Journal of Physical Education and Sport ® (JPES), Vol. 22 (issue 4), Art 118, pp. 930 - 940, April 2022
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Effect of plyometric training in land surface aquatic medium & aquatic medium with a weighted vest on the aerobic capacity of athletes

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Published online: April 30, 2022
(Accepted for publication April 15, 2022)
DOI:10.7752/jpes.2022.04118

Abstract:
Background: It is already established that plyometric training is a powerful training means for speed and power development; however, very few studies have attempted to know the impact of Plyometric Training on aerobic capacity so far. Sufficient studies were not found by the researchers on plyometric training in land and aquatic medium with & without weight vests for the development of aerobic capacity. Consequently, it was planned to investigate the impact of plyometric training in land and aquatic medium on aerobic capacity from a comparative standpoint. Purpose: Therefore, the present experimentation was aimed to compare the effectiveness of plyometric training programs for 14 weeks on the aerobic capacity of the athletes conducted in three different conditions in land and aquatic medium. Approach: Forty-eight (N = 48) middle-distance track athletes were finally selected based on simple randomization. The selected participants were divided into four equal groups of strength (n=12) each: i) Land Plyometric Training Group (LPTG) ii) Aquatic Plyometric Training Group (APTG) iii) Weighted Vest Aquatic Plyometric Training Group (APTGWV) and iv) Control Group (CG). The same plyometric training was performed for fourteen weeks on the respective training groups in different conditions on dry land surfaces (without a weighted vest) and aquatic medium (without a weight vest & with a weighted vest). Aerobic capacity in terms of maximum oxygen consumption i.e. VO_2max ($ml.kg^{-1}.min^{-1}$) was measured through Queen's-College-Step-Test (QCST). To draw a statistical inference on aerobic capacity among the groups in baseline & post-intervention conditions, analysis of covariance (ANCOVA) was used. Tukey's post-hoc LSD test was employed to identify the location of difference among the groups. Statistical inferences were drawn at $p<.05$ level. Results: Different plyometric training groups improved significantly in comparison to the control group in aerobic capacity. Therefore, plyometric training was found as an effective means of developing aerobic capacity. A significant difference was also observed between the land plyometric training group and the weighted vest aquatic plyometric training group in aerobic capacity. However, the rest of the experimental groups didn't differ significantly. Conclusions: Plyometric training is not only beneficial for speed and power development but also proved as an effective means for developing aerobic capacity. It is further established that weighted vest aquatic plyometric training is the best one among the training groups for improving the aerobic capacity of the athletes. Normal aquatic plyometric training is equally effective as land Plyometric training for improving aerobic capacity.
Key Words: - **Aerobic ability; Aerobic fitness; Queen's College Step Test (QCST); VO_2max; Aquatic plyometric training; Weighted vest aquatic plyometric training.**

Introduction

Aerobic capacity in terms of maximum oxygen consumption (VO_2max) is an indicator of aerobic fitness. An increase in VO_2max indicates an improved level of aerobic capacity of an individual. Maximum oxygen consumption or VO_2max denotes the maximum rate at which oxygen can be taken up and consumed by the body during intense exercises (Bauri et al., 2016). Plyometric training includes high-intensity movements that are executed rapidly, with muscle lengthening followed by shortening during concentric contraction. The most basic type of plyometric exercise is jump training, which consists of a series of jumps, skips, bounding, and hops executed at a high intensity and with maximal efforts (Sáez de Villarreal et al., 2012). The significant responses to repeated jump and bounding indicated important considerations for specific training methods of sports that lead to the enhancement of oxygen consumption and utilization, preservation of neuromuscular performance, inter-muscle coordination patterns, muscle buffer capacity, and phosphocreatine recovery (Agustiyawan et al., 2020; Billaut et al., 2005; Stone & Kilding, 2009).

Prolonged muscular activity is influenced by several aerobic factors like maximal oxygen consumption (VO_2max), its utilization, production of energy, availability and supply of constant energy in the working muscles and running economy (RE) (Coyle, 1995). Energy expenditure varies at different velocities affects the RE simultaneously(Andrade, Beltrán, Labarca-Valenzuela, Manzo-Botarelli, Trujillo, Otero-Farias, Álvarez, Garcia-Hermoso, Toledo, Del Rio, et al., 2018a). It also depends mostly on neuromuscular characteristics i.e. on Reactive Strength Index (RSI), and muscle strength & stiffness (Noakes, 1988). In fact, running economy as an important determinant of aerobic capacity can be affected by neuromuscular activation with the intensity of

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stimulus (Andrade, Beltrán, Labarca-Valenzuela, Manzo-Botarelli, Trujillo, Otero-Farias, Álvarez, Garcia-Hermoso, Toledo, Del Rio, et al., 2018b; Conley & Krahenbuhl, 1980). Furthermore, neuromuscular performance, such as jump-related explosive muscle activities, has been linked to aerobic performance at various distances (Hudgins et al., 2013). Therefore, the total energy cost of running is determined by the sum of both aerobic and anaerobic (neuromuscular factors) metabolism (Daniels et al., 1985). Hence, for the endurance athletes, both middle and long-distance runner the training strategies is the most important thing that should be so targeted to increase both aerobic and neuromuscular factors related to aerobic performance (Andrade, Beltrán, Labarca-Valenzuela, Manzo-Botarelli, Trujillo, Otero-Farias, Álvarez, Garcia-Hermoso, Toledo, Del Rio, et al., 2018).

