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Research article

CARDIOVASCULAR RESPONSES DURING DEEP WATER RUNNING VERSUS SHALLOW WATER RUNNING IN SCHOOL CHILDREN

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ABSTRACT

Overview: As the school going children especially the adolescents' need workout routine; it is advisable that the routine is imbibed in the school's class time table. In India as growing number of schools provide swimming as one of the recreational activities; school staff often fails to notice the boredom that is caused by the same activity. Deep as well as shallow water running can be one of the best alternatives to swimming. Hence the present study was conducted to find out the cardiovascular response in these individuals. **Methods:** This was a Prospective Cross-Sectional Comparative Study done in 72 healthy school going students (males) grouped into 2 according to the interventions (Deep water running and Shallow water running). Cardiovascular parameters such as Heart rate (HR), Saturation of oxygen (SpO2), Maximal oxygen consumption (VO2max) and Rate of Perceived Exertion (RPE) were assessed. **Results**: Significant improvements in cardiovascular parameters were seen in both the groups i.e. by both the interventions. **Conclusion:** Deep water running and Shallow water running can be used to improve cardiac function in terms of various outcome measures used in the study.

Keywords: Deep water running, Shallow water running, cardiovascular responses.

INTRODUCTION

The importance of regular physical exercise, as part of therapy in everyday life, has a favorable influence on the important parameters of the cardiovascular system. A number of studies have also shown that regular physical exercise can decrease risk of the development of many cardiovascular diseases and also other health problems of both adults as well as children.[1] People who are physically active live longer. Regular exercise reduces the risk of dying prematurely.[2]

Recommendations for appropriate amounts of physical activity for the young population, including school-age youth, have been developed by several organizations and agencies. Although recent reviews have summarized the benefits of regular physical activity on the health of youth and its potential for reducing the incidence of chronic diseases that are manifested in adulthood, a more systematic approach is indicated. [1-9] These reports present results of a systematic evaluation of evidence dealing with the effects of regular physical activity on several health and behavioral outcomes in school-age youth, with the goal of developing a recommendation for the amount

of physical activity deemed appropriate to yield beneficial health and behavioral outcomes.

According to the current worldwide survey, childhood and adolescent health problems are one of the top five problems in the world in the year 2012. [3] They also identified that this health issue is important not only for the health care industry but also for the health of the children as they mature into adults. The health industry has recognized this problem and is beginning to mobilize with new programs aimed specifically at children. Numerous health risks have been associated with adolescent overweight, including hypertension, respiratory disease, several orthopedic disorders, diabetes mellitus and elevated serum lipid concentrations. [4, 5] Development of specialized physical activity programs are necessary as school systems face the reality of cutting programs, such as physical education and recess, to spend more time preparing for the standardized tests and examinations. Also; due to recent advances in technology; video games and gaming consoles have become more popular than outdoor sports activities thus; limiting the regular physical exercise.

Current recommendations indicate that school-aged youth should participate daily in 60 minutes or more of moderate-to-vigorous physical activity that is appropriate and enjoyable; and involves a variety of activities including resistance training, aerobic activities such as swimming, bicycling, running and jogging. [1, 3, 10] Program developed should be such that it helps boys and girls develop competence and confidence in their abilities to engage in different types of physical activities. Fitness professionals who incorporate such training into kid-friendly classes and personal training sessions need to understand and appreciate the physical and psychosocial perspective of children and adolescents. [11] Therefore, program design considerations for developing successful programs should be such that regular participation in a training program has the potential to positively influence many health and fitness measures.

As the school going children especially the adolescents' need workout routine; it is advisable that the routine is imbibed in the school's class time table. In India as a growing number of schools provide swimming as one of the recreational activities; school staff often fails to notice the boredom that is caused by the same activity. Deep as well as shallow water running can be one of the best alternatives to swimming. If the program is supervised and well taught it can be beneficial for both physical as well as psychological perspectives in the growth of the children. But; the change following the water running that would occur in terms cardiovascular parameters is still unidentified are not expressed. The evidence shows that there are many benefits of both deep water running and shallow water running. Since there were no prior studies performed to compare both the above groups; hence, it's very important to study the changes in the cardiovascular responses and document them.

