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Comparative effect of land plyometric and aquatic plyometric training on lower limb explosive strength of athletes

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Abstract
Objective: The objective of the present study was to find out the Effect of Land Plyometric and Aquatic-based Plyometric Training on Lower Limb Explosive Strength of district level Athletes.
Subject: Thirty six (N = 36) district level athletes were randomly selected as subjects for the present study from Nadia district of West Bengal. The age ranged from 12-18 years.
Group division: All the subjects were divided into three equal groups: i) *Land Plyometric training Group* (N =12) as experimental group–I ii) *Aquatic Plyometric Training Group* (N=12) as experimental group–II and iii) *Control Group* (N=12). Equated group design was adopted in the present study.
Experimental Protocol: Plyometric training was intervened for fourteen weeks on both the experimental groups. Experimental group-I underwent land Plyometric training whereas experimental group-II underwent aqua-based Plyometric training for fourteen weeks continuously for three days in a week and 90 min per day as per the structured training schedule. But the control group did not involve in the treatment program. During the training period participants of every group were allowed to do their routine activities as it was not under the control of the researchers.
Variable Studied: In the present study explosive leg strength was measured through jumping ability along vertical as well as horizontal direction which was measured by Sargent jump and standing board jump respectively.
Statistical analysis: To find out significant difference in lower limb explosive strength among the groups in pre and post intervention condition; analysis of covariance (ANCOVA) was conducted. To find out the exact location of the difference within different groups Tukey's LSD test was adapted as post hoc test. The significance of means were tested at $p<0.05$ level. For statistical calculations Excel Spread Sheet of windows version 7 was used.
Results: It was observed that the F value was significant at 0.05 level. Tukey's post hoc test confirmed that both Land Plyometric and Aquatic Plyometric training groups improved significantly with respect to the control group in Leg Explosive Strength. But no significant difference was observed between land Plyometric training group (experimental group-I) and aquatic Plyometric training group (experimental group-II) which confirmed that both type of training was equally effective for developing explosive leg strength.

Keywords: plyometric training, land plyometric training, aquatic plyometric training, explosive leg strength, vertical jump, horizontal jump

Introduction

The word plyometric originated from two Greek words, "*plio*", meaning 'more' and "*metric*", meaning 'to measure' or as described it "measurable increase", and was first used in 1975 by an American track and field coach, Fred Wilt (Chu, 1998; Dintiman & Ward, 2003) [5, 9]. Plyometrics is a type of training involving jumping; bounding and other high impact exercises that focus on maximizing the stretch reflex of the muscles. To teach the muscles to produce maximum force faster, this enhances performance for athletes and exercisers alike (Chu, 1998) [5]. Benefits from the plyometric training include improved measures of muscular strength and power explosive (Bobbert, 1990; Matavulj *et al*., 2001; Wilson *et al*., 1996). Plyometrics has been a very popular training technique used by many coaches and training experts to improve speed, explosive power output, explosive reactivity and eccentric muscle control during dynamic movements (Coetzee, 2007) [6].

In recent years, aquatic training has become an important training to mode to improve selected physiological variables (Peyre–Tartaruga, 2009, Miller, other authors, 2007). Performing plyometrics in the water can be more beneficial at improving force production than on land because of the resistance that is provided by water. (Colado *et al*., 2010) [7]. Aquatic plyometric training provides a form of training that can enhance performance during a competitive season for a power-based sport (Miller *et al*., 2002; Robinson *et al*., 2004).

Jumping ability is one of important factor for execution of any type of sport skill where explosive type of muscular force/power generation is needed (Baechle & Earle, 2008 [2]; de Villarreal, Izquierdo, & Gonzalez-Badillo, 2011 [8]; "Muscular strength | Human Performance Resource Center," n.d.; "Physical strength," 2019). That is why this type of ability for force generation is called explosive strength or explosive power as per the sports

training terminology. In most of the athletic events as well as sports; explosive strength of the lower limb dominated the performance. The vertical/horizontal jumping ability exclusively depends on the explosive leg strength. Vertical jump height may have been improved from pre- to post-testing due to the specificity of the plyometric training program. Plyometrics are known to improve muscular force and power due to the elastic energy that is stored during the eccentric phase. When followed immediately by a concentric contraction the total force production is increased making for a more powerful and higher jump. (Baechle & Earle, 2008) [2]. The present study was designed to increase the knowledge about the effects produced after the performance of aquatic plyometric training vs. land-based plyometric training. Thereby, the purpose of this study was to compare the effect of land plyometric and aquatic-based plyometric training on lower limb explosive strength of district level athletes selected from Nadia district of West Bengal.

