulatory diseases caused by obesity. This study explores and compares the effects of aquatic exercise on the heart rate, blood pressure, rate of perceived exertion and VO_2 max, between normal and overweight persons. Methods: 20 healthy male volunteers aged 18-35 years were made to run on an underwater treadmill at varying speed and resistance using a modified version of the 'HydroWorx X80 Bootcamp Workout' protocol, thrice a week for 6 weeks. Results: Statistically significant difference was seen in heart rate, blood pressure, Modified Borg score and VO_2 Max within both groups, before and after intervention. However, there was no significant difference seen between the groups. Conclusion: Underwater treadmill training helps reduce heart rate, blood pressure, rate of perceived exertion in normal as well as overweight men. Also there is an increase in the maximal oxygen consumption for both groups. [G Baxi, Natl J Integr Res Med, 2018; 9(4):13-19]

Key Words: Aquaciser, Cardiovascular fitness, Obesity, Underwater treadmill, Underwater exercises.

Author for correspondence: Dr. Gaurang Baxi, Associate Professor, Dr. D. Y. Patil College of Physiotherapy, Dr. D. Y. Patil Vidyapeeth, Sant Tukaram Nagar, Pimpri, Pune 411018. E-Mail: gaurangbaxi82@gmail.com M: 9371007824

Introduction: Water has been used throughout history as a modality to promote healing and elicit various favourable physical and biological effect on the immersed body[1]. After centuries of trial and error, healing through aquatic therapy has recently advanced with the development of modern scientific research practices. Aquatic therapy has profound physiological and biological effects that are related to principles of hydrodynamics. These comprise of hydrostatic pressure, buoyancy, density, viscosity, specific gravity and thermodynamics. Aquatic therapy represents a new generation of rehabilitation that is informative enough to be condition, injury and sports specific. Exercises under water is effective in the management of patients with musculoskeletal, neurologic, cardiopulmonary pathology, and other conditions including obesity, hypertension and diabetes.[2]

Obesity is an established risk factor for coronary heart disease (CHD), ventricular dysfunction, congestive heart failure, stroke, and cardiac arrhythmias.[3]Additionally, studies have identified obesity to be a predisposing factor for other co-morbidities like postural defects, balance impairments and predisposition to falls.[4]Obesity is rampant in both developed and developing countries, all age groups, particularly young adults in the age group of 18 to 35 years.[5] Reducing weight improves or prevents many of the obesity related risk factors for CHD. It is thus imperative that healthcare professionals understand the benefits of managing obesity and be able to effectively implement weight-management strategies in obese patients.[6] Aerobic training is known to counteract obesity by promoting body fat reduction, reduction in waist circumference, while improving maximal aerobic capacity.[3]

Though the health advantages of aerobic exercise training are well established, there is also an increased risk of musculoskeletal injury with ongoing modes of exercises like sprinting and running.[6] This is due to the amassed stress on lower extremities in obese individuals. Joint surfaces can be protected by performing exercises underwater, without fear of impact loading.[7] Aquatic rehabilitation is therefore important because it allows gradual progressive loading of major joints and allowing them to have immediate full range of motion with less joint burden.[8]

To overcome risk of joint injuries and falls during physical training in overweight and obese individuals, the American College of Sports Medicine recommends non-weight bearing exercises. [8] Buoyancy and hydrostatic pressure exerted by water help reduce the stress on the lower extremity joints and spine, when exercise training is done under water.[2]

Aerobic fitness improves post exercises in water and have similar effects on body composition to that of exercises on land.[6] An extensive variety of aquatic exercises have affected the physiologic function positively.[9] Underwater treadmill exercises use very sub-maximal to low level impact training for individuals with joint pathologies during rehabilitation, or in conditions of partial weight bearing or when land-based activities are not tolerated.[7] Aquatic therapy is used as a joint sparing intervention in cases of rheumatic arthritis, pre and post-operative management of muscular conditions and strength and endurance training in cardio respiratory diseases.[10]

