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Original Article

The effect of aquatic plyometric training with and without resistance on selected physical fitness variables among volleyball players

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Abstract
The purpose of this study is to analyze the effect of aquatic plyometric training with and without the use of weights on selected physical fitness variables among volleyball players. To achieve the purpose of these study 36 physically active undergraduate volleyball players between 18 and 20 years of age volunteered as participants. The participants were randomly categorized into three groups of 12 each: a control group (CG), an aquatic Plyometric training with weight group (APTWG), and an aquatic Plyometric training without weight group (APTWOG). The subjects of the control group were not exposed to any training. Both experimental groups underwent their respective experimental treatment for 12 weeks, 3 days per week and a single session on each day. Speed, endurance, and explosive power were measured as the dependent variables for this study. 36 days of experimental treatment was conducted for all the groups and pre and post data was collected. The collected data were analyzed using an analysis of covariance (ANCOVA) and followed by a Scheffé's post hoc test. The results revealed significant differences between groups on all the selected dependent variables. This study demonstrated that aquatic plyometric training can be one effective means for improving speed, endurance, and explosive power in volley ball players.
Key words: aquatic exercise, speed, endurance, explosive power

Introduction

In recent years, aquatic training has become an important training to mode to improve selected physiological variables (Beale, 2005; Peyre–Tartaruga, 2009, Miller, other authors, 2007) for volley ball players. The benefits of aquatic exercise originate from the supportive nature of the water environment, muscular strengthening, and toning of muscles which result from the resistive properties of water as a dense liquid. Aquatic exercises can increase the strength, speed, endurance, explosive power and aerobic capacity, according to research (Rutledge, 2007, Peyre–Tartaruga, 2009). An aquatic training program can decrease compression forces, vibration forces, and torsional forces that a player may endure while training on land (Roswell, 2009). The physical properties of water have been utilized in aquatic therapy to decrease gravitational forces placed on a weakened extremity and increase body movements (Morton, 2007, Rooney, 2005), Broman, 2006), Roswell,2009). Plyometric is considered a high-intensity conditioning program. Research has shown that athletes who use Plyometric exercises are better able to increase acceleration, vertical-jump height, leg strength, joint awareness, and overall proprioception (Fatouros et al., 2000; Martel et al., 2005; Miller, 2002; Robinson et al., 2004; Vossen, 2000). Plyometric programs have also been correlated to musculoskeletal injuries and delayed-onset muscle soreness because of the high-intensity and compression forces on the joints and muscles (Holcomb et al., 1998; Miller et al., 2002 ;). Aquatic plyometric training is not a new concept, but it has recently become more popular, mostly because of the potential to decrease injuries compared with land plyometric contractions by decreasing impact forces on the joints (Miller et al., 2002; Robinson et al., 2004). Aquatic settings are beneficial not only for rehabilitation but also for conditioning because of the unique properties of water, specifically, buoyancy and resistance resulting from its viscosity (Miller et al., 2002). Previous studies comparing land-based and aquatic plyometric programs have been completed in varying depths of water (Martel et al., 2005; Robinson et al., 2004). These studies have shown that both aquatic plyometric training with and without resistance training have benefits depending on the type and goal of training. The intention of this study is mark out the effect of aquatic plyometric training and its outcomes among volleyballers.

Method

To achieve the purpose of this study, we randomly assigned 36 physically active undergraduate volleyball players between 18 to 20 years of age distributed into three groups with 12 participants each; a control group (CG), an aquatic plyometric training with weight group (ATWG), and an aquatic plyometric training

