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RESEARCH ARTICLE

Effect of Pre-Participation Aquatic Training Program on Running Performance in Marathon Runners

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Abstract
Objective: The most important objective was to determine the effect of an aquatic pre-participation training program for improving the running performance of middle-aged marathon runners. **Method:** The study was conducted among 100 recreational male and female runners (aged 25 to 35 years) fulfilling the inclusion and exclusion criteria. The subjects were randomly divided into two equal groups, the control group (n=50) and the experimental group (n=50) by using SPSS software. 6 weeks of aquatic training was conducted for the experimental group for 5 days per week while the control group underwent swimming. The scores were statistically examined by paired 't-test. **Results:** Results showed that there was a significant reduction in pain in both groups with a p-value <0.0001. Both groups showed significant improvement in cardiac endurance VO2 max. The mean post-VO2 max of the experimental group and control group showed significant improvement in VO2 max with p-value <0.0001. Experimental group showed more improvement in 1RM leg press test as compared to the control group. Mean pre and post-1RM leg press test was (pre:66.10±14.0) (post:73.40±15.20) with p value <0.0001. While of the control group was (pre:68.02±15.09) (post:69.40±13.94) with p value 0.0275. There was significant improvement in 50m sprint run test in the experimental group with pre mean 6.23±0.44 and post mean 6.00±0.46 with (p value <0.0001). Much improvement was not seen in 50m SRT of the control group, the pre mean was 6.11±0.44 and post mean was 6.06±0.48 with (p value 0.0832). **Conclusion:** It concluded that the pre-participation aquatic training program had shown a significant positive response in improving speed strength and reducing pain.

Keywords
Marathon Runners, Aquatic Training, VO2 Max, Pain, 50 M Sprint Test

INTRODUCTION

Long distance race is technically known as a Marathon but Marathon running has different distance parameters which consist of 3km, 5km, 10km, and more. Running a marathon requires intense training because the event calls for stamina, mental toughness, and tactical pacing. To prepare their bodies for the length and rigor of the race, runners must increase their strength through long runs and speed drills. Knowing the specific reactions of recreational runners to training interventions is crucial for designing training protocols because of the rising number of recreational runners who regularly compete in marathon and half marathon events worldwide (Ferrauti et al.,2010). Running is closely alike walking based on locomotor activity. But still, they have differences as a person who can walk will not have the ability to run.

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Running a marathon requires appreciable balance, significant muscle strength, and a considerable range of motion (**Landry M et al.,2014**) . Running performance completely depends on anthropometric measures like body mass index (BMI), skin fold measurement, and girth extremity (**Voight et al.,2011**) . The relationship between flexibility and running economy is one biomechanical factor that has produced contradictory results (**Beaudoin et al.,2005**). Anthropometric measurements help to increase the endurance of the runner. In addition to anthropometric prerequisites (such as body weight and body composition of the lower extremities, upper and lower body size relation), a number of movement criteria are intended to establish an economic running technique model (**Ferrauti et al.,2010**). Balance and coordination are improved through water-based exercise, which also stimulates the visual, vestibular, and perceptual systems (**Dundar et al.,2009**; **Asimenia et al.,2013**).

Marathon runners require rigorous fitness and healthy dietary needs. To get the right run during the marathon, a runner needs to increase their cardiovascular fitness and endurance, as well as the ability to conserve and manage energy during the race (**Ferrauti et al.,2010**). Due to poor fitness and because of exertion a runner is prone to develop injuries. Injuries caused by running are idiopathic but are frequently based on training errors. The few independent factors causing injuries are any previous injury, a competitive training motive, and an increase in the repetition of workouts too quickly. Running causes injuries because it is a weight-bearing exercise that works against gravity. Knee, ankle, or foot injury can result from running (**Kadav et al.,2023**; **Sandeep et al.,2022**). Common injuries occurring are Runner's knee, Hamstring pull, IT band syndrome, Shin splint, and Achilles tendinitis (**Cheuvront et al.,2005**).

The best and most important way to avoid injuries is to pay close attention to the overall training program and should increase the repetition moderately depending on the tolerance of the runner (**Cheuvront et al.,2005**) . The training of a marathon runner should include strength, power, and endurance exercises. Strength training helps to improve muscle work and proves effective to perform higher oxygen volume exercises. They even help to improve many parameters that are correlated with running the economy (**Landry et al.,2014**).