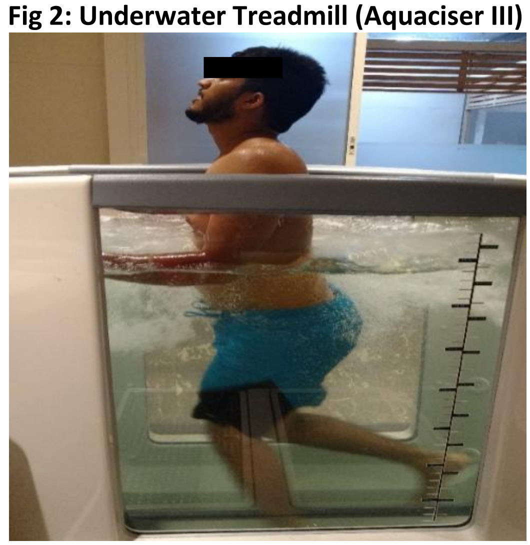
Despite the enormous health benefits which aquatic exercises potentially have to offer, their use as exercises and in rehabilitation remains under-utilised. Aquatic exercise has been shown to equal or surpass other forms of exercise including walking and running.[9] Various researchers have reported the positive effects of aquatic exercises on circulatory diseases caused by obesity.[2,9,6] However, few studies have compared the effects of aquatic exercises on cardiovascular parameters in overweight and normal individuals. This study explores and compares the effects of aquatic exercise on the heart rate, blood pressure, rate of perceived exertion (RPE) and VO_2max, between normal and overweight persons.

Methods: The study was conducted in the outpatient department of Dr. D.Y. Patil College of Physiotherapy, Pune. The study was approved by the institutional ethical committee. 20 healthy male volunteers in the age group of 18 to 35 years, having BMI between 18.5 and 29.9 were recruited, informed consent was obtained. Individuals having any open wounds, neurological impairments, cardiac impairments and hydrophobia were excluded from the study. Instructions were given to them about the procedure to be performed on the underwater treadmill. The AquaCiser III Underwater Treadmill System (manufactured by Hudson Aquatic Systems, USA) installed in the Institute OPD was used. This equipment is designed to provide hydrotherapy with aerobic exercise, providing a high-resistance, low-impact aerobic workout. (Fig. 1).

Height and weight of participants was measured barefoot and in swimming costume.BMI was used to classify the participants into overweight and normal groups, using Asian age and sex specific BMI cut-offs.[11] Resting heart rate was noted using a stopwatch. Blood pressure measured manually. Participants were instructed to continue their normal daily activities in addition to the training program for 6 weeks, maintain their current diet, refrain from additional workouts and not to consume any oral nutritional supplements.

Fig. 1: AquaCiser III Underwater Treadmill System

Fig 2: Underwater Treadmill (Aquaciser III)



Prior to starting the intervention, VO2 max of the participants was calculated by Rockport fitness test. Participants were asked to wear comfortable clothing and do light stretching of all major joints before the test. They were instructed to walk as fast as possible for 1 mile i.e. 1.6 km. Pulse rate was taken after the test. Time taken for covering the distance of 1.6 km test was noted, and VO2 Max was calculated using the formula given below.[12]

$$VO_2 \text{ Max} = 132.853 - 0.0769 \text{ (Weight in Kg)} - 0.3877 \text{ (Age)} + 6.315 \text{ (Gender)} - 3.2649 \text{ (Time)} - 0.1565 \text{ (HR)}$$

Where: males = 1, females = 0

In order to familiarize the subjects with the test, each individual was given a practice session prior to the day of testing on the underwater treadmill. Subjects were instructed to maintain a reciprocal arm action for walking and running on the underwater treadmill. This was defined as having the elbows flexed to 90° with the forearms in the mid-prone position. The temperature of the water was maintained at 35^{o} C for all subjects for every session. (Fig. 2)

All participants were made to jog and run on the underwater treadmill at varying speed and resistance using a modified version of the 'HydroWorx X 80 Boot camp Workout' protocol. This protocol utilizes the natural properties of water and the underwater treadmill jet machine to create a balanced workout for the whole body. The workout was designed by Murphy Grant, Director of Sports Medicine at the University of Kansas.[12]

The workout is a high-speed interval program with a variety of rest periods, upper body exercises, and lower extremity workouts. (Table 1)The protocol was modified slightly, as the resistance offered by the water jets in the Aquaciser III exercise training system is constant, as against a variable jet resistance recommended as per the original Bootcamp protocol. The total duration for the intervention was kept for 6 weeks, as physiological changes happen over this time period.[2] After 6 weeks of training (3 days/week, total 18 sessions) the heart rate, blood pressure and RPE difference among the normal and obese subjects was compared.