Materials and Methods

This study was conducted to compare the effect of two different types of plyometric training executed in separate medium, i.e. on land and in water medium, on lower limb explosive strength. In the present study explosive leg strength was measured through jumping ability along vertical as well as horizontal direction which was measured by Sargent jump and standing board jump respectively. All the subjects were divided into three equal groups: i) *Land Plyometric training Group* (N =12) as experimental group–I ii) *Aquatic Plyometric Training Group* (N=12) as experimental group–II and iii) *Control Group* (N=12). Equated group design was adopted in the present study. Plyometric training was intervened for fourteen weeks on both the experimental groups. Experimental group-I underwent land Plyometric training whereas experimental group-II underwent aquatic-based Plyometric training for fourteen weeks continuously for three days in a week and 90 min per day as per the structured training schedule given below. But the control group did not involve in the treatment program. During the training period participants of every group were allowed to do their routine activities as it was not under the control of the researchers. For evaluating the lower limb explosive strength of athletes' pre and post-training data were recorded for each group. The training schedule and training intensity has been described below.

Table 1

Training Week	Plyometric Drill	Training Intensity
I & II Week	Side to side ankle hops (single leg)	Low
	Side to side ankle hops (both leg)	Low
	Standing long jump and reach	Low
	Double leg hops	Low
	Jump & squat	Low
III & IV Week	Side to side ankle hops (single leg)	Low
	Side to side ankle hops (both leg)	Low
	Standing long jump and reach	Medium
	Double leg hops	Medium
	Jump & squat	low
V & VI Week	Single leg hops (alternatively)	Low
	Standing long jump	Medium
	Double leg hops	Medium
	Jump & squat	Medium
	Tuck jump	Low
VII & VIII Week	Single leg hops (alternatively)	Medium
	Double leg bounding	Low
	Standing long jump	High
	Jump & squat	High
	Tuck jump	Low
IX & X Week	Single leg hops (alternatively)	High
	Double leg bounding	Medium
	Jump & squat	High
	Tuck jump	Medium
	Split squat jump	Low
XI & XII Week	Single leg hops (alternatively)	High
	Double leg bounding	High
	Tuck jump	Medium
	Split squat jump	Medium
	Scissor jump	Low
XIII & XIV Week	Single leg hops (alternatively)	High
	Double leg bounding	High
	Tuck jump	Medium
	Split squat jump	High
	Scissor jump	Medium

Statistical Analysis

To find out significant difference in lower limb explosive strength among different groups in the pre and post intervention condition; analysis of covariance (ANCOVA) was conducted. To find out the exact location of the difference between different groups Tukey's LSD test was adapted as post hoc test. The significance of means were tested at $p<0.05$ level. For statistical calculations Excel Spread Sheet of windows version 7 was used.

Results

Table 2: Mean and SD of Age, Height and Weight for the Subjects of Different Groups in Pre-experimental Condition

Sl. No.	Name of the Group	No. of Subjects	Age (years) Mean ± S.D	Height (cm.) Mean ± S.D	Weight (Kg.) Mean ± S.D
1	Land Plyometric Training Group	12	15.25 ± 1.86	152.92 ± 7.44	44.09 ± 6.36
2	Aquatic Plyometric Training Group	12	15.67 ± 1.56	155.92 ± 5.50	48.54 ± 5.40
3	Control Group	12	14.75 ± 1.54	154.33 ± 4.91	45.40 ± 7.39

Total no. of Subjects: (N) = 36

In Table – 1, the mean and standard deviation of age, height, and weight of the subjects for different groups have been presented. Thus Table-1 shows that the total number of subjects for the study was 36. They were divided into three equal groups i.e. Land Plyometric Training Group, Aquatic Plyometric Training Group and Control Group. In pre-experimental condition the Mean ± S.D value of age for the three groups were 15.25 ± 1.86, 15.67 ± 1.56 and 14.75 ± 1.54 respectively. The Mean ± S.D value of height for the three groups were 152.92 ± 7.44, 155.92 ± 5.50 and 154.33 ± 4.91 respectively. In pre-experimental condition the Mean ± S.D value of weight for the three groups were 44.09 ± 6.36, 48.54 ± 5.40 and 45.40 ± 7.39 respectively. In Fig-1 the descriptive statistics of different group of subjects have been presented.

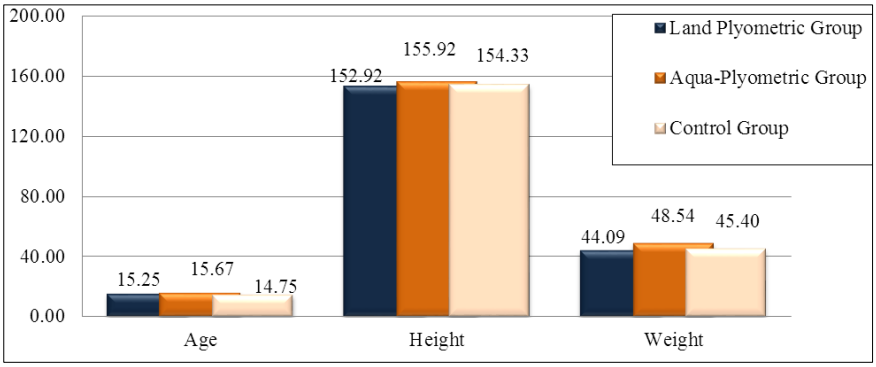

Fig 1: Mean Value of Lower Limb Explosive Strength in Baseline, Post Treatment and Adjusted Post Treatment of Different Group of subjects