Plyometric training i.e., a jump-based strength training method is a commonly used training strategy to increase neuromuscular strength through the stretch-shortening cycle (SSC) in muscle actions (Ghosh & Biswas, 2020; Markovic & Mikulic, 2010; Ramírez-Campillo et al., 2013) that may positively affect the aerobic performance factors (Conley & Krahenbuhl, 1980), and increases the RSI simultaneously (Paavolainen et al., 1999). A previous study reported that after 6-weeks of plyometric training recreational runners improved their running economy (Turner et al., 2003). Moreover, the running economy can be increased independently by the changes in VO_2max in plyometric training (Paavolainen et al., 1999). Therefore, plyometric training may increase running economy and reactive strength index, which may positively affect aerobic performance (Andrade, Beltrán, Labarca-Valenzuela, Manzo-Botarelli, Trujillo, Otero-Farias, Álvarez, Garcia-Hermoso, Toledo, & Del Rio, 2018; Morgan & Pollock, 1977).

In the field of athletics, the trainers always prefer to use an athlete-friendly training environment to develop the aerobic capacity with a less possible chance of injury. Prolonged physical activity on the dry land surface provides constant impetus on the musculoskeletal juncture, particularly on the muscle-tendon complex and the ligaments of different joints that leads the athlete towards suffering from unwanted injury. These injuries disrupt the constant development of the athlete and shorten their career. Training in an aquatic medium saves the athlete from these training hazards and helps the athletes to be fresh even after spending strenuous training sessions. Plyometric drills in water, called Aqua-Plyometric-Training, may provide athletes with several benefits. Due to its buoyant properties, the water acts as a counterforce to gravity and gives support to the athlete's body as it moves downward and resists movement in the upward motion (Miller et al., 2001; Suomi & Koceja, 2000). In aquatic plyometric training (APT), water reduces pressure on the musculoskeletal system as the aquatic environment provides buoyancy and reduces stress on the limbs due to weight. The viscosity and resistance to movement within the water require additional muscle activation to overcome the resistance and initiating a similar movement on land or other surfaces is easier (Arazi & Asadi, 2011). The buoyancy created by the water reduces the amount of force transmitted throughout the body when the athlete lands, reducing the risk of possible injuries.

Aquatic training provides an athlete-friendly environment that offers well thermoregulation of the body, comfort, safety, changed training environment which permits the coaches to impose higher training intensity during movement execution with more repetitions. While performing an exercise along the vertical direction of the water surface increases turbulence, consequently maximizes the resistance due to water drag force that helps the coaches to strengthen the active muscles in reduced weight-bearing condition due to the buoyancy of water imposes less impact force which helps the athlete to avoid unwanted injury. Thus, aquatic training provides a similar training effect and sometimes better effect than land with less chance of injury and allows the coaches and trainer to choose this training as a better alternative to the land-based training. In aquatic training, the coaches get quick improvement as in this training the involvement of muscle and joints are more at a time thus the energy cost is also higher than the other training means. Resistance due to movement in water is considerably higher than on land; as the water is 800 times denser than air. Jumping along the horizontal direction within water; with or without a weighted vest; needs increased effort to overcome water resistance that helps an athlete strengthen muscles. Plyometric training with additional weight in aquatic mediums became popular in modern-day training and the trainers frequently used this training means in their training sessions for the athletes.

Therefore, in the present study the researchers were interested to see the effect of plyometric training in land & aquatic medium on the aerobic capacity of the athlete in a weighted vest and without weight conditions in land and aquatic medium from a comparative standpoint. It is already established that plyometric training is very impactful on speed and power development, however, very little effort has been initiated by the sports scientist to know the impact of plyometric training on aerobic capacity so far. In this regard, it is also proved that weighted vest plyometric training has a potential benefit on human performance, particularly on speed and power related activities, however, implementing additional weight on the athletes while performing plyometric training on dry land involves a high risk of unwanted injury in the muscle-tendon complex at the same time. In this context, furthermore, the impact of weighted vest plyometric training on aerobic capacity still was not studied so far. Thus, it was planned to determine the impact of plyometric training on aerobic capacity and to overcome the hazards of injury related to land plyometric training, subsequently, the aquatic medium was considered as a replacement of the land plyometric training to reduce the ground impact and to see whether it can be beneficial for conducting weight vest plyometric training for improving aerobic capacity in aquatic medium or not at all. No randomized control trial has been published ever to investigate the impact of plyometric training on the aerobic capacity of athletes conducted in land & aquatic medium with pre imposed conditions (with & without weight). This surprising fact led the researcher to think of this unknown dimension of sports training. Based on the information mentioned above it was hypothesized that different plyometric training for 14 weeks could be beneficial for the improvement of the aerobic capacity of athletes.

