The effect of aquatic plyometric training on some physical fitness variables among volleyball players

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Purpose

The purpose of the study was to compare effects of chest- and hip-deepwater aquatic plyometrics and land-based plyometrics on some physical fitness variables among volleyball players. **Methods:** Twenty-four players participants were randomly categorized into three groups of 8 each : a control group (land-based plyometrics (LBPT), chest deep aquatic Plyometric training group (CDAPT), and hip deep aquatic Plyometric training group (HDAPT). The three groups underwent their respective experimental treatment for 10 weeks, 3 days per week and a single session on each day. power, lower body strength and speed were measured as the dependent variables for this study. Sixty nine 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 (ANOVA) and followed by a Tukey's post hoc test. **The results** revealed significant differences between groups on some selected dependent variables. This study demonstrated that aquatic plyometric training can be one effective means for improving body fat, power (vertical jump, Broad jump, average power) and Lower limb strength in volleyball players.

Key words: volleyball, aquatic plyometric, power, endurance and speed

Introduction

Plyometric is considered a high-intensity conditioning program. It consists of explosive exercises that requires muscles to adapt rapidly from eccentric to

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concentric contractions. Muscles, when stretched during an eccentric contraction, store elastic energy for a very brief period of time. The energy stored, followed quickly by a concentric contraction, produces greater force than a concentriccontraction alone. Therefore,training muscles to adapt from an eccentric to a concentric contraction should enable them to increase the speed and force with which they perform. (Baechle, 1994; Potteiger et al.,1999; Robinson, Devor, Menick, & Buckworth, 2004). 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 (Prins & Cutner, 1999; Tovin,Wolf, Greenfield, & Woodfin, 1994). 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, and aerobic capacity, according to research (Khariaa & Mohammed 1999; Rutledge, 2007; Peyre–Tartaruga, 2009). 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.

Previous studies comparing land-based and aquatic plyometric programs have been completed in varying depths of water (Gehlsen et al., 1984; Gregory, 1986; Prins & Cutner, 1999; Robinson et al., 2004; Tovin et al., 1994). These studies have shown that both shallow-water and deep-water training have benefits depending on the type and goal of training; however, previous studies have not used a predefined water depth to perform aquatic plyometric programs. In addition, training in water too deep might inhibit the stretch reflex and negate plyometric-training benefits. The purpose of the study was to compare effects of chest- and hip-deepwater aquatic plyometrics and land-based plyometrics on power, lower body strength and speed among volleyball players.

Method

To achieve the purpose of this study, we randomly assigned 24 menofia university volleyball team players of 19 to 21 years of age distributed into three groups with 8 participants each; control group (land-based plyometrics), chest deep aquatic Plyometric training group, and hip deep aquatic Plyometric training group.

Table (1)

Statistical characterization of Three groubs in research variables, (N=28)

		Control Group Land-based plyometrics	Chest deep aquatic Plyometric	Hip deep aquatic Plyometric
Age	Mean	20	19.13	20.13
	Std. deviation	1.31	0.83	1.25
	Skewness	0	-0.27	-0.30
Hieght (cm)	Mean	182.75	181.5	180
	Std. deviation	3.20	2.07	4.11
	Skewness	-0.80	0	0.80
Wieght (kg)	Mean	75.73	69.16	72.09
	Std. deviation	8.10	7.12	6.55
	Skewness	-0.66	1.72	1.16

Instrumentation : The bioelectrical impedance analysis (BIA) method was used to measure body composition as it is more reliable and more acceptable way of measuring body composition.

Pre- and Post-test Measurements: Before data collection participants were engaged in a warm-up session consisting of 5 min stretching lower limb and 5 min runing around the pool. Participants were tested on the following variables: Body composition using bioelectrical impedance analysis (BIA), Speed using the time for a 20M sprint; Endurance with Coopers' test; Lower limb strength using the

1RM squat test , Leg power using the vertical jump and Broad jump and average power were assessed using Lewis equation P = √4.9 x BM x √h. where: P = average power (kg·m·s), BM = mass of person (kg) and h = vertical jump height (cm). The three groups underwent their respective experimental treatment for 10 weeks, 3 days per week and a single session on each day. Participants were tested on all variables before and after the plyometric program.. Within 2 days of the completion of the 10-week plyometric-training program, participants were posttested. Participants were verbally encouraged to perform all jumps at maximal effort for both pre- and posttesting measures.