Rest and discontinued training program may help in the rehabilitation of sports injuries. For early rehabilitation of sports injuries, aquatic therapy is ideal, because of buoyancy which eventually decreases the gravity of the body and viscosity. These offer considerable assistance and resistance to a runner while performing training (**Prins et al.,1999**). Aquatic exercises help to improve joint mobilization, balance and gait training. It also facilitates stretching, strengthening, and endurance training (Sawant, R. S., & Shinde, S. B.,2019**)**. Aquatic therapy helps with functional recovery and also initiates resistance training for runners. It is used as a recovery technique and also to enhance the training program of a runner (**Kisner et al,2017**).

Water has unique properties which help to improve the therapeutic benefits. An aquatic environment with buoyancy, hydrostatic pressure, viscosity, and surface tension has a direct effect on the human body. Aquatic therapy also enhances patient relaxation and minimizes the risk of injury as well as delayed onset of muscle soreness. Buoyancy can be applied in three different ways during rehabilitation: as support, as resistance, and as assistance. To improve mobility, people frequently use these exercises. The cardiovascular changes brought on by immersion are also brought on by hydrostatic pressure, which also significantly affects the exercise training parameters (**Dumke et al.,2010**). Exercises performed in water may be beneficial for patients with acute painful musculoskeletal injuries. This happens because of the effect of relaxation, elevated pain threshold, and decreased muscle spasms (**Kisner et al, 2017**) .

Physiologic changes occur when a human is immersed both during rest as well as during exercises (**Dumke et al.,2010**) . A water-based training program provides support to the limbs and allows range of motion, with less muscle activation. This helps to improve advanced dynamic strengthening on land. Aquatic therapy helps athletes to return early to the game and also speeds up the overall rehabilitation process. Many athletes found water-based exercises more effective during their rest period and beneficial in regaining strength and mobility and also maintaining cardiovascular endurance (**Prins J et al.,1999**; **Thein et al,2000**).

The purpose of this study was to study the effectiveness of aquatic exercises to improve the running performance of the runner. Athletes have been suggested to be predisposed to hamstring strain injuries by intrinsic factors such as muscle weakness, muscle strength imbalance, poor passive flexibility, fatigue, insufficient warm-up, age, prior injury, poor neuromuscular control, and poor running techniques (**Watsford et al, 2010**). Marathon runners require a pre-training program to improve cardiovascular endurance as well as strength and energy to complete the long run (**Kolhatkar et al,2020**). We are here to discuss water-based training program proves to be more effective than a land-based program. Aquatic therapy improves the flexibility of muscles and also reduces the workload on the muscles (**Wicker et al, 2011**) . It helps to improve the speed of the patient run and also helps to strengthen the lower limbs.

MATERIALS AND METHODS

Selection of Subjects

For the corresponding study, the sample size was 100 [n=4×(SD)2/mean×(€)2]. 100 recreational marathon runners were selected from Karad who had a habit of exercising and were able to run a long distance. The age of the runners ranged from 25 to 35 years of age. The sample was similar to the characteristics of the subjects in related studies (Markovic et al.,2007) (Sporri et .,2018). (All the subjects volunteered to participate in this study with written informed consent. The runners were divided into an experimental group (n=50) and a control group (n=50) randomly by using SPSS software.

The participating athlete was informed about the study protocol, their rights, and the associated risks of participation before providing written informed consent. This intervention was conducted on humans. The interventional study was accepted by Institutional Human Ethics Committee of Krishna Institute of Medical Sciences, “Deemed to be University,” Karad (Protocol number-299/2022-2023). The study was explained along with the exercise protocol. Before performing the intervention on participants, an informed consent was obtained from them. The study was carried out in accordance with the recommendations of the Declaration of Helsinki. Additional precautions were taken by the investigator(s) to protect the volunteers in this study.

Selection of Test

VAS: To measure the amount of pain using Visual Analogue Scale (VAS) It is a scale that ranges from 0 to 10. Zero indicates “no pain” and ten indicates “worst pain imaginable”. Participants were asked to mark on a scale how much pain they have from 0 to 10 at rest and on activity(Intra class correlation co-score 0.97 [95% CI=0.96 to 0.98]).