Material & methods

Participants

Initially, sixty healthy middle distance track athletes with a training age of at least four years were recruited based on of simple randomization from the district of Nadia in West Bengal located in the eastern part of India. The age of the subjects ranged from14 - 16 years. After required medical check-ups they were finalized as subjects for the present study. Furthermore, to include the subjects in the present study, a signed copy of the statement of consent and willingness from all the participants as well as from their guardians were collected before the commencement of the study. The proposal of the research work was placed and duly approved by the *Departmental Research Committee* (DRC) of the University of Kalyani by satisfying the research aims, procedures and requirements. After the collection of pre-experimental data (baseline) and before starting the training program they were given one week rest period. During the periods of the experimental intervention, nine subjects left the training program and three subjects were consciously excluded due to their irregularity in the training program. Finally, forty-eight (N=48) athletes, who participated regularly and finished the program till the post-test data collection, were confirmed as successful participants for the present study. After one week of the completion of the training program, the post-treatment data were collected. Demographic details of the information of the participants have been presented in Table 1.

Table 1. Demographic details of the subjects

Groups	No. of Subjects (N = 48)	Age (years) Mean ± S.D	Height (cm.) Mean ± S.D	Weight (Kg.) Mean ± S.D	BMI (Kg.m^{-2}) Mean ± S.D	RSBP (mmHg) Mean ± S.D	RDPP (mmHg) Mean ± S.D	RHR (beats/minute) Mean ± S.D	Training Age (Years) Mean ± S.D
LPTG	12	15.25 ± 0.66	154.92 ± 7.44	46.09 ± 6.36	20.33 ± 1.43	121.26 ± 1.64	81.56 ± 1.42	65.44 ± 0.75	4.42 ± 1.51
APTG	12	14.87 ± 0.56	155.92 ± 5.50	48.54 ± 5.40	21.66 ± 1.73	120;68 ± 1.75	79.63 ± 1.72	67.62 ± 0.66	4.35 ± 0.94
APTGWV	12	15.12 ± 0.83	158.33 ± 8.17	49.58 ± 4.62	22.47 ± 1.99	124.46 ± 1.96	84.65 ± 1.94	72.80 ± 0.94	4.47 ± 0.82
CG	12	14.85 ± 0.64	154.33 ± 4.91	45.40 ± 7.39	20.82 ± 1.57	123.33 ± 1.89	83.54 ± 1.62	69.22 ± 0.84	4.23 ± 1.28

LPTG = Land plyometric training group; APTG= Aqua-plyometric training group; APTGWV= Weighted Vest Aqua-plyometric training group; CG=Control group; BMI=Body mass index; RSBP= Resting systolic blood pressure; RDBP=Resting diastolic blood pressure; RHR=Resting heart rate

Procedures

In this research work, aerobic capacity was considered the dependent variable, and it was measured by Queen's College Step Test (QCST) in terms of maximum oxygen consumption i.e. VO2 max in ml.kg^{-1}.min^{-1}.
Queens College Step Test (QCST) Protocol: Measure: This test provides a valid measure of aerobic capacity in terms of VO_2 max in field settings (substitute for complex laboratory measures) and was widely used in research for the last few decades. *Instruments:* For conducting the test a 0.413 m high step, stopwatch, metronome, and digital heart rate monitor were used. *Test Trial:* Up and down steps (24 steps/minute) as pre-setted by metronome were performed for 3 minutes by the athlete on the platform rhythmically as a four-step cadence, 'up-up-down-down'. The athlete stops immediately on completion of three minutes of the test periods of stepping. *Measurement of Heart Rate:* In the recovery period from 5-20 seconds, the heartbeats were counted for 15-second. This 15 second reading was multiplied by 4 to get the heart rate in beats per minute (bpm) as the value required for computing VO_2 max *Calculation of VO_2 max:* VO_2 max was calculated by the following formula (McArdle et al., 1972).

$$VO_2max\ (ml.kg^{-1}.min^{-1}) = 111.33 - (0.42 \times \text{heart rate (bpm)})$$

Reliability and validity of QCST: In the Indian population the validity of the test was found (r=-0.83) (Chatterjee et al., 2005). In pre and post-treatment the test (QCST) was performed on two consecutive days, VO_2max was calculated for both days and test-retest reliability was computed by calculating the coefficient of correlation (r=0.93). _Score:_ Based on collected data on two consecutive days, the computed best value of VO_2max was taken as the score.