Plyometric-Training Program: A 10-weeks plyometric-training program (1-3-2014 to 7-5-2014) was developed. It included 3 days per week and a single session on each day according Chimera, Swanik, Swanik, & Straub, (2004). plyometric exercise session must begin with a general warm-up, stretching, and a specific warm-up. The specific warm-up for plyometric training should consist of low-intensity, dynamic movements (marching, jogging, skipping, footwork and lunging). The training program was based on the recommendations of intensity and volume from previous literature (Miller, Berry, Gilders, & Bullard, 2001; Piper & Erdmann, 1998). Training programs were identical in drills, sets, repetitions,and volume for both the chest- and hip-deep aquatic-training groups (Table 1). Training volume ranged from 90 foot contacts to 140 foot contacts per session, and the intensity of the exercises increased

Table (2)
Ten-Week Plyometric-Training-Program Drills and Intensity

Training week	Plyometric drill	Sets x Repetitions	Training volume	Training intensity	Rest
Week (1) 1-3/5-3-2014	Side-to-side ankle hops	2×15	90	low	30 sec
	Standing jump-and-reach	2×15		low	30 sec
	Front cone hops	5×6		low	30 sec
Week (2) 8-3/12-3-2014	Side-to-side ankle hops	2×15	120	low	30 sec
	Standing long jump	2×15		low	30 sec
	Lateral jump over barrier	5×6		medium	60 sec
	Double-leg hops	3×10		medium	60 sec
Week (3-4) 15-3/26-3-2014	Side-to-side ankle hops	2×12	120	low	30 sec
	Standing long jump	2×12		low	30 sec
	Lateral jump over barrier	4×6		medium	60 sec
	Double-leg hops	3×8		medium	60 sec
	Lateral cone hops	2×12		medium	60 sec
Week (5-6) 29-3/9-4-2014	Single-leg bounding	2×12	140	high	90 sec
	Standing long jump	3×10		low	30 sec
	Lateral jump over barrier	4×8		medium	60 sec
	Lateral cone hops	3×10		medium	60 sec
	Tuck jump with knees up	4×6		medium	60 sec
Week (7-8) 12-4/24-4-2014	Single-leg bounding	2×10	140	high	90 sec
	Jump to box	2×10		low	30 sec

Follow Table (2)
Ten-Week Plyometric-Training-Program Drills and Intensity

Training week	Plyometric drill	Sets x Repetitions	Training volume	Training intensity	Rest
	Double-leg hops	3×6		medium	60 sec
	Lateral cone hops	2×12		medium	60 sec
	Tuck jump with knees up	6×5		high	90 sec
	Lateral jump over barrier	3×10		high	90 sec
Week (9-10) 26-4/7-5-2014	Jump to box	2×10	120	low	30 sec
	Depth jump to prescribed height	4×5		high	90 sec
	Double-leg hops	6×4		medium	90 sec
	Lateral cone hops	2×10		medium	90 sec
	Tuck jump with knees up	4×5		high	90 sec
	Split squat jump	2×10		medium	60 sec

throughout the course of the training program. Participants were instructed to perform exercises to their maximal ability. Participants were given a brief description and demonstration of each exercise before completing each training session.All participants were supervised by the researchers and verbally encouraged to perform with maximal effort.

Statistical Analysis: Means and standard deviations were calculated for body composition (body fat), power (vertical jump, Broad jump, average power), speed (20M sprint), Lower limb strength (1RM Squat) and endurance (12min run) for each training group. A factorial repeated-measures ANOVA was used to examine significance between the independent variables of testing (pre- and post-) and groups (control and chest and hip deep) on the dependent variables. Statistical significancewas set a priori atp < .05.All statistical tests were calculated using the Statistical Package for the Social Sciences (SPSS) for Windows.

Results

Table (3) and figure (1,2) shows the pre-test means of LBPT, CDAPT and HDAPT on some physical fitness variables. In Land-based plyometrics groups the F-value needed for significance for df (1, 14) at α < 0.05 level was 4.60. The obtained F-value for the pre-test mean on vertical jump, average power and speed was statistically significant. In Chest deep aquatic Plyometric training groups the F-value needed for significance for df (1, 14) at α < 0.05 level was 4.60.