Table 1: Treadmill Protocol used

Exercise	Time	Modified Bootcamp Protocol	Original Bootcamp Protocol
Warm up walk	1.5 min	5 mph	5 mph
Warm Up Skip	1.5 min	5 mph	5 mph
Warm up jog	2 min	5 mph	5 mph
Interval run	2.25 min	5.2 mph, resistance jets	5.2 mph, 60%resistance jets
Interval jog	2 min	3.5 mph, resistance jets	3.5 mph, 45% resistance jets
Interval run	4 min	5.5mph, resistance jets	5.5mph, 65% resistance jets
Interval jog	2 min	3 mph, resistance jets	3 mph, 45% resistance jets
Interval run	5 min	6 mph, resistance jets	6 mph,75% resistance jets
Cool down walk	5 min	Comfortable speed	Comfortable speed

Summary of Procedure

Enrolment of Subjects as per inclusion criteria

↓

Informed consent taken

↓

Resting parameters assessed (Height, weight, BMI, BP, HR)

↓

VO_2 Max was calculated using Rockport fitness test

↓

6 weeks training (3 days/week, total 18 sessions) on underwater treadmill

↓

Post 6 weeks outcome measures was taken

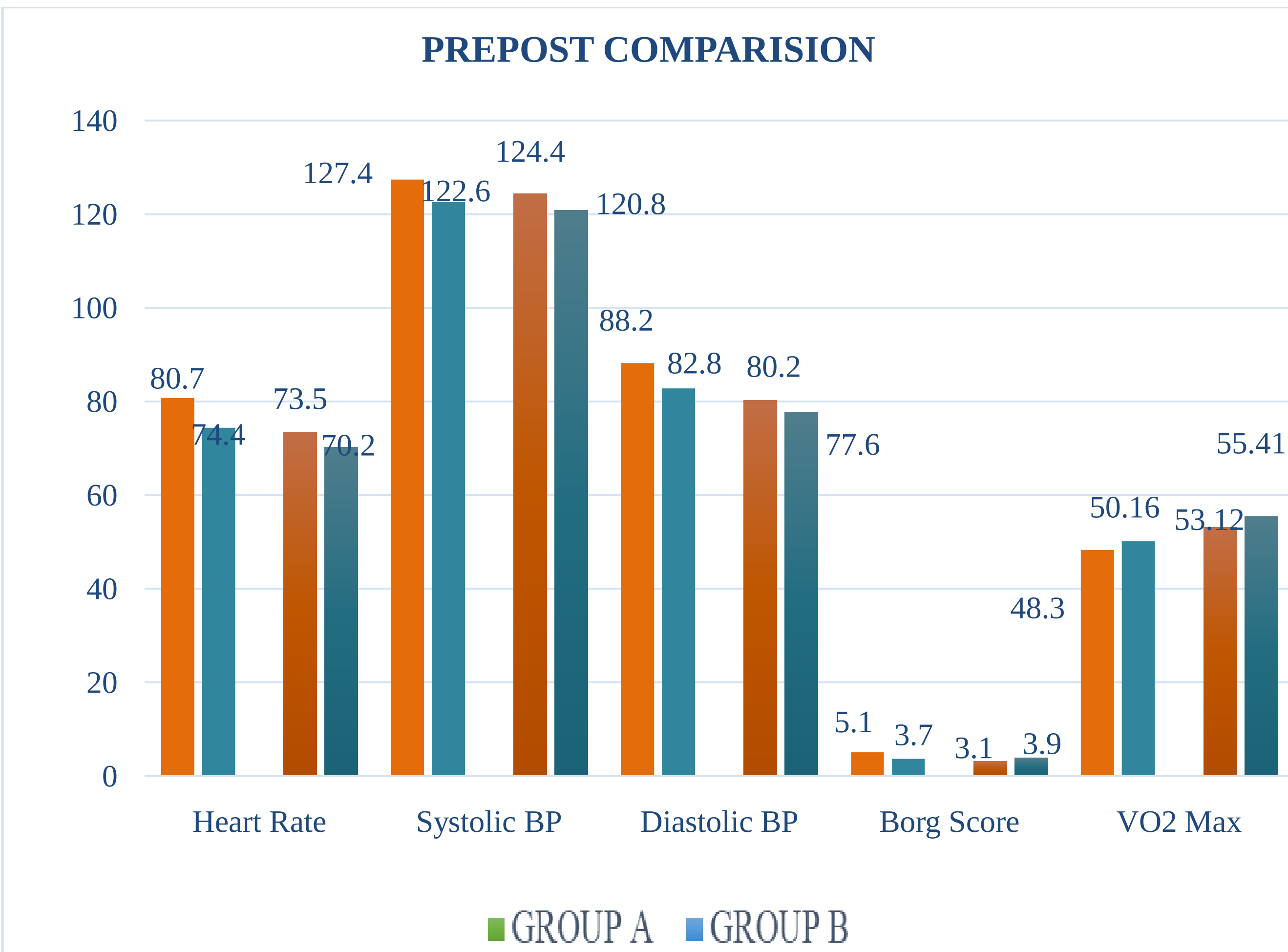
Result: Sample size was estimated and accordingly, a total of 20 participants were enrolled for this study. Of these, 10 were overweight and 10 were having normal BMI. SPSS (version 23) was used to establish normality of baseline data. For normally distributed values, paired and unpaired t test were applied and for variables which were not normally distributed, the Mann Whitney Rank Sum test and Wilcoxon Signed Rank test were applied. Accordingly, the following statistical tests were used: T test and paired t test: for heart rate and diastolic blood pressure, Mann Whitney Rank Sum and Wilcoxon Signed Rank test: for systolic blood pressure, BORG, VO2 max.