Hence; the aim of the study was to compare cardiovascular responses after deep water running and shallow water running. Accordingly the hypotheses were formulated.

METHODS

There were 100 students who were screened for age, symptoms, and/or risk factors for any medical contraindications to exercise or any risk for disease. After finding their suitability as per inclusion and exclusion criteria were requested to participate in the study.8 students did not meet the inclusion criteria. The students were randomly selected for the study with the use of random table numbers. Thus, out of 92 students 72 were selected to participate in the study. These 72 students were explained about the study and intervention. A written informed consent form previously approved by the Institutional Ethical committee (IEC) was obtained and was signed by the School Principal and each student. The 72 students participated in the study. The demographic data for each student was filed. Pre treatment assessment of HR; SpO_2, RPE, VO_2max were done.

In group A(N=35) students were receiving Deep Water Running. It takes place in water deep enough for students to be submersed to the neck. The use of flotation aids, such as a buoyancy belt was used to suspend the student so a lack of ground contact occurs during the exercise. In Group B (N=37) students were receiving Shallow Water Running. It was performed in shallow water typically below the xiphoid level, where students run/walk propelling themselves through the water. [12]

Both the interventions were given for the duration of 6 weeks (3 times/ week) for 45minutes. At the end of 6 weeks post test measurements of the students were

taken. Data was collected and recorded. All the students completed the study. The data was recorded on the 1st day of the intervention and on the 18th day of intervention for each participant.

RESULTS

The results of the study were analyzed in terms of increase or decrease in Heart Rate, $VO_{2max,}$ RPE, SpO_2 and comparison was made between the first and 18th day of the treatment. Statistical analysis was done by GraphPad InStat (Trial version) software. The data were entered into an excel spreadsheet, tabulated and subjected to statistical analysis. Various statistical measures such a mean, standard deviation (SD) and test of significance such as paired and unpaired 't' test were utilized to analyze the data. The results were concluded to be statistically significant with $p < 0.05$ and highly significant with $p < 0.001$ and not significant with $p > 0.05$. Paired 't' test was used to compare the differences of scores on pre-intervention and post-intervention within a single group. Unpaired 't' test was used to compare differences between the two groups i.e. the control group (Group A) and the study group (Group B).

Table 1: Table showing demographic data

Demographics	Group A	Group B
Age (years)	16.51± 1.269	16.40± 1.116
Height (mts)	1.5± 0.0943	1.57± 0.064
Weight (kgs)	54.17± 6.853	52.10± 4.408
BMI(kg/m^2)	22.12±1.773	21.02± 1.323

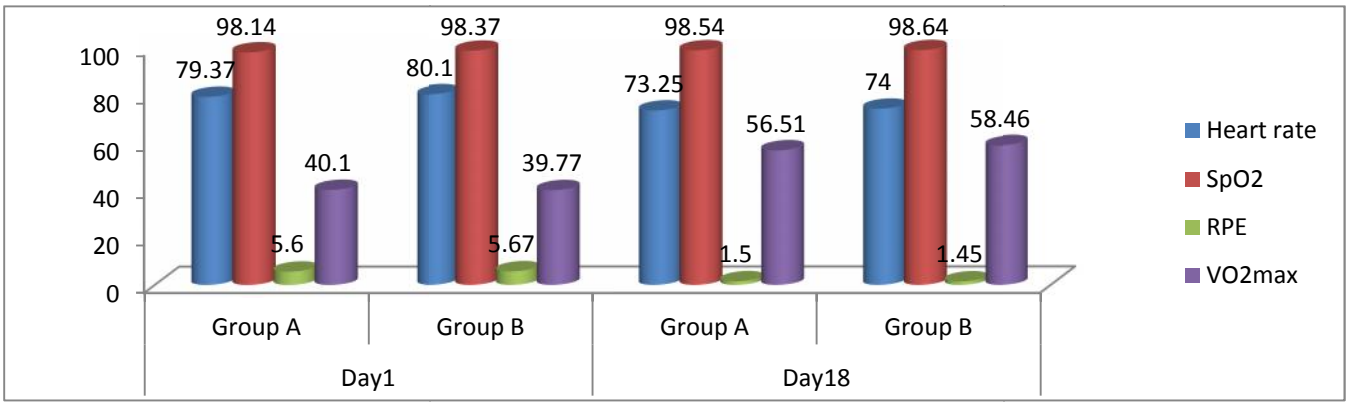

Fig.1.The following graph shows the mean of parameters of participants in group A and group B on 1st day & 18th day.