Table 3: Mean, Standard Deviation and Analysis of Co-Variance (ANCOVA) of Lower Limb Explosive Strength among Land Plyometric Group, Aquatic Plyometric Group and Control Group in Baseline, Post Treatment and Adjusted Post Test

Test		Land Plyometric Group-I	Aquatic-Plyometric Group -II	Control Mean	Source of variance	Sum of squares	df	Mean squares	'F' Ratio
Baseline	Mean ± SD	43.42 ± 4.98	43.00 ± 5.06	40.33 ± 6.07	Between	67.17	2	33.58	1.155
					Within	960	33	29.08	
Post Treatment	Mean ± SD	46.58 ± 5.11	47.42 ± 4.49	41.37 ± 6.26	Between	257.37	2	128.68	4.520*
					Within	939.41	33	28.47	
Adjusted Post Test	Mean	45.50	46.72	43.16	Between	74.30	2	37.15	11.265*
					Within	105.53	32	3.30	

*(The table values required for significance at. 05 level with DF (2, 33) and (2, 32) were 3.29 and 3.30 respectively)

From Table – 2 It was found that the Baseline Mean ± SD value of lower limb leg explosive strength for Land Plyometric Training Group, Aquatic Plyometric Training Group and Control Group were 43.42 ± 4.98, 43.00 ± 5.06 and 40.33 ± 6.07 respectively. The Post Test Mean ± SD value of lower limb leg explosive strength for Land Plyometric Training Group, Aquatic Plyometric Training Group and Control Group were 46.58 ± 5.11, 47.42 ± 4.49, 41.37 ± 6.26 respectively. The Adjusted Post Test Mean value of lower limb leg explosive strength for Land Plyometric Training Group, Aquatic Plyometric Training Group and Control Group were 45.50, 46.72 and 43.16 respectively.

From Table-2 it was also found that the baseline F-value of lower limb leg explosive strength among the three groups were 1.155 which was less than the required table value 3.30 for significance with df (2,32) at 0.05 level. It signifies that Land Plyometric Training Group, Aquatic Plyometric Training Group and Control Group were exactly equated at baseline.

From Table-2 it was also found that the post-treatment F-value of lower limb leg explosive strength among the three groups were 4.520 which was greater than the required table value 3.30 for significance with df (2,32) at 0.05 level. It signifies that there was

significant difference among three different groups of subjects in post-treatment condition.

It was also evident From Table-2 that the adjusted post-test F-value of lower limb leg explosive strength among the three groups were 11.265 which was grea ter than the required table value 3.30 for significance with df (2, 32) at 0.05 level. It signifies that there was a significant difference among three different group of subjects i.e. Land Plyometric Training Group, Aquatic Plyometric Training Group and Control Group in Adjusted posttest condition. To locate the exact difference among the groups in lower limb leg explosive strength Tukey's LSD test was performed as Post hoc test which was presented in Table-3. The Pre-test, Post-test and adjusted posttest mean value of the Land Plyometric Training Group, Aquatic Plyometric Training Group and Control Group on lower limb leg explosive strength were presented graphically in Fig -2.

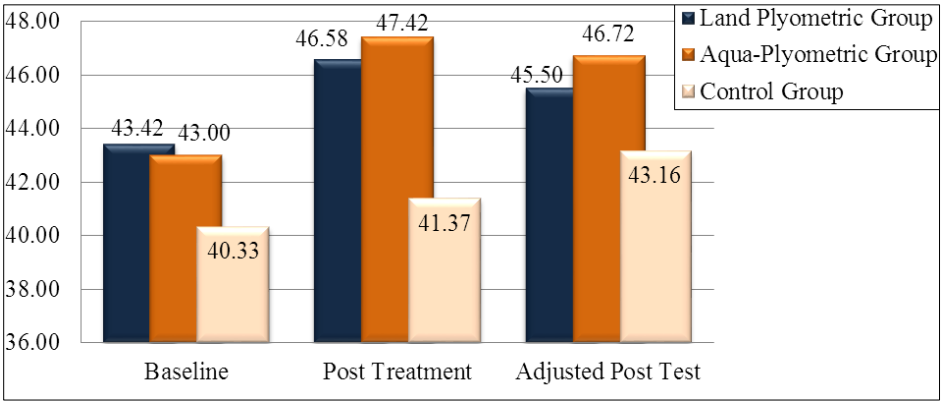

Fig 2: Mean Value of Lower Limb Explosive Strength in Baseline, Post Treatment and Adjusted Post Treatment of Different Group of subjects