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without weight group (ATWOG). Three selected criterion/dependent variables were measured. Speed was assessed using the time for a 50M sprint; endurance was assessed with Coopers' test and leg explosive power was assessed using the standing vertical jump height. Control group was not exposed to any training, but was tested on the same three dependent variables. Both experimental groups underwent their respective experimental treatment for 12 weeks, 3 days per week and a single session on each day. Individualized weight to list was assigned using a 1 RM test for each individual in the ATWG. The participants were instructed to wear a weight jacket which was filled in appropriate weights. Warming up exercise was performed on ground and in hip-deep water. The players performed these exercise in water at hip-depth level. The aquatic exercises were performed both with and without weights. The water temperature and climatic conditions were controlled; hence these aspects were kept as one of the part of the study that was controlled and kept consistent. The ATWG and ATWOG groups initially performed warm up exercises. After that both the groups performed the following aquatic exercises: 1. Single leg jump (alternative leg); 2. Double leg jump; 3.Alternative leg jump; 4. Side hop jump these exercises were performed for 60 minutes in a day and for 3 days per week. Observations were made for 12 weeks and then post test data were taken. The collected data were analyzed using with an analysis of covariance (ANCOVA) to control for initial differences among groups.

Statistical Analysis

Means and standard deviations were calculated for the speed, endurance, and explosive power measures for each training group. ANCOVA and Scheffé's post hoc test were used to determine the statistical significance between the variables of the three groups (i.e., control, APTWG and APTWOG). Statistical significance was set to a priority at $\alpha \leq 0.05$. All statistical tests were calculated using the Statistical Package for the Social Science (SPSS) for Windows (Version 15).

TABLE: 1 **Twelve –Week Plyometric-Training-Program**

Training week	Plyometric drill	Sets x Repetitions	Rest
1 and 2	Side-to-side ankle hops	2×10	90 sec
	Standing jump-and-reach	2×10	90 sec
	Front cone hops	4×6	90 sec
3 and 4	Side-to-side ankle hops	2×12	90 sec
	Standing long jump	2×12	90 sec
	Lateral jump over barrier	4×6	60 sec
	Double-leg hops	3×8	60 sec
5 and 6	Side-to-side ankle hops	2×12	90 sec
	Standing long jump	2×12	90 sec
	Lateral jump over barrier	6×4	60 sec
	Double-leg hops	3×6	60 sec
	Lateral cone hops	2×12	60 sec
7 and 8	Single-leg bounding	2×12	30 sec
	Standing long jump	2×12	60 sec
	Lateral jump over barrier	3×8	60 sec
	Lateral cone hops	8×4	60 sec
	Tuck jump with knees up	3×6	60 sec
9 and 10	Single-leg bounding	2×12	30 sec
	Jump to box	2×12	90 sec
	Double-leg hops	4×5	60 sec
	Lateral cone hops	2×14	60 sec
	Tuck jump with knees up	4×5	30 sec
	Lateral jump over barrier	3×12	30 sec
11 and 12	Jump to box	2×12	90 sec
	Depth jump to prescribed height	4×5	60 sec
	Double-leg hops	6×4	60 sec
	Lateral cone hops	2×12	60 sec
	Tuck jump with knees up	4×5	30 sec
	Jump to box	2×10	30 sec

Results

Table 2 shows the pre-test means of APTWG, and APTWOG on speed. The F-value needed for significance for df (2, 57) at $\alpha \leq 0.05$ level was 3.15. The obtained F-value for the pre-test mean on speed was 0.05 which was not found to be significant. In post test analysis the F-ratio on the speed variable was 14.28. The analysis of covariance adjusted the differences in pre test means with post test means between the aquatic Plyometric training with weight and without weight groups. The F-value needed for significance for df (2, 56) at α ≤ 0.05 levels was [missing value]. The F-value obtained from testing the adjusted means between the control and aquatic Plyometric training with and without weight groups on speed was 58.73which was statistically significant.