Experimental design & Training Protocol

In this study, a single pre-test-post-test control group design (shown in Fig. 1) was employed where three experimental training groups and one control group were recruited for fourteen weeks (experimental time frames were shown in Fig. 2). Experimental group-1 underwent land plyometric on grassy turf; experimental group-2 underwent plyometric in a constructed water reservoir with water up to waist level whereas experimental group-3 underwent plyometric in a constructed water reservoir with water up to waist level by adding a weighted jacket which was filled in appropriate progressive weight (Biswas & Ghosh, 2019). But the control group did not receive any treatments as mentioned above.

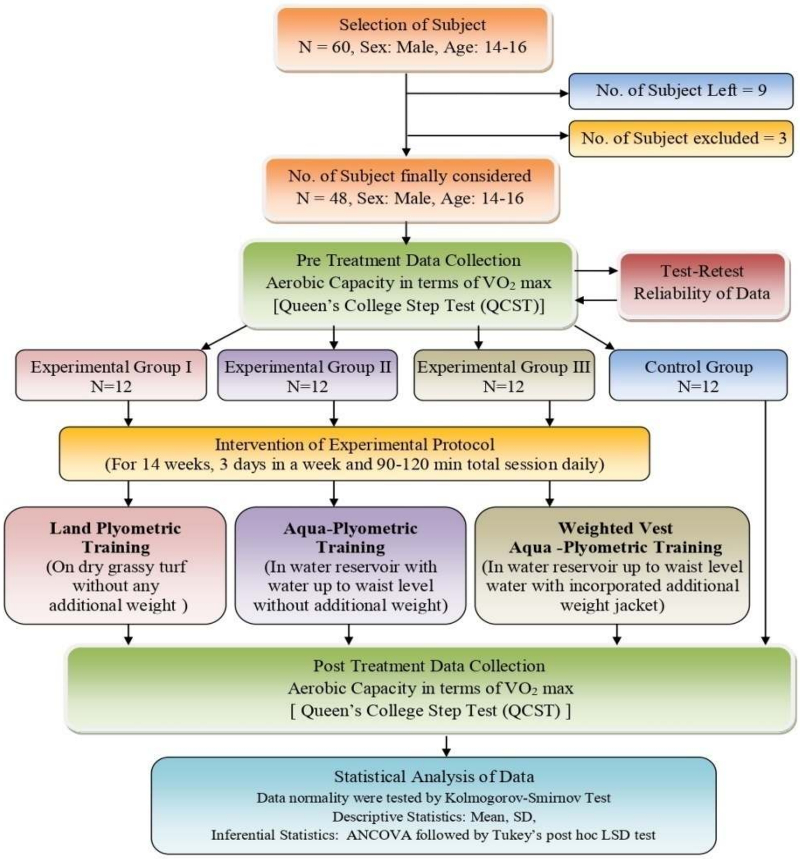

Fig. 1 Experimental Design

All the groups were given a proper warm-up before starting the training program every day, and they were also provided proper cooling down exercises when the training was completed. The total schedule of the daily session was 90-120 min including warm-up and cool down. The subjects were involved in the training three days a week for a total period of 14 weeks. The total time frame of the present study was eighteen weeks including data collection and rest periods.

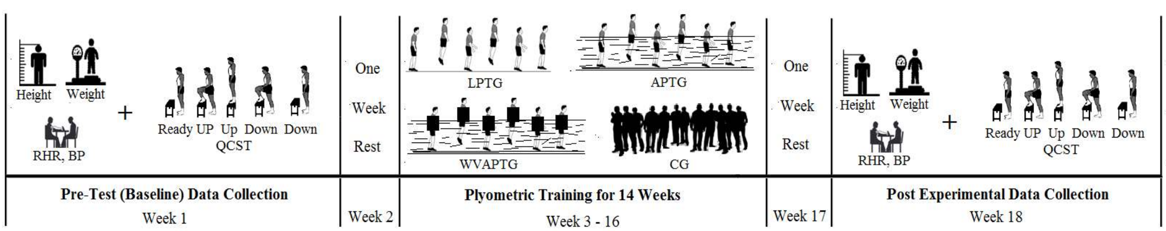

Fig. 2 Experimental time frame

Note: RHR = Resting Heart Rate, BP = Blood Pressure (Systolic & Diastolic), LPTG = Land Plyometric Training Group, APTG = Aquatic Plyometric Training Group, APTGWV / WVAPTG = Weighted Vest Aquatic Plyometric Training Group, CG=Control Group, QCST = Queen's College Step Test.

Land plyometric training: In land plyometric training seven plyometric exercises such as upward jump & squat, single-leg hop (both legs), double leg bounding, split jump, tuck jump, box jump and depth jump were sequentially arranged for the athletes on the grassy turf. The intensity and the volume were progressively increased. Two to three-minute passive recovery was given between each set of exercises (Arazi & Asadi, 2011; Bompa, 2000; Miller et al., 2007; Söhnlein et al., 2014). The detailed protocol of the land plyometric training is shown in Table 2.