Table 2: Baseline Values

		Heart rate*	Systolic Blood Pressure **	Diastolic Blood Pressure *	Modified Borg Score **	Vo2max**
A(Overweight) n=10	Mean (SD)	80.7 (7.499)	127.4 (6.535)	88.2 (10.56)	5.1(0.8756)	48.3 (3.898)
	Median		118		5	47.76
B (Normal) n=10	Mean (SD)	73.5 (7.307)	124.4 (3.627)	80.2 (7.33)	3.9 (0.3162)	53.12 (2.921)
	Median		118		4	53.01
		P =0.043 t=2.175	P= 0.256 Z=1.135	P=0.065 t =1.968	P= 0.002 Z= 3.076	P=0.009 Z=2.608

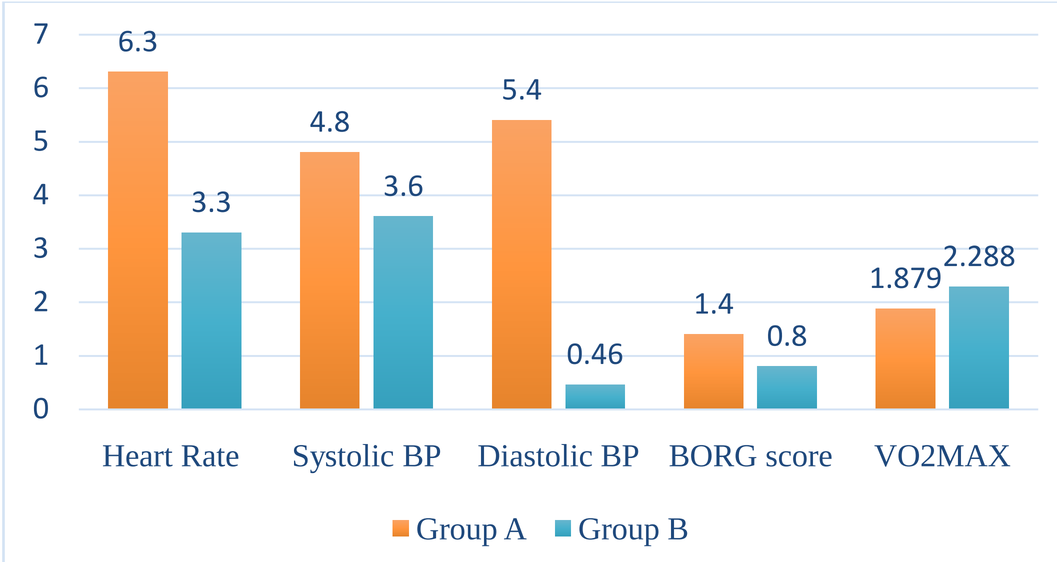
*T test **Mann Whitney Rank Sum Test

Graph 1: Comparison of Pre and Post values



Interpretation: Statistically significant difference was seen in the pre and post values of heart rate, blood pressure, Modified Borg score and VO_2 Max for both groups. This suggests that underwater treadmill running was effective in both the groups in reducing heart rate, blood pressure, rate of perceived exertion and in improving the maximum oxygen consumption.