Table.2: Showing mean difference of outcome measures in Group A and Group B and their Statistical inference

Outcome Measure	MEAN DIFFERENCE		t	df	P	Inference
	Group A	Group B				
Heart Rate(b/m)	6.12±3.47	6.108±1.70	0.018	70	0.9851	Not Significant
SpO_2	0.4±0.14	0.27±0.11	4.338	70	<0.0001	Highly Significant
RPE	4.06±0.63	4.22±0.55	1.142	70	0.2575	Not Significant
$VO_{2max(}$ml/kg/min$_)$	16.41±4.32	18.69±4.45	2.202	70	0.0310	Significant

The difference between parametsers for DWR on day 1 and on day 18 were found to be extremely significant for HR (p= <0.0001) and RPE (p=<0.0001) and VO_{2max} (p=<0.0001), very significant for SpO2 (p=0.0058). This indicates that the interventions in form of Deep water running in school children was effective in improving cardiovascular parameters in terms of Heart rate, SpO_2, RPE, and VO_{2max}.

The difference between parameters for SWR on day 1 and on day 18 were found to be extremely significant

for HR (p= <0.0001) and RPE (p=<0.0001), VO_{2max} (p=<0.0001), and SpO_2 (p=0.0004). This indicates that the interventions in form of Shallow water running in school children was effective in improving cardiovascular parameters in terms of Heart rate, SpO_2, RPE, and VO_{2max}.

The results between SWR and DWR on day 18 were not significant in improving VO_{2max} (p=0.2032), RPE (p=0.5090), SpO_2 (p=0.3224), HR (p=0.2253). This indicates that both the interventions in form of Deep water running and Shallow water running in school children were effective in improving cardiovascular parameters in terms of Heart rate, SpO_2, RPE, and VO_{2max}.

The results of mean differences of the outcome measures indicate that both Deep Water running and Shallow water running improve Heart rate and RPE similarly. The VO_{2max} is improved more in Deep Water running as compared to Shallow Water Running and SpO_2 is best improved during Shallow Water Running as compared to Deep Water Running.

DISCUSSION

The study conducted in Loni; to compare Deep water running to Shallow water running. It is also believed to be the first study in India to compare the two water running techniques in hydrotherapy. This study titled cardiovascular responses in deep water running versus shallow water running in school children was performed in school boys aged between 15 to 19 years. This population was chosen to generalize the results for this age group. This study was conducted at Pravara swimming pool, Loni, was completed in the month of November 2012. The results of the study indicated that the intervention in the form of Deep water and shallow water running in school children was effective in improving cardiovascular parameters in terms of Heart rate, Spo2, RPE, and VO_{2max} and were also comparable to other studies.

In a study by Chu KS et al in 2002[13] measured maximal physiological responses to Deep-Water and Treadmill Running in Young and Older Women**,** they observed Lower HR_{max} values in DWR for both age groups ($p < .05$). Another study by Town GP and colleagues[14] concluded that HR_{max} values for SWR and DWR were 88.6% and 86% of TMR, respectively. In a Comparative study the authors Michaud et al[15] found that heart rate were significantly greater ($p < 0.05$) for treadmill running. These results when compared with the present study; the mean heart rate of participants during Shallow water running and deep water running at the end of the study were 73.25±2.201 and 74.13±3.66 respectively.

Authors noted that heart rate has been reported to decrease during head-out water immersion exercise compared with air. [16-19] The mechanism responsible for the lower heart rate during immersion is the redistribution of blood volume from the periphery to the central region. The increased hydrostatic pressure of the water, concomitant with peripheral vasoconstriction to reduce heat loss forces peripheral blood into the thorax. This results in an enhanced venous return and a decreased stroke volume while maintaining cardiac output. [17] The possible explanation for reduction of heart rate in this present study was in accordance with an explanation given by Sophie Heywood.[20] According to Sophie Heywood; the hydrostatic pressure which is depth dependent; there is increased stroke volume and cardiac output. The Cardiac output (CO) is the product of Stroke volume (SV) and Heart rate. Thus, during water immersion it is found that heart rate is reduced.[20] The hydrostatic pressure causes an immediate increase in venous return, right atrium pressure and, hence, stroke volume. Increased stroke volume allows for the maintenance of cardiac output with lower HR as stated by Christie et al. in 1990. [18] A reflex response of the cardiovascular system to the cold receptors in the skin could also have contributed to the depressed HR in the water as the water temperature of 32.5 C is slightly lower than thermo-neutral for the resting condition.[21]