Aqua-plyometric training: In aqua-plyometric training, the athletes did same exercise those were upward jump & squat, single-leg hop (both legs), double leg bounding, split jump, tuck jump, box jump and depth jump sequentially into a plan-fully constructed water reservoir with water up to waist level (Holmberg et al., 2021; Miller et al., 2007). The intensity and the volume were progressively increased. Two to three-minute passive recovery was given between each set of exercises (Arazi & Asadi, 2011; Bompa, 2000; Miller et al., 2007; Söhnlein et al., 2014). The detailed protocol of the aqua-plyometric training is shown in Table 1.

Weighted vest aqua-plyometric training: In weighted vest aqua-plyometric training the athletes did the same exercise those were upward jump & squat, single-leg hop (both legs), double leg bounding, split jump, tuck jump, box jump and depth jump sequentially into plan-fully constructed water reservoir with water up to waist level by adding weighted jacket which was filled by appropriate weight. The weighted jacket weighed 5% of their body mass and gradually increases to about 10% of their body mass (Bosco, 1985; Bosco et al., 1986; Kamalakkannan et al., 2011; Rantalainen et al., 2012; Sands et al., 1996). The intensity and the volume were progressively increased. Two to three-minute passive recovery was given between each set of exercises. The detailed protocol of the weighted vest aqua-plyometric training is shown in Table 1 for better understanding. for better understanding. In Fig: 3 plyometric training in three different mediums has been shown.

Table 2. Details of experimental protocol on varied plyometric training in different mediums

Training Week	Training Volume	Plyometric Drill	Set × Repetitions	Training Intensity
I & II Week	96	Side to side ankle hops	2×15	Low
		Standing long jump and reach	2×10	Low
		Double leg hops	3×10	Low
		Jump & squat	2×8	Low
III & IV Week	104	Side to side ankle hops	2×15	Low
		Standing long jump and reach	2×10	Medium
		Double leg hops	3×8	Medium
		Jump & squat	3×10	Low
V & VI Week	118	Single leg hops (alternatively)	2×10	Low
		Standing long jump	2×12	Medium
		Double leg hops	3×10	Medium
		Jump & squat	3×8	Medium
VII & VIII Week	120	Single leg hops (alternatively)	2×6	Medium
		Standing long jump	2×12	Low
		Double leg bounding	3×8	Medium
		Jump & squat	3×8	High
		Tuck jump	4×6	Medium
IX & X Week	106	Single leg hops (alternatively)	2×6	High
		Double leg bounding	3×8	Medium
		Jump & squat	3×6	High
		Tuck jump	4×6	Medium
		Split squat jump	2×8	Low
XI & XII Week	98	Single leg hops (alternatively)	2×6	High
		Double leg bounding	3×6	High
		Tuck jump	4×6	Medium
		Split squat jump	2×8	Medium
		Scissor jump	2×8	Low
XIII & XIV Week	86	Double leg bounding	3×6	High
		Jump & squat	3×5	High
		Tuck jump	4×5	High
		Split squat jump	3×6	High
		Scissor jump	3×5	Medium

Fig. 3 The Training conducted in different mediums A: Land Plyometric Training (LPT), B: Aqua-Plyometric Training (APT), C: Weighted Vest Aqua-Plyometric Training (APTWV).

Measurement of Resting Heart Rate(RHR): Before measuring the resting heart rate all the participants were instructed to take rest for 30 minutes. Just before measurement subjects lie still and breathe calmly for 3–5 minutes. In all participants, baseline resting heart rate was measured at the right radial artery by using a wristwatch and counting the number of beats felt in 30 seconds, then multiplied that number by two to compute a heart rate, expressed in beats per minute (BPM).
Measurement of Blood Pressure (BP): Just after the measurement of RHR the Blood pressure (both systolic and diastolic) of the participants was measured by a digital blood pressure monitor (BP-09, Jotech Healthcare) according to the guidelines of the manual.
Estimation of Maximum Heart Rate (HR_{max}): While constructing the training schedule a well-accepted age-predicted regression equation (Tanaka et al., 2001) was used for calculating the maximal heart rate of the healthy subjects in the present study. The equation was as follows- $HR_{max} = 208 - 0.7 \times Age$. Three measurements were taken and the lowest value was taken as a score.
Other Instruments Used: Age was measured from birth certificates. Height was measured by an anthropometric rod made of brass (Aarson Scientific Works), weight was measured by a digital weighing machine (Omron HBF-212 digital), and a wristwatch for measuring resting heart rate. Resting systolic blood pressure; Resting diastolic blood pressure; were measured by a digital monitor (BP-09, Jotech Healthcare).
Statistical analysis