1 RM leg press test: Lower body strength is measured by 1 RM leg press test. weight close to the subjects one repetition maximum is selected. The subject is asked to conduct as many leg presses before failure. If The number of successful bench presses exceeds 12, then 15 min rest is given to the subjects, weight is increased, and the test is repeated (**Lippincott Williams 2013**)

VO2 Max: The Queen's College Step Test was used to calculate the VO2 max. Prior to the test, participants were instructed to warm up for 5-7 minutes (e.g., by brisk walking and stretching). A stopwatch, metronome, and 16 ½ inch wooden stepping bench were also used. There were 24 beats per minute on the metronome. There was a brief demonstration. For three minutes, the participants were asked to step up and down repeatedly. Following the test, the pulse rate was recorded in a standing position for 15 seconds. Beats per minute are converted from this recovery pulse rate. The VO2 max in females is calculated as follows: VO2 max(ml/kg/min) = 65.81-(0.1847X step test PR/min) . In the Indian population the validity of the test was found (r=-0.83) (**Chatterjee et al., 2005**).

50-meter sprint run test: Using a stopwatch, the athletes' sprinting times in hundredths of a second (s) for a 50-meter dash were manually recorded in order to calculate their speed (**Fletcher & Anness, 2007**). Equipment includes a measuring tape, a grassy field marked at 50 meters, a start clapper, a skilled timer and a scorekeeper. Procedure: During the exam, only one sprint of 50 metres in length was permitted. The "time" in seconds it took to cover the distance was recorded by a stopwatch, which provided the data. There could be no more than two practise runs. The participants were urged to put forth their best effort. A standing start was used during the test. There were two allowed trials. The fastest time

measured in hundredths of a second was considered to be data speed was calculated using the following formula: speed = distance/time = 50/time. Meter/second (m.s-1) is the symbol for speed.

Criterion Measures

The study was pre/post experimental design. 100 recreational marathon runners were included in this study. Inclusion criteria included recreational marathon runners aged 25-35 years, who had pain while long-running, with no fear of water, and those who were willing to participate in the study. Subjects with open wounds, skin conditions, and high fever as well as those with a history of cardiac and respiratory conditions were excluded from the study. Aquaphobic participants were categorically barred from the study.

Table 1:Aquatic training protocol

WEEKS	EXERCISES	REPETITION	REST
WEEK 1	Treadmill (Slow run)	10 mins	30 sec
	Water Jog (on the spot)	10 mins	30 sec
	Flutter kicks	20kicks x 3 sets	45 sec/set
	Jumping Jacks	20kicks x 3 sets	45 sec/set
	Pool burpees	15 repetitions	45 sec
	Breaststroke	3 pool rounds	45 sec
	Sit kicks in deep water	20kicks x 3 sets	45 sec
WEEK 2-4	Treadmill (moderate speed run)	15 mins- 20 mins	30 sec
	Water jog with long step length: Forward Backward	4 pool rounds	30 sec
	Resistance flutter kicks	30 kicks x 3 sets	45 sec
	Pool burpees	20-30 repetitions	45 sec
	Sit kicks in deep water with ½ kg weight cuff	20 kicks x 2 sets	45 sec/set
	Pool tuck jumps	20 jumps x 3 sets	45 sec/set
WEEK 4-6	Treadmill	20 mins	30 sec
	Water jog with ½ kg weight cuff	4 pool rounds	45 sec
	Skiers with ½ kg weight cuff	20 repetition x 3 sets	45 sec/set
	Frogger exercise: Forward Backward	4 pool rounds	45 sec
	Pool hacky sack	20 repetitions x 3 sets	45 sec/set
	Swimming	10 mins	45 sec

Design of the Study

1.100 recreational marathon runners were screened and selected on the basis of inclusion criteria. Simple random sampling was selected for randomization of the sample by using SPSS Software.

2. Subjects were screened by assessing BMI, lower body strength by 1 RM leg press test, pain score by VAS, and cardiac endurance by VO2 max pre and post-intervention.

3. Informed consent was taken from the participants and was filled by them before the intervention. The procedure of the study was explained to each of them.

4. Participants were randomly divided into two equal groups; the Control group (n=50) and the Experimental group (n=50). The experimental group underwent an aquatic training program and the control group underwent swimming, where no special exercises were administered. The pre-participation Aquatic training program took place for a period of 6 weeks with 5 days of training (Monday to Friday) and the overall time for the exercises was 50 mins with 10 mins rest period.