This study showed extremely significant difference between the SpO2 in SWR group at the start of the study and SPO2 on at the end of the study (p<0.0001). The mean SpO2 of participants in SWR at the end of the study was 98.54±0.5054. The difference between the SPO2 in DWR group at the start of the study and SpO2 on at the end of the study were very significant (p<0.0001). The mean SpO2 of participants in DWR on at the end of the study was 98.65 (SD= ±0.4808). These results are comparable with other studies. Bishop et al.[22] reported a higher O2 pulse during DWR compared with TMR. Results of O2 pulse during DWR was 4.34 and 3.81 during TMR (p<0.01). The higher O2 pulse during DWR was largely a result of lower VO2 not that of higher HR.

The rate of perceived exertion measured in this study was on the Borg's (CR10) scale. In a study by authors Hall et al studied the cardio-respiratory responses to underwater treadmill walking in healthy females; found that the Borg scale of perceived exertion(6-20) showed that walking in water at 4.5 and 5.5 km/hr was significantly harder than on land ($p<0.001$). [23] It was also concluded that walking in chest-deep water yields higher energy costs than walking at similar speeds on land. [23] These responses were similar to the present study. The difference between the RPE on at the start of the study and RPE on at the end of the study were extremely significant ($p<0.0001$) for both the groups.

The difference between the VO_{2max} on at the start of the study and Vo_{2max} on at the end of the study were extremely significant ($p=<0.0001$) for both the groups. These results where comparable with a study by Davidson K and McNaughton DK who examined the ability of deep water running training to improve cardiovascular fitness in a young sedentary population. [24] Ten untrained female subjects were allocated into a DWR and road running (RR) group. Subjects underwent pre-test VO_{2max} testing which was repeated after each training program. Results indicated both methods produced a significant increase in VO_{2max} compared with the pre-test without a significant difference between the two.

Authors studied the intensity of exercise in deep-water running and found that VO_2 during the last session of deep-water running (73% of maximum VO_2) was not significantly different from that of the treadmill hard run (78%), but was significantly higher than that of the treadmill normal run (62%).[25] In a comparative study it was found that peak oxygen consumption was significantly greater ($p < 0.05$) for treadmill running.[15] Although at a similar relative exercise intensity treadmill running VO_2, was significantly greater than deep-water running. Several studies have shown that maximal oxygen uptake (VO_{2max}) attained during treadmill running is lowered during DWR. [16, 26-29] Town and Bradley in 1991 found that the highest values reached for VO_2 and HR were 73.5 and 86% of VO_2 max and HR max on land, respectively.[28] A study found VO_2 and HR during DWR to be 86 and 91% of those obtained on land. [27] These findings are similar to those reported in other studies. [27, 30] Responses to sub maximal exercise on the treadmill and when immersed to the neck have also been investigated. [30-32] A study reported lower HR during DWR than treadmill running at any given VO_2.[30]

Implications for practice: In the participants of this study; it was found that both DWR and SWR serve as effective tool in improving cardiovascular responses. The above results point out that such form of exercise if given as a form aerobic training may improve cardiovascular indexes and so increases cardio-respiratory endurance and parameters. The results also indicate that both Deep Water running and Shallow water running improve Heart rate and RPE similarly. The VO_{2max} is improved more in Deep Water running and SpO_2 is best improved during Shallow Water Running so the intervention can be modified s per the requirements of the participant.

In addition to benefits that physical activity has on physical health and fitness, physical activity also has a positive influence on academic performance and self-esteem. Because of the protective and health benefits of habitual physical activity, it is important that children are physically active and that they continue this behavior through adolescence into adulthood.