Graph 2: Inter group comparison



Interpretation: No significant difference was seen between both groups for heart rate, blood pressure, Modified Borg Score and VO2 max.

Discussion: This study was conducted to determine the effects of Underwater Treadmill Training on Cardiovascular Responses in Normal and Overweight Individuals. Specifically, heart rate, blood pressure, RPE and VO2 max were studied.

Heart rate: The mean heart rate for obese individuals before the intervention was 80.7 ± 7.5 and for normal individuals was 73.5 ± 7.31. Post 6 weeks intervention a statistically significant reduction in heart rate was seen in both the groups. The post mean heart rate was 74.4 ± 5.72 and 70.2 ± 4.08 for obese and normal individuals respectively with p value <0.05. But when compared between the two groups there wasn't much difference among the two, in order to conclude the benefit of the protocol on any specific group. These finding are in similar to previous studies. A study done by Karen Davidson and Lars McNaughton suggested deep water running elicits lower heart rates when compared with land-based activities like running at similar exercise intensities.[13]A previous study by Kasi and Kumar also suggested reduction of heart rate and blood pressure in obese adults post shallow water running .[6]

A possible reason for the reduced HR response can be that of the interaction between Bainbridge reflex and baroreceptors. When the level of immersion is sufficient, the hydrostatic pressure on the thoracic cavity causes the peripheral blood to be distributed centrally. Hence, this produces an increase in stroke volume which will cause reduction in heart rate via baroreceptor reflex. During low to moderate exercise intensity, it is possible that, the increased atrial pressure acts to offset the bradycardia.[14]

Blood pressure: The mean systolic blood pressure for obese individuals before the intervention was 127.4 ± 6.54 and normal individuals was lower at 124.4 ± 3.63. After 18 sessions on underwater treadmill, both the groups showed a statistically significant decrease in the values presented. The mean systolic BP for obese group was 122.6 mm Hg ± 2.35 and for the normal BMI group was 120.8 mm Hg ± 2.35 with p value < 0.05.

A possible reason of why SBP increased as speeds increased during water treadmill walking and not during land treadmill walking is that the hydrostatic pressure increased blood volume in the thorax, resulting in greater end-diastolic blood volume. A greater stroke volume and cardiac output might have resulted in higher SBP during water exercise. In addition, the added resistance of walking against water might produce sufficient strain to mechanically compress the peripheral arterial system. This is the mechanism by which blood pressure increases during resistive exercise such as weight training. Because of the increase in SBP during water treadmill walking, it might be prudent to monitor the blood pressure of water-exercise participants, especially those with history of hypertension.[15]

Rate of perceived exertion: The perceived exertion decreased may be due to the adaption to training level or due to higher level of exercises performed.[16] The modified Borg scale is an established indicator of intensity of exercises in aquatic therapy.[17]

A study examining the subjective perception of effort (SPE) and other physiological variables during walking under water on a treadmill revealed a strong linear relation between HR and SPE ($r = 0.99$; $p < 0.01$).[16, 18]

VO_2 Max: The pre mean for overweight individuals was 48.3 $\pm$ 3.89 and pre mean for normal was 53.12 $\pm$ 2.92, post values were 50.16 $\pm$ 4.76 for overweight individuals and 55.41 $\pm$ 2.92 for normal individuals with p value <0.05. This indicates an increase in the maximum oxygen consumption for both the groups. But when comparison was made between both the groups there was no significant difference between the groups.

When under water running is performed for 3 to 5 days a week at an intensity of 60 % to 75% of HRmax, for a duration of 20 to 60 min like other aerobic activities, there is a significant gain in cardiac fitness. Similar finding shave been reported by other researchers, where the magnitude of VO_2 max increased.[14] It can be thus inferred that with adherence to proper running techniques, maximum response of underwater treadmill running can be achieved. This form of exercise provides a lower stress and provides additional cardiovascular exercise that maintains aerobic conditioning and in turn less injury.[13]

The increased oxygen consumption is proportional to the intensity of exercise. When exercise intensity is increased, the muscles involved have to do more mechanical work, therefore more amount of oxygen is supplied and also taken up by muscles.[14] The increase in oxygen consumption can be attributed to the additional resistance by water on the body while walking under water. In a study comparing the depth of immersion of the body, running in chest deep immersion produced a VO_2 max that was 13.6 ml/min/kg lower than thigh deep water level at 5.5km/h. This difference was attributed to the effect of buoyancy being increased further at chest level, which decreases the metabolic cost even more.[14]

This study was conducted on men only; women were excluded for the sake of convenience. Further studies can explore the effects of underwater treadmill training on women as well. Young men in the age group of 18 to 35 years were only included. Hence, the findings cannot be generalised to other age groups, especially geriatric populations.