All the data are presented in the form of mean and standard deviation. The reliability of data was calculated by the coefficient of correlation in the pre-test (baseline). Kolmogorov–Smirnov test was used for testing data normality. This test confirmed the normality of the data. Thus analysis of covariance (ANCOVA) was used as necessary parametric statistics between the baseline and post-intervention data to draw the inference in aerobic capacity among the experimental groups. Tukey's LSD post-hoc test was also employed to identify the location of the difference exactly between the groups. Statistical inference was drawn at $p<.05$ level. To calculate the *percentage of change in aerobic capacity* the following equation was used: *Δ% = [(Post-treatment mean – Baseline mean) × 100 / Baseline mean]*. The Kolmogorov-Smirnov test of normality was calculated by social science statistics software. The ANCOVA was performed by Vassar Stats, a statistical computation software package, and Tukey's post hoc LSD test and other calculations were performed by an excel spreadsheet of Microsoft office software in Windows version 10.

Results

All the three different plyometric training groups i.e. land plyometric training (LPT), aquatic plyometric training (APT) and weighted vest aquatic plyometric training (APTWV) were improved significantly (in adjusted post-test $F=12.012$; $p<.001$) in comparison with the control group (CG) in aerobic capacity. It was also observed that after the intervention of plyometric training the *percentage of change in aerobic capacity* for LPTG, APTG, APTGWV and CG were 9.06%; 11.113%; 13.13%; and 2.30% respectively. Thus the weighted vest aquatic plyometric training group improved best in aerobic capacity (13.13%) due to the fourteen-week plyometric training intervention among the groups. Based on the result the hypothesis was accepted. The details of the results are shown in Table 3 and the mean values are depicted in Fig.3 for a better understanding of the research outcomes.

Table 3. Analysis of Covariance (ANCOVA) of aerobic capacity among LPTG, APTG, APTGWV and CG in baseline, post treatment and adjusted post test

Test	LPTG ($ml.kg^{-1}.min^{-1}$)	APTG ($ml.kg^{-1}.min^{-1}$)	APTGWV ($ml.kg^{-1}.min^{-1}$)	CG ($ml.kg^{-1}.min^{-1}$)	Source of variance	SS	df	MS	'F' value	p-value
Baseline Mean ± SD	43.25 ± 7.63	44.25 ± 6.40	45.08 ± 7.77	43.42 ± 7.08	Between	25.67	3	8.56	0.163	.92
					Within	2306	44	52.42		
Post Treatment Mean ± SD	47.17 ± 8.28	49.17 ± 7.32	51.00 ± 8.25	44.42 ± 7.05	Between	286.56	3	95.52	1.593	.21
					Within	2638.25	44	59.96		
Adjusted post test Mean	47.94	48.91	49.88	45.02	Between	158.05	3	52.68	12.012	<.001
					Within	188.59	43	4.39		
(Δ %)	9.06%	11.11%	13.13%	2.30%						

LPTG = Land plyometric training group; APTG = Aquatic plyometric training group; APTGWV= Aquatic plyometric training group with weighted vest; CG = Control group; SD=Standard deviation; SS=Sum of square; df=Degree of freedom; MS=Mean squares; Δ % = Percentage of Improvement in aerobic capacity.

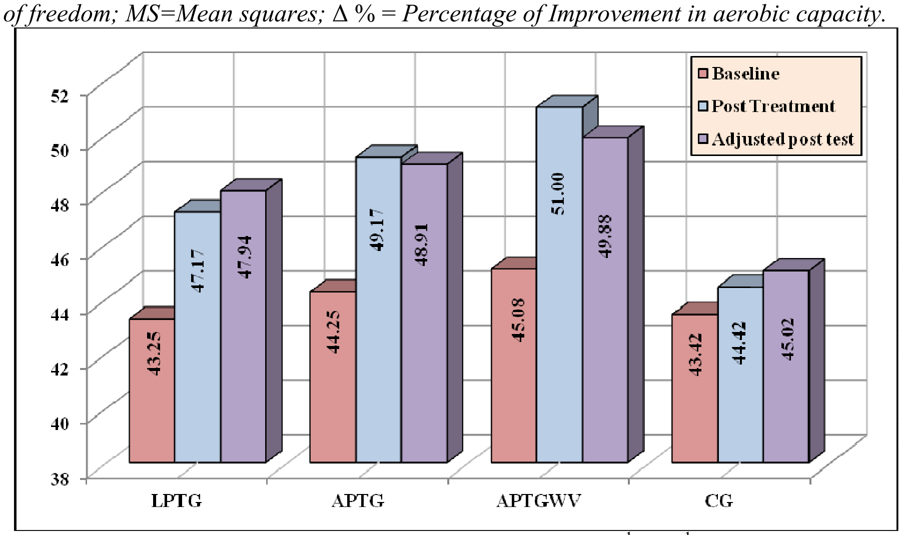

Fig. 4 Differences of aerobic Capacity in terms of VO_2 max ($ml.kg^{-1}.min^{-1}$) as assessed through QCST in Baseline, Post Treatment & Adjusted Post Treatment for the experimental groups (LPTG, APTG, APTGWV) and control group (CG)

To find out the intergroup exact mean difference Tukey's LSD post-hoc test was performed. A significant difference was observed between the weighted vest aquatic plyometric training group and the land plyometric training group for the development of aerobic capacity. On the other hand, there was no significant difference between land plyometric and aquatic plyometric training groups in aerobic capacity. It was also found no significant difference between aquatic plyometric training and aquatic plyometric with a weighted vest training group in aerobic capacity. The details of the results are shown in Table 4 for a better understanding of the research outcomes.