Aquatic therapy is justifiably a rapidly expanding, beneficial form of rehabilitation. Understanding the theory of water techniques is essential in implementing an aquatic therapy program. The success of the program depends on the pleasure and benefits achieved by the patients. The environment should also be conductive to family and social interaction that ultimately encourages the compliance of long-term exercise programs.

In the current study; all the boys who participated successfully completed the study without missing a single session with the same enthusiasm, eagerness, zeal and keenness throughout the study. The goals established at the initial and subsequent evaluations were met as quickly and as sensibly as possible.

Limitations of the study: Certain limitations of the present study include small sample size, relatively short term intervention, little follow up and the present study has focused only on boys so the findings are applicable to patients within this category only.

Suggestions for future research: Healthy school going boys who were between the age group of 15 to 19 years were included in this study. Since the study included regular participation for continuous 6 weeks girls were not included for the same. Therefore; further study can be conducted to generalize the results for

female population. Also; this study was the first to measure the cardiovascular parameters changes during water running. Since the study was conducted in a rural area, adequate instruments to measure VO_{2max}; were not available. Hence, future authors who are interested in research can use a VO_{2max} analyzer for their study. Moreover; as the above mentioned results cannot be generalized to all the types of age groups in both the genders; the same intervention must be studied in another age group to see the effect of this intervention in both the genders.

CONCLUSION

Thus accepting the alternate hypothesis and rejecting the null hypothesis, we conclude that 6 weeks of training given in terms of DWR and SWR is effective in improving cardiovascular responses when measured on PACER test, Borg's Scale and Pulse oxymeter.

REFERENCES

1. Rosengren A, Wilhelmsen L. Physical activity protects against coronary death and deaths from all causes in middle-aged men. Evidence from a 20-year follow-up of the primary prevention study in Goteborg. Ann Epidemiol. 1997;7(1):69-75.
2. Leitzmann MF, Park Y, Blair A, Ballard-Barbash R, Mouw T, Hollenbeck AR, Schatzkin A. Physical activity recommendations and decreased risk of mortality. Arch Intern Med. 2007;167(22):2453-60.
3. Walter R. Thompson. Worldwide survey of fitness trends for. ACSM's Health & Fitness journal 2012, 15(6):9-18.
4. Gortmaker SL, Dietz WH Jr, Cheung LW. Inactivity, diet and the fattening of America. J Am Diet Assoc 1990; 90:1247-55.
5. Ramesh K Goyal, Vitthaldas N Shah, Banshi D Saboo, Sanjiv pathak, Naveen Shah, Mukesh Gohel et al Prevalence of Overweight and Obesity in Indian Adolescent School Going Children: Its Relationship with Socioeconomic Status and Associated Lifestyle Factors. JAPI.2010; 58:151-58.
6. Edu sports survey report 2012 view at http://articles.timesofindia.indiatimes.com/2012-0908/health/33018852_1_vitamin-d-deficiency-lifestyle-obesity; http://indiatoday.intoday.in/story/indian-kids-not-involving-in-outdoor activities/1/154945.html; http://www.dnaindia.com/academy/report_sports-no-more-mere-childs-play_1711275.
7. Kapil U, Singh P, Pathak P, Dwivedi S, Bhasin S. Prevalence of Obesity Amongst Affluent Adolescent School Children in Delhi. Indian Pediatrics 2002; 39:449-452.
8. Parekh A, Parekh M, Vadasmiya D. Prevalence of overweight and obesity in adolescents of urban and rural area of Surat,Gujrat. National Journal Of Medical Research. 2012;2:(3) 325-29.
9. Sedentary Lifestyle 2012 view at http://articles.timesofindia.indiatimes.com/keyword/sedentary-lifestyle/recent/5.
10. American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription. 7th ed. Philadelphia: Lippincott Williams & Wilkins, 2006.
11. Strong, W., R. Malina, C. Blimkie, Stephen R. Danials, Rodney K. Dishman, Bernard Gutin et al. Evidence based physical activity for school-age youth. Journal of Pediatrics 2005;146(6) 732-37.
12. Gappmaier E., Lake W, Nelson AG, & Fisher AG. Aerobic exercise in water versus walking on land: Effects on indices of fat reduction and weight loss of obese women. The Journal of Sports Medicine and Physical Fitness. 2006, 46: 564-69.
13. Chu KS, Rhodes EC, Taunton JE. Maximal physiological responses to deep-water and treadmill running in young and older women. J Aging Phys Act 2002; 10: 306-13.
14. Town, G. P., S. S. Bradley. Maximal Metabolic Responses to Deep and Shallow Water Running in Trained Runners. Medicine and Science in Sports and Exercise. 1991, 23 (2): 238-241.
15. Michaud TJ, Rodriguez J, Andres FF, Flynn MG, Lambert CP. Comparative Exercise Response of Deep Water and Treadmill Running. Journal of Strength and Conditioning Research. 1995, 9(2): 104-109.
16. Dowzer CN, Reilly T, Cable NT, & Nevill A. Maximal physiological responses to deep and shallow water running. Ergonomics. 1999, 42: 275-81.
17. Avellini BA, Shapiro Y, Pandolf K.B. Cardio-respiratory physical training in water and on land,