TABLE –2, Analysis of Variance & Covariance of Pre, Post and Adjusted Post Test on Speed

	CG	ATWG	ATWOG	Source of Variance	Sum of Squares	df	Mean Squares	F- ratio
Pre-Test Means SD (±)	7.56	7.56	7.58	BG	0.005	2	0.003	0.01
	0.35	0.38	0.38	WG	8.06	57	0.42	
Post - Test Means SD(±)	7.52	6.81	7.27	BG	5.11	2	2.55	14.28*
	0.32	0.46	0.46	WG	10.19	57	0.17	
Adjusted Post - Test Means	7.52	6.82	7.25	BG	5.06	2	2.53	58.73*
				WG	2.41	56	0.04	

* Significant at 0.05 level

FIGURE –1, The pre, post and adjusted mean values control, Aquatic Training with and without weight on speed

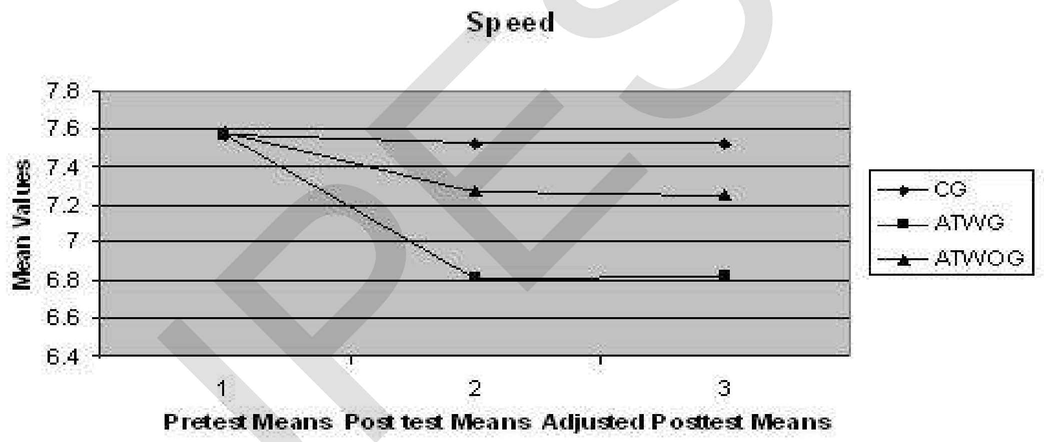

Table 3 shows that the pre-test means of APTWG and APTWOG on the endurance measure. The F-value needed for significance for df (2, 57) at α ≤ 0.05 level was 3.15, but the obtained F-value for the pre-test mean on endurance was 0.006. It was not found to be significant. The post test analysis the F-ratio on the variables such as speed was 1.47. The analysis of covariance adjusted the differences in pre test means with post test means between the aquatic Plyometric training with weight and without weight. The F-value needed for significance for df (2, 56) at α ≤ 0.05 levels .The F-value obtained from testing the adjusted means between the control, aquatic training with and without weight groups on endurance was 89.77. It was found to be significant.

TABLE –3, Analysis of Variance & Covariance of Pre, Post and Adjusted Post Test on Endurance

	CG	ATWG	ATWOG	Source of Variance	Sum of Squares	df	Mean Squares	F- ratio
Pre-Test Means SD (±)	2168.50	2151.00	2145.00	BG	5963.33	2	2981.66	0.05
	224.66	236.55	252.03	WG	3229135	57	56651.49	
Post - Test Means SD(±)	2137.50	2258.00	2212.50	BG	148103.30	2	74051.66	1.47
	203.15	225.16	243.04	WG	2869870	57	50348.59	
Adjusted Post - Test Means	2124.75	2261.57	2221.67	BG	197759.7	2	98879.90	89.77*
				WG	61682.4	56	1101.46	

* Significant at 0.05 level

FIGURE –2, The pre, post and adjusted mean values control, Aquatic Training with and without weight on endurance