Table (3)
Analysis of Variance of Pre and Post Test on some physical fitness variables

Groubs	variables	Tests	Pre-Test		Post-Test		F value	Sig
			Means	SD (±)	Means	SD (±)		
Land-based plyometrics	**Body composition**	Body Fat	15.83	2.83	15.18	2.56	0.22	0.64
	power	vertical jump	55.13	4.76	59.75	3.62	4.78*	0.04
		Broad jump	2.32	0.11	2.46	0.09	0.57	0.46
		average power	1183.02	131.17	1231.73	125.98	8.34*	0.01
	speed	20 M Sprint	3.21	0.26	3.08	0.17	4.62*	0.05
	strength	1RM Squat	80.96	10.83	92.03	9.75	1.43	0.25
	Endurance	12 min Run	2538.76	417.54	2580.31	422.03	0.04	0.85
Chest deep aquatic Plyometric	**Body composition**	Body Fat	14.1	3.77	11.75	2.75	0.83	0.38
	power	vertical jump	54.75	4.92	67.88	4.05	8.92*	0.01
		Broad jump	2.43	0.20	2.66	0.12	5.94*	0.03
		average power	1236.8	135.98	1379.4	162.36	4.67*	0.04
	speed	20 M Sprint	3.19	0.15	2.97	0.08	5.27*	0.03

Follow Table (3)
Analysis of Variance of Pre and Post Test on some physical fitness variables

Groubs	variables	Tests	Pre-Test		Post-Test		F value	Sig
			Means	SD (±)	Means	SD (±)		
	strength	1RM Squat	80.84	10.73	92.25	8.50	24.24*	0.00
	Endurance	12 min Run	2601.39	363.30	2760.61	302.85	1.09	0.31
Hip deep aquatic Plyometric	**Body composition**	Body Fat	12.94	2.64	11.78	2.47	2.02	0.17
	power	vertical jump	49.88	4.45	59.62	8.09	33.92*	0.00
		Broad jump	2.32	0.19	2.54	0.22	7.62*	0.02
		average power	1074.93	71.14	1173.73	89.87	4.60*	0.05
	speed	20 M Sprint	3.26	0.08	3.05	0.08	5.56*	0.03
	strength	1RM Squat	71.17	13.66	86.38	12.81	14.02*	0.002
	Endurance	12 min Run	2719.85	317.81	2877.88	285.41	0.91	0.36

* Significant at 0.05 level F(1,14) = 4.60

The obtained F-value for the pre-test mean on vertical jump, Broad jump, average power, speed and Lower limb strength (1RM Squat) was statistically significant. In Hip deep aquatic Plyometric training groups The obtained F-value for the pre-test mean on vertical jump, Broad jump, average power, speed and Lower limb strength (1RM Squat) was statistically significant.

Table (4)
Tukey's Post - hoc Test for Mean Differences between Groups of some physical fitness variables

Groubs	Control Group Land-based plyometrics	Chest deep aquatic Plyometric	Hip deep aquatic Plyometric	Mean Difference	Sig
Body composition (Body fat%)					
Land vs **Chest**	15.18	11.75		3.44*	0.04
Chest vs **Hip**		11.75	11.77	-0.03	1

Follow Table (4)
Tukey's Post - hoc Test for Mean Differences between Groups of some physical fitness variables

Groubs	Control Group Land-based plyometrics	Chest deep aquatic Plyometric	Hip deep aquatic Plyometric	Mean Difference	Sig
Land vs **Hip**	15.18		11.77	3.41*	0.04
Power (vertical jump)					
Land vs **Chest**	59.75	67.88		-8.13*	0.02
Chest vs **Hip**		67.88	59.63	8.25*	0.02
Land vs **Hip**	59.75		59.63	0.13	0.99
Power (Broad jump)					
Land vs **Chest**	2.46	2.66		-0.21*	0.03
Chest vs **Hip**		2.66	2.54	0.12	0.29
Land vs **Hip**	2.46		2.54	-0.09	0.52
average power					
Land vs **Chest**	1231.73	1379.43		-147.70	0.08
Chest vs **Hip**		1379.43	1173.73	205.71*	0.01
Land vs **Hip**	1231.73		1173.73	58.01	0.65
Speed (20 M Sprint)					
Land vs **Chest**	3.08	2.97		0.11	0.17
Chest vs **Hip**		2.97	3.06	-0.09	0.34
Land vs **Hip**	3.08		3.06	0.03	0.91
Lower limb strength (1RM Squat)					
Land vs **Chest**	92.04	92.25		-147.70	0.08
Chest vs **Hip**		92.25	86.38	205.71*	0.01
Land vs **Hip**	92.04		86.38	58.01	0.65
Endurance (Cooper 12 m)					
Land vs **Chest**	2580.31	2760.61		-180.30	0.94
Chest vs **Hip**		2760.61	2877.88	-118.46	0.79
Land vs **Hip**	2580.31		2877.88	-181.09	0.59