European Journal of Applied Physiology 1983; 50: 255-63.
18. Christie JL, Sheldahl LM, Tristani FE, Wann LS, Sagar KB, Levandoski SG, Ptacin MJ, Sobocinski KA, Morris RD. Cardiovascular regulation during head-out water immersion exercise, journal of applied physiology, 1990; 69: 657-64.
19. Connelly TP, Sheldahl LM, Tristani FE, Levandoski SG, Kalkhoff RK, Hoffman MD, Kalbflei Sch JH. Effect of increased central blood volume with water immersion on plasma catecholamines during exercise, journal of applied physiology 1990; 69: 651 -56.
20. Hinman RS, Heywood SE, & Day AR. Aquatic physical therapy for hip and knee osteoarthritis: Results of a single-blind randomized controlled trial. Physical Therapy. 2007;87: 32-43.
21. Gleim GW, & Nicholas JA. Metabolic costs and heart rate responses to treadmill walking in water at different depths and temperatures. The American Journal of Sports Medicin. 1989;17, 248-252.
22. Bishop PA, Frazier S, Smith J, Jacobs D. Physiological responses to treadmill and water running, physician and sportsmedicine, 1989; 17:87-94.
23. Hall J, Macdonald IA, Maddiso PJ, O'Hare JP. Cardio-respiratory responses to underwater treadmill walking in healthy females. European Journal of Applied Physiology and Occupational Physiology. 1998;77:278-84.
24. Davidson K and McNaughton DK. Deep water running training and road running improve VO2max in untrained women. Journal of Strength and Conditioning Research. 2000; 14:191-95.
25. Ritchie SE, Hopkins WG. The Intensity of Exercise in Deep Water Running. International Journal of Sports Medicine 1991;12 (1): 27-29.
26. Glass B, Wilson D, Blessing D, Miller E. A Physiological Comparison of Suspended Deep Water Running to Hard Surface Running. Journal of Strength and Conditioning Research. 1995;9(1): 17-21.
27. Butts NK, Tucker M, Smith R. Maximal Responses to Treadmill and Deep Water Running in High School Female Cross Country Runners. Research Quarterly for Exercise and Sport. 1991, 62 (2): 236-39.
28. Town GP, Bradley SS. Maximal Metabolic Responses to Deep and Shallow Water Running in Trained Runners. Medicine and Science in Sports and Exercise. 1991;23 (2): 238-41.
29. Frangolias DD, Rhodes EC. Maximal and Ventilatory Threshold Responses to Treadmill and Water Immersion Running. Medicine and Science in Sport and Exercise 1995, 27 (7): 1007-13.
30. Svedenhag J, Seger J. Running on Land and in Water: Comparative Exercise Physiology. Medicine and Science in Sport and Exercise. 1992;24 (10): 1155-60.
31. D'Acquisto LJ, D'Acquisto DM, Renne D. Metabolic and cardiovascular responses in older women during shallow water exercise. J Strength Cond Res 2000; 15: 12-19.
32. Kimberley Meredith-Jones, Michael Legge, Lynnette M. Jones. Circuit based deep water running improves cardiovascular fitness, strength and abdominal obesity in older, overweight women. Medicina Sportiva . 2009,13 (1): 5-12.