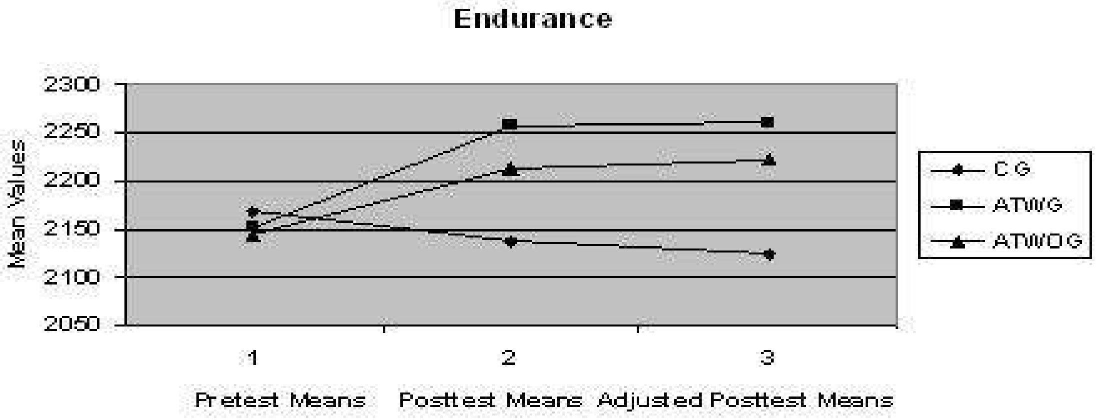

Table 4 shows that the pre-test means of CG, APTWG and APTWOG on explosive power. The F-value needed for significance for df (2, 57) at $\alpha \leq 0.05$ levels was 3.15. The obtained F-value for the pre-test mean on explosive power was 0.12. It was found to not be significant. In post test analysis the F-ratio on the variables such as explosive power was 1.88. The analysis of covariance is adjusting the differences in pre-means with post-test means between the aquatic Plyometric training with weights and without weights. The F-value needed for significance for df (2, 56) at $\alpha \leq 0.05$ .The F-value obtained from testing the adjusted means between the control and , aquatic Plyometric training with and without weight groups on explosive power were 160.24. It was found to be significant.

TABLE –4, Analysis of Variance & Covariance of Pre, Post and Adjusted Post Test on Explosive power

	CG	ATWG	ATWOG	Source of Variance	Sum of Squares	df	Mean Squares	F- ratio
Pre-Test Means	46.20	45.30	45.75	BG	8.10	2	4.05	0.12
SD (±)	5.75	5.84	5.67	WG	1891.15	57	33.17	
Post - Test Means	47.40	51.00	48.90	BG	130.80	2	65.40	1.88
SD(±)	6.13	5.75	5.76	WG	1976.6	57	34.67	
Adjusted Post - Test Means	46.94	51.45	48.90	BG	203.89	2	101.94	160.24*
				WG	35.62	56	0.63	

* Significant at 0.05 level

FIGURE -3, The pre, post and adjusted mean values control, Aquatic Training with and without weight on explosive power (Vertical Jump)

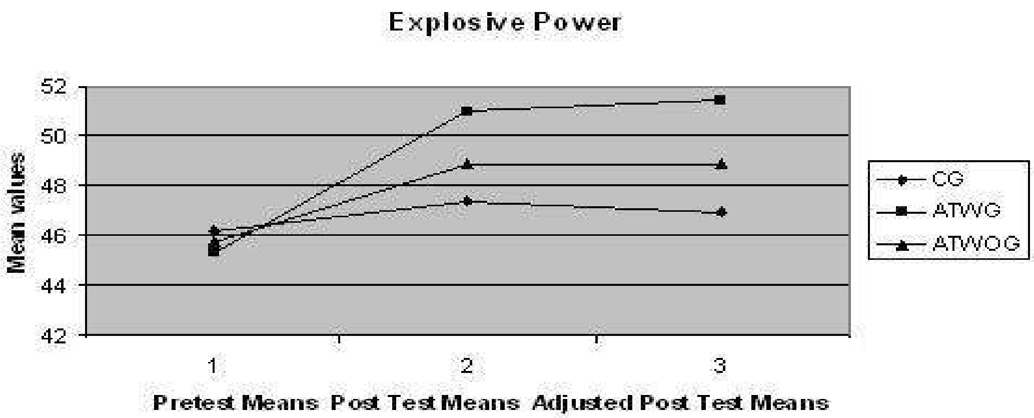

TABLE-5, Scheffee's Post - hoc Test for Mean Differences between Groups of Speed, Endurance and Explosive power