Training Program (**Thein et al.,2000**; **Stemm et al.,2007; Robinson et al.,2004; Miller et al.,2002; Markovic et al., 2007; Sporri, et al., 2018**)

The subjects in the experimental group underwent pre-participation aquatic training. A 50-minute exercise protocol with a 10-minute rest period was established. The exercise protocol started with 10 mins of warm-up, followed by 30 mins of actual exercise training, and lastly 10 mins of cool down. The exercise protocol was 50 mins which were being performed 5 times a week. Every week the exercise protocol was changed with advancements in exercises to improve the strength, power, and endurance of the subject. The main focus during the initial phase [week 1] of the aquatic training is the unloading of the joints and stabilization. The goals are to increase the range of motion, increase circulation,and decrease pain.progression of the exercises in week 2-4 is done by gradually increasing the repetitions and resistance which improves the strength and flexibility.The progression in week 4-6 aim to increase cardiac endurance and strength.This was done by increasing the duration of exercises,along with the repetitions and resistance as shown in Table 1 . At every practice session of the participant, we focused on the security and safety of the subject more than the accuracy. So, we instructed the subject to perform the activity with a bit of changed movement to avoid injuries.

Statistical Analysis

Data collected was registered in an excel sheet and the statistical analysis was conducted using SPSS 26.0 for Windows (SPSS Inc., Chicago, IL, USA). Statistical analysis was conducted by using descriptive statistics, paired t-test was used to identify any significant difference between pre and post-training within the groups. The level of significance was set at $p \leq 0.05$.

RESULTS

Table 2. Demographic Data

	Total No	Experımental Group (N=50) [Mean±SD]	Control Group (N=50) [Mean±SD]
Age (Years)	100	26.78±1.54	27.16±1.65
BMI (kg/m2)	100	21.63±1.83	21.25±1.88

Table 3:Gender distribution

Gender	Total No	Experımental Group (n=50)	Control Group (n=50)
Male	100	38	42
Female	100	12	8

Table 4. Comparison of Pre and post-test mean scores of the selected outcome measures

	Experımental Group			Control Group		
Outcome Measures	Pre-Test [Mean±SD]	Post-Test [Mean±SD]	P Value	Pre-Test [Mean±SD]	Post-Test [Mean±S]	P value
VAS	6.02±1.47	1.69±1.09	<0.0001	5.94±1.61	4.57±1.71	<0.0001
VO2 MAX (ml/kg/min)	56.49±5.38	59.55±4.69	<0.0001	54.45±4.85	55.33±4.74	<0.0001
1 RM Leg Press Test (kg)	66.10±14.0	73.40±15.20	<0.0001	68.02±15.09	69.40±13.94	0.0275
50 SRT (m.s-1)	6.23±0.44	6.00±0.46	<0.0001	6.11±0.44	6.06±0.48	0.0832

DISCUSSION

The present study investigated the efficacy of 6 weeks of an aquatic training program on recreational athletes in the experimental group and the efficacy of a swimming program in the control group.

Eunkuk kim et al., (**2010**) demonstrated that 4 weeks of aquatic exercises in elite athletes showed significant reduction in VAS ($p<0.05$). **Hajouj et al**, (**2021**) demonstrated that 6 weeks of aquatic proprioceptive training in athletes with anterior cruciate ligament reconstruction showed a significant reduction in VAS ($p<0.05$). **Vaile, et**

al., (2008) in their study showed that aquatic therapy was found to be effective in reducing physiological and functional deficits.The pain perceived was improved (p<0.001) following aquatic therapy.

In the current study reduction in the mean VAS was 4.33 in the experimental group with p-<0.0001 which is considered significant while in the control group the reduction in the mean VAS was 1.37 with (p<0.0001) which was considered extremely significant. The hydrostatic effect may stimulate the sensory nerve endings in the skin, which would explain how pain is reduced in aquatic environments. Additionally, it was proposed that sensory overflow influences pain modulation and may raise the pain threshold, which rises in response to changes in temperature and water turbulence. Water's pain-relieving properties are attributed to a variety of buoyancy-related mechanisms. By reducing peripheral edema and reducing sympathetic nervous activity, hydrostatic pressure may reduce pain. The ease of movement could lead to a decrease in pain.

Biswas, & Ghosh, (2022) demonstrated that 14 weeks of aquatic plyometric training program is effective for improving aerobic capacity with significant increase in VO2 max with p value <0.001. Dawar Rezaimanesh et al.,(2011) demonstrated that six weeks of aerobic and anaerobic intermittent swimmimg exercise are effective on VO2 max with p<0.0001) Nagraj et al., (2020) demonstrated that six weeks of water aerobic exercise on college men students had significant improvement in VO2 max with p value (<0.05). Michishita et al., (2023) demonstrated that eleven weeks of aquatic training on soccer players had significant improvement in VO2 max with p value 0.05 (Dowzer et al, 1999) conducted a study to compare. The physiological reaction to walking or running on a land treadmill and a water treadmill at two various depths. Vo2 max was higher while using a water treadmill than while using a land treadmill, indicating an increase in aerobic fitness.