Table 4: Tukey's LSD test on Lower Limb Explosive Strength in Adjusted Post Test Mean Score for Different Groups

Adjusted Post Test Mean Scores				Required confidence interval
Land Plyometric Group-I	**Aquatic Plyometric Group -II**	**Control Group**	**Mean Difference**	
45.50	46.72		1.22	
45.50		43.16	2.33*	1.511
	46.72	43.16	3.56*	

Calculated Value of Critical Difference at 0. 05 level of significance with DF (32) was 1.511

From Table-3 i.e. from the table of Tukey's LSD test on lower limb leg explosive strength for Adjusted Post Test Mean Score between Land Plyometric Training Group & Control Group, the mean difference i.e. 2.33 was found significantly greater than the Critical Difference (CD) 1.511 at 0.05 level of significance at df (32). It indicates that Land Plyometric training was effective for developing lower limb leg explosive strength.

It was also found from Tukey's LSD test on lower limb leg explosive strength for Adjusted Post Test Mean Score between Aquatic Plyometric Training group & Control Group, the mean difference i.e. 3.56 was found greater than the value of Critical Difference (CD) 1.511 at 0.05 level of significance at df (32). It was clear from the mean difference that Aquatic Plyometric training was also as effective as Land Plyometric training for the developing lower limb leg explosive strength.

From Table-3 i.e. from the table of Tukey's LSD test on lower limb leg explosive strength for Adjusted Post Test Mean Score between Land Plyometric Training Group & Aquatic Plyometric Training groups, the mean difference was. 1.22 which was found less than the value of Critical Difference (CD) 1.511 at 0.05 level of significance at df (32). It clearly indicates that Land Plyometric Training and Aquatic Plyometric Training had same type effect for developing lower limb leg explosive strength.

Discussion

The present study was performed to investigate the effects of land plyometric and aquatic plyometric training on leg explosive strength of athletes. At the end of the 14 week experimentation it was found that both the land plyometric training group & aquatic plyometric training group led to increases of the lower limb leg explosive strength in comparison to control group. The findings of this result supported by (Atanasković, Georgiev, & Mutavdzić, 2015; Jurado-Lavanant, Fernández-García, Pareja-Blanco, & Alvero-Cruz, 2017; Kobak, Rebold, Desalvo, & Otterstetter, n.d.; Markovic, nd.; Ploeg *et al*., 2010; Ramírez-Campillo *et al*., 2014; Slimani, Chamari, Miarka, Del Vecchio, & Chéour, 2016; Söhnlein, Müller, & Stöggl, 2014) [1, 13, 20, 21, 22, 23].

On the other hand it was also observed that there was no significant difference in explosive leg strength between the subjects of land plyometric group and aquatic plyometric group. So it can be concluded that land & aquatic plyometric training are equally effective for improving leg explosive strength. This finding of the present study were supported by (Atanasković *et al*., 2015; Funk, Smythe, & Killgore, 2014; Jurado-Lavanant *et al*., 2017; Kobak *et al*., n.d.) [1, 11, 13].

Few previous studies reported differences between land-based and aquatic-based plyometric training with aquatic groups reporting significantly less muscle soreness (Martel *et al*., 2005; Miller *et al*., 2002; Robinson *et al*., 2004; Shaffer 2007). The aquatic setting provides an excellent training medium for enhancing performance due to the buoyant properties of water. High volumes of plyometric training should increase athletic performance (Ploeg *et al*., 2010) [20]. The buoyancy involved when performing an aquatic plyometric training it lowers the

impact at landing, thus attenuating the mechanical stress (Sanders, 2002), which reduces the risk of injury. These results suggest that aquatic plyometric training could be an alternative method to regular plyometric training having same effect on explosive leg strength. Present study has the same result as the previous studies mentioned above which confirms that though land and aquatic plyometric training have same effect on explosive strength but in addition the aquatic plyometric training have lesser chance of soft tissue injury over the strength devolvement. Thus, it is recommended to choose aquatic plyometric training according to the availability of the facilities in place of simple land plyometric training to minimize the chance of injury during the intervention of the experimental protocol for the development of explosive leg strength.

Conclusion

From the above result and discussions of the present study it can be concluded that both the Land Plyometric training and Aquatic Plyometric training significantly improved the lower limb leg explosive strength in comparison to control group of the district level athletes but there was no significant difference in explosive leg strength between the subjects of land plyometric group and aquatic plyometric group. Thus, it is recommended to choose aquatic plyometric training in place of simple land plyometric training to minimize the chance of injury for the development of explosive leg strength.

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