Control Group	With Weight	With out Weight	Mean Difference	C.I
SPEED				
7.52	6.82		0.70*	
7.52		7.25	0.27*	0.15
	6.82	7.25	0.43*	
ENDURANCE				
2261.57	2221.67		39.9*	26.38
2261.57		2124.75	136.82*	
	2221.67	2124.75	96.92*	
EXPLOSIVE POWER				
51.45	48.90		2.55*	
51.45		46.94	4.51*	0.63
	48.90	46.94	1.96*	

* Significant at 0.05 level

Table 5 shows that the mean difference values of control and aquatic Plyometric training with weight group, control and aquatic Plyometric training without weight groups & aquatic Plyometric training with weight and aquatic Plyometric training without weight groups on speed were 0.70, 0.27 and 0.43 respectively which were greater than the confidence interval value of 0.15 at $\alpha \leq 0.05$ level of confidence. The mean difference values of control and aquatic Plyometric training with weight group, control and aquatic plyometric training without weight groups and aquatic plyometric training with weight and aquatic plyometric training without weight groups on endurance were 0.10, 0.05 and 0.06, respectively. The comparison of control and aquatic plyometric training with weight group was greater than the confidence interval value of 0.07 at $\alpha \leq 0.05$ level of confidence. The mean difference values of control and aquatic plyometric training with weight group, control and aquatic plyometric training without weight groups and aquatic plyometric training with weight and aquatic plyometric training without weight groups on explosive power were 2.55, 4.51, and 1.96, respectively, which were greater than the confidence interval value of 0.63 at $\alpha \leq 0.05$ level of confidence.

Discussion

This study was performed to determine whether there are any significant differences in vertical jump height, speed, and endurance as a result of participating in an aquatic Plyometric training program in two different training. The study reveals after 12 weeks of Plyometric training in the aquatic environment, there were significant differences in force production for the selected vertical jumps. In addition, there were significant differences speeds of the two groups. What was interesting to note is that the with weight group had significant increases, Previous studies that showed significant increases in force and power as a result of plyometric training had been conducted over an 8- to 12-week training period (Fatouros et al., 2000; Luebbers et al., 2003; Miller et al., 2002; Robinson et al., 2004). Still other studies showed that 6 weeks of plyometric training were effective in producing significant changes (Chimera et al., 2004; Martel et al., 2005; Vossen et al., 2000). Most of these studies found significant increases between groups, but for participants who also were strength training during the plyometric-training period (Chimera et al.; Martel et al.). Martel et al. found significant increases in vertical jump performance during a 6-week training period. Participants in the current study were supposed to from strength-training regimen and were participating in organized volleyball players. Previous research has also shown that for increases in vertical jump to be. Future studies should investigate using untrained versus trained participants in the aquatic setting while also using a 12- to 24-week plyometric program to determine which training period is more effective and to determine whether concurrent strength-training regimens of trained athletes or better outcomes. Plyometric training should follow the same guidelines as other weight-training programs and should only be performed two or three times per week (Lees & Graham-Smith, 1996). Aquatic plyometric programs, because of the buoyant and viscous properties of water, might need the number of sessions per week adjusted. Conducting Plyometric in an aquatic setting can decrease the speed of the stretch-shortening cycle of the lower extremity, especially at the knee, compared with land plyometrics, in water. Additional investigation should also examine the appropriate frequency and volume of training in the aquatic environment to determine what is most effective. Most previous studies had at least 30 participants, which provided greater statistical power to identify meaningful differences that did occur (Fatouros et al., 2000; Gehri et al., 1998; Luebbers et al., 2003; Miller et al., 2002; Robinson et al., 2004). Our study began with 60 participants.

Conclusion

The present study reveals that the 12 weeks of plyometric training in an aquatic environment, with and without weight shown significant differences among the three groups with respect to speed, endurance, and explosive power measures. Finally it is also concluded that the subjects with weight group has shown greater improvement comparable to the subjects without weight group and control group regard to all the parameters.

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