In the current study the experimental group showed iprovement in the mean VO2 max by 3.06 with p<0.0001 while in the control group the improvement in the mean VO2 max was 0.88 with p<0.0001 both the groups showed significant improvement in VO2 max. Movement resistance in the water is higher than in the water because the aquatic medium is denser than the air medium. As the depth of immersion increases, the hydrostatic pressure also rises. The aforementioned factor results in a greater energy expenditure during exercise in an aquatic environment than on land at the same time, increasing blood flow rates throughout the body. As a result, increases in stroke volume, heart rate, and cardiac output have an impact on the body's overall oxygen consumption (VO2 max). Arazi and Asadi ., (2011) demostrated that 8 weeks of aquatic and land plyometric training on basketball players has improved leg strength with increase in 1RM leg press (p<0.005) Hailu et al ., (2015) demonstrated that 12 weeks of water based exercises increases strength by 17% greater than land based exercises.

In the current study, the experimental group showed improvement in the mean 1 RM leg press test by 7.3 kg With a (p<0.0001) the control group showed improvement in the mean 1 RM leg press test by 1.38 kg with a p-value (0.0036) which is considered significant. Both the groups showed improvement in the lower body strength. Water provides a natural form of resistance, aquatic exercises often involve a wide range of leg movements, These movements engage multiple muscle groups in the legs the nervous system becomes more efficient at recruiting muscle fibers. The muscles adapt to the increased resistance by undergoing hypertrophy, which contributes to increased leg strength.

Biswas et al., (2022) demonstrated that 14 weeks of aqua-based plyometric training has shown improvement in running performance with a significant increase in the 50 m sprint test with a p<0.05. Arazi et al demonstrated that eight weeks of aquatic and land plyometric training on basketball players has improved running performance with a significant increase in 60 m sprint with a p<0.05. In the current study, the experimental group showed improvement in the mean 50 m sprint run test by 0.23 With a p<0.0001) the control group showed improvement in the mean 50 m sprint run test by 0.05with a p-value (0.0832) which is not quite significant. Active recovery, increased strength, and improved coordination could all contribute to athletes' increased speed after aquatic training. Aquatic exercises additionally improve joint range of motion and flexibility, which helps to enhance overall running performance. Based on the result, an aquatic exercise training program has shown significant improvement in runners' fitness as well

as strength, cardiac endurance,speed of the runners. In this study recreational male and female runners were selected, so further attempts can use a teenage group with an elite group of runners and future research should use larger samples to be better generalizability.

Conclusion

Aquatic therapy is proved to be effective for reducing pain, increasing range of motion and improving balance and coordination. Aquatic therapy has also given relaxation and soothing effect to the patient after the treatment as fatigue level of muscles is reduced and work load on muscles is also minimized. It concluded that pre-participation aquatic training program had shown significantly positive response in improving the speed and reducing pain. Whereas, the control group had limited changes in the post-test responses for strength and speed test. It proved that 6 weeks pre-participation aquatic exercise training program was effective for reducing pain and improving the speed test timings.

Clinical Implications

The preparation of marathon runners for the physical and mental demands of a marathon race includes pre-participation training. Running marathons is a strenuous activity that greatly impacts the body. Athletes can develop the necessary strength, flexibility, and endurance during pre-participation training to lower their risk of injury. It enables them to identify any flaws or imbalances in their musculoskeletal system and take appropriate action. The study can be conducted on large sample size with the use of aquatic equipments.

Suggestions

In-depth research can bedone to determine the most effective aquatic training regimens for different sports and athletic disciplines. Future research can look into how different combinations of aquatic exercises, durations, and intensities affect performance outcomes in particular. More studies may investigate into how aquatic training affects athletes' motivation, mood, and perceptions of exertion.

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Conflict of İnterest

Authors declare no conflict of interest.

Ethics Statement

The interventional study was accepted by Institutional Human Ethics Committee of Krishna Institute of Medical Sciences, "Deemed to be University," Karad (Protocol number-299/2022-2023).

Author Contributions

Study Design, SBS and SD; Data Collection, MM; Statistical Analysis, SD; Data Interpretation, MM and SD; Manuscript Preparation, SBS and SD; Literature Search, SBS, and MM. All authors have read and agreed to the published version of the manuscript.

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