Conclusion: From the results of this study, we conclude that underwater treadmill training can help reduce heart rate, blood pressure, rate of perceived exertion in normal as well as overweight men in the age group of 18 to 35 years. Also there is an increase in the maximal oxygen consumption in both normal and overweight groups. The results of this study need to be further validated on a larger sample size.

References:

1. Dumitrascu M, Munteanu C, Lazarescu H. Hidrotherapy. Balneo Research Journal. 2012;3(1):23-27.
2. Wilk K, Joyner D. The use of aquatics in orthopedic and sports medicine rehabilitation and physical conditioning. Thorofare, NJ: Slack Incorporated; 2014.
3. Bhardwaj P, Bhardwaj A. Therapeutic applications of yoga for weight reduction in obese population: an evidencebased overview. Online Journal of Multidisciplinary Research. 2015;1(1):1-5.
4. Pataky Z, Armand S, Müller-Pinget S, Golay A, Allet L. Effects of obesity on functional capacity. Obesity. 2013;22(1):56-62.
5. Coll J, Bibiloni M, Salas R, Pons A, Tur J. Prevalence and related risk factors of overweight and obesity among the adult population in the Balearicislands, a Mediterranean region. Obesity Facts. 2015;8(3):220-233.
6. K K, Kumar M S. Effect of land and shallow water aerobic exercises on selected physiological and biochemical variables of obese adult. Journal of Physical Education and Sport. 2014;14(4):532-536.
7. Silvers W, Rutledge E, DolnyD. Peak cardiorespiratory responses during aquatic and land treadmill exercise. Medicine & Science in Sports & Exercise. 2007;Vol. 39(6):969-975.
8. Denning W, Bressel E, Dolny D. Underwater treadmill exercise as a potential treatment for

adults with osteoarthritis. International Journal of Aquatic Research and Education. 2010;4(1):70-78.
9. Becker, B.E. Aquatic therapy: scientific foundations and clinical rehabilitation applications. *PM R*. 2009;1:859–872.
10. Hageman P, Walker S, Pullen C, Pellerito P. Test-Retest Reliability of the Rockport Fitness Walking Test and Other Fitness Measures in Women Ages 50–69 Years. Journal of Geriatric Physical Therapy. 2001;24(2):7-11.
11. Noor M, Koon P. Strategy for the Prevention of Obesity - Malaysia. Malaysian Association for the Study of Obesity. 2005; 1:1-18.
12. Salazar A, Dolny D. The Low Impact, Pain-Free, Calorie-Burning Fitness Advantage. 1st ed. United States of America; 2012.
13. Davidson K, Mcnaughton L. Deep water running training and road running training improve &vo$_2$max in untrained women. The Journal of Strength and Conditioning Research. 2000;14(2):191.
14. Pohl M, Mcnaughton L. The Physiological responses to running and walking in water at different depths. Research in Sports Medicine. 2003;11(2):63-78.
15. Dolbow D, Farley R, Kim J, Caputo J. Oxygen consumption, heart rate, rating of perceived exertion, and systolic blood pressure with water treadmill walking. Journal of Aging and Physical Activity. 2008;16(1):14-23.
16. Graef F, Fernando L, Kruel M. Heart rate and perceived exertion at aquatic environment: differences in relation to land environment and applications for exercise prescription. Rev Bras Med Esporte. 2006;12:198-203.
17. Pinto S, Alberton C. Rating of perceived exertion and physiological responses in water-based exercise. Journal of Human Kinetics. 2015;49(1):99-106.
18. Shono T, Fujishima K. Physiological responses and RPE during underwater treadmill walking in women of Middle and advanced age. Journal of physiological anthropology. 2000; 19:195- 200.

Conflict of interest: None
Funding: None
Cite this Article as: G Baxi, T Palekar, M Nair, S Basu, D Gohil. Effect of Underwater Treadmill Training on Cardiovascular Responses in Normal and Overweight Individuals. Natl J Integr Res Med 2018; 9(4):13-19