Table 4. Tukey's LSD post-hoc test on aerobic capacity in adjusted post test mean score for different groups

Adjusted Post Test Mean Scores				Mean Difference	Required confidence interval (p<.05)
LPTG	APTG	APTGWV	CG		
47.94	48.91			0.969	1.724
47.94		49.88		1.944*	1.724
47.94			45.02	2.922*	1.724
	48.91	49.88		0.974	1.724
	48.91		45.02	3.891*	1.724
		49.88	45.02	4.866*	1.724

*LSD= Least significant difference; LPTG = Land plyometric training group; APTG= Aqua-plyometric training group; APTGWV= Aqua-plyometric training group with weighted vest; CG=Control group. * Calculated value of critical difference at p<.05 level of significance with df(43) was 1.724*

Discussion

The findings of the present study indicated a significant improvement in aerobic capacity ($F=12.012$, $p<.001$) measured through QCST in all three plyometric training groups i.e. land plyometric training group, aquatic plyometric training group and weighted vest aquatic plyometric training group in comparison with the control group. The result was accorded with the findings of (Brown et al., 2010; Gopperunthevi, 2014; Joel, 2011; Kamalakkannan et al., 2011; Revathi, 2013; Senthil Kumar, 2016) for the improvement in aerobic capacity, by all three types of plyometric training intervened for fourteen weeks on the experimental groups (improvement percentage or LPTG, APTG, APTGWV was 9.06%, 11.11% and 13.13% respectively), the researcher is of the opinion that the training schedule which was used in the present study, long in duration (about one and half hours per day & thrice per week for fourteen weeks) and repetitive middle-intensity plyometric exercises with approximately 60-70% of max HR in nature that have been adapted in the training schedule that might cause a significant improvement in the aerobic capacity.

Again the result of the present study on aerobic capacity also indicated that there was no significant difference between land plyometric training (without a weighted vest) and aquatic plyometric training (without a weighted vest) after fourteen weeks of plyometric training programs which means Plyometric training conducted in both the mediums i.e. in the land and aquatic medium had an identical effect for developing the aerobic capacity of the athletes. The researcher reviewed several studies but very few of them have compared the effect of land plyometric training and aquatic plyometric training on aerobic capacity. One of them reported that land plyometric training was as effective as aqua plyometric training for developing aerobic capacity (Senthil Kumar, 2016) which accorded the result of the present study. As per the finding of the present research, both types of plyometric training improved aerobic capacity equally. Thus aquatic plyometric training may be undertaken as alternative training means to land plyometric training to provide them with a new training environment for the development of aerobic capacity which will also be motivating and enjoyable too. Selecting aquatic plyometric training will also have other positive aspects to avoiding the risk of musculoskeletal injury. As the aquatic Plyometric training provides an athlete-friendly environment because it offers well thermoregulation of the body, comfort, safety, changed training environment that will permit the coaches to impose a higher training load with increased intensity during movement execution with more repetitions also.

On the other hand, though there was no significant difference between the aquatic plyometric training and weighted vest aquatic plyometric training for developing aerobic capacity, it indicated that the effect of both types of training environment was the same. Thus both types of aqua plyometric training groups did not differ significantly may be due to the identical training environment effect. But the improvement percentage (Δ %) in aerobic capacity of APTGWV (13.13%) was greater than APTG (11.11%). Due to the unavailability of studies conducted on aerobic capacity in a comparative standpoint between aquatic plyometric training and weighted vest aquatic plyometric training as a training medium the researcher was unable to present supportive literature in favor of the above findings. Kamalakkannan et al., 2011 experimented on the effect of aquatic plyometric training with and without resistance on cardio-respiratory fitness as measured by Coopers' test and reported that with resistance group (equivalent to weighted vest aquatic plyometric training group) significantly improved than without resistance group (equivalent aquatic plyometric training group) in aquatic medium. Therefore, using additional resistance (here it is gravitational resistance incorporated through additional wearable weight) in an aquatic medium provides a better effect than without resistance (without wearable weight). Thus while targeting better improvement of aerobic capacity through aqua Plyometric training it is suggested to use wearable resistance during training, it increases body weight which is generally reduced due to buoyancy within water during the training.

The findings of the present study also indicated that in aerobic capacity the weighted vest aquatic plyometric training had improved significantly than the land plyometric training group. This result also proved that weighted vest aquatic plyometric was more effective (Δ % = 13.13) than land plyometric training (Δ % = 11.11) for the development of aerobic capacity. Since the aquatic medium is denser than the air medium, movement resistance in water is greater in comparison with land (Miller et al., 2001). The physical properties of the water such as buoyancy, viscosity, thermodynamics, hydrostatic pressure, and fluid dynamics take a crucial role in the development of aerobic capacity (Becker, 2009; Thein & Brody, 1998). Buoyancy is defined as an upward thrust opposite to gravity that depends on the volume of body parts immersed in water and the specific gravity of the body as well. Due to buoyancy body weight decreases in the immersion condition whereas in land plyometric the bodyweight remains an unchanged need for additional muscular effort to move upward (Wertheimer & Jukić, 2013). On the other hand, along the horizontal direction, there is no effect of gravity but very light air resistance comes into existence consequently drag force acts but the value is very less than aquatic viscous resistance and water drag. The hydrostatic pressure also increases with the increase of the depth of immersion. The above reason causes a maximum expenditure of energy in the same time of exercise in the aquatic medium than land which consequently increases the blood circulation rate of the body as a result stroke volume, heart rate, and cardiac output increases may affect the overall oxygen consumption (VO_2) of the body. Probably for the above reason, aerobic capacity increased in weighted vest aquatic plyometric training better than land plyometric training. Additional weight incorporation in the aquatic medium increases downward force thus upward vertical component of force due to buoyancy decreases thus upward movement resistance also increases and almost becomes equivalent to the land medium. But the viscosity and drag resistance along with hydrostatic pressure is always imposed on the body while performing training in a weighted vest aquatic plyometric. No such type of force acted on the body (if acted i.e. negligible) for land plyometric training, thus the athletes comparatively feel free for land plyometric training. Thus, overcoming additional resistance will always increase the energy expenditure in weighted vest aqua plyometric than land plyometric training, which may cause better improvement in aerobic capacity in weighted vest aquatic plyometric than land plyometric training.

Conclusions

Fourteen weeks of plyometric training conducted on land (without a weight vest) and aquatic medium (with & without a weight vest) significantly improved the aerobic capacity of the athletes in comparison to the control group and also confirmed that the weighted vest aquatic plyometric training improved better than the land plyometric training. No significant difference was also found in the aquatic plyometric (without weight vest) group vs. land plyometric (without weight vest) group and aquatic plyometric group (without weight vest) vs. weighted vest aquatic plyometric training group for improving aerobic capacity. Based on the findings of the present study following generalised conclusions can be drawn -

1) The aerobic capacity of the athletes in all three experimental groups (EGs) had improved significantly in comparison with the control group (CG) due to the effect of fourteen weeks plyometric training. Thus Plyometric training is an effective training method for developing aerobic capacity.
2) Both LPT and APT had identical training effects for developing the aerobic capacity of the Athletes. Thus anyone training method among these two methods can be chosen for developing aerobic capacity where APT shows a slightly better training effect than LPT. Therefore APT is a better choice than LPT.
3) The APT was as effective as APTWV for the development of aerobic capacity. However, both type of plyometric training in an aquatic medium is found effective for developing aerobic capacity, but weighted vest aqua Plyometric training (APTWV) provides little better training effect than without weighted vest aqua plyometric training (APT). Therefore APTWV is a better option than APT for developing aerobic capacity.
4) But the APTWV was significantly more effective than LPT for the development of aerobic capacity. It confirms that weighted vest aqua plyometric training (APTWV) is a better choice than land Plyometric training (LPT) while targeted to improve the aerobic capacity of the Athletes.

Thus, from the above conclusions, it is reflected that while selecting a particular training medium for developing aerobic capacity through plyometric training, it is recommended to all concerned that an aquatic medium would always be a better choice than a land surface, wherein aqua plyometric training with weight vest would be the best choice. Aquatic training always provides an athlete-friendly environment that offers well thermoregulation of the body, comfort, safety, changed training environment which permits the coaches to impose higher training intensity during movement execution with more repetitions. While performing an exercise along the vertical direction against gravity, increased turbulence occurs on the water surface, consequently, it maximizes the aquatic resistance due to drag force that helps the coaches to strengthen the active muscles in reduced weight-bearing condition due to the buoyancy of water that imposes less impact force and helps the athlete to avoid unwanted injury also.

Acknowledgements

The researchers are greatly acknowledged and thankful to the Anami Club, Badkulla, Nadia, West Bengal in India for providing the subjects and also their whole hearted cooperation and support for conducting this study successfully. The researchers also thankful to the Departmental Research Committee (DRC) of the Department of Physical Education, University of Kalyani, Nadia, West Bengal. India.

Conflicts of interest - There are no conflicts of interest to declare.

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