* Significant at 0.05 level F(2,21) = 3.46

Table (4) shows that the mean difference values of Land-based plyometric training and Chest deep aquatic Plyometric training group, Land-based plyometrics and Hip deep aquatic Plyometric training groups & Chest deep aquatic Plyometric training and Hip deep aquatic Plyometric training groups on body fat were 15.18, 11.75 and 11.77. The mean difference values of Land-based plyometric training and Chest deep aquatic Plyometric training group, Land-based plyometric and aquatic plyometric training Hip deep aquatic Plyometric groups and Chest deep aquatic Plyometric training and Hip deep aquatic Plyometric training groups on endurance were 2580.31, 2760.61 and 2877.88, respectively. The comparison of Land-based plyometric training and Chest deep aquatic Plyometric training group was greater than the confidence interval value of 0.94 at α < 0.05 level of confidence

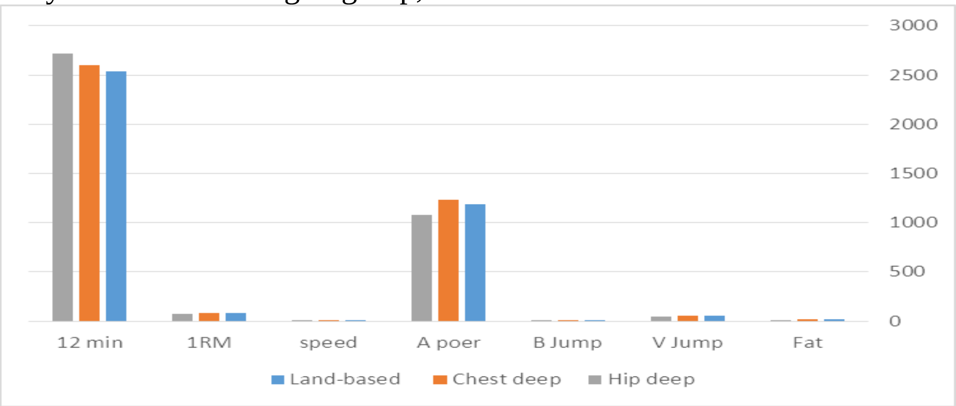

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FIGURE (1) The pre tests means values on some physical fitness variables

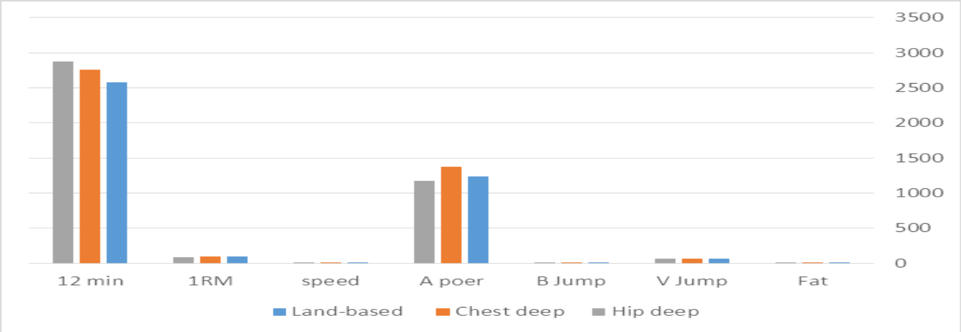

FIGURE (2) The post tests means values on some physical fitness variables

Discussion

Our study was performed to determine whether there were differences in some physical fitness variables due an aquatic plyometric training program in three different environments. We found that after 10 weeks of plyometric training in the aquatic environment, there were no significant differences in Body fat and endurance measurements pre and post-tested within each group. On the other, there were significant difference among the pre and post-tested measurements for the rest of variables in within each group.

As regard to sgnificance in body fat among the three groups, there was a high significant difference in chest-deep aquatic plyometric training *(3.44, 3.41) compared to the other groups. As regard to sgnificance in vertical jump, Broad jump, average power and Lower limb strength among the three groups, there was a high significant difference in chest-deep aquatic plyometric training *(8.13, 8.25), *(0.21), *(205.71) and (205.71) compared to the other groups. On the contrary. there were no significance in endurance among the three groups, there were no significance among them. In addition, there were no significant differences in endurance for any of the three groups. What was interesting to note is that the chest-deep group had slight increases, although not significant, in body fat and endurance between three plyometric jumps; The researchers attribute that, Many sports such as volleyball have both an anaerobic (i.e., power) and an aerobic component. Therefore, multiple types of training must be combined to best prepare volleyballers for these types. Because aerobic exercise may have a negative effect on power production, it is advisable to perform plyometric exercise before aerobic endurance training. The design variables do not change and should complement each other to most effectively train these volleyballers for competition.

In addition, the variations in height, especially for participants over 180cm tall, over the experimental groups might have contributed to the differences because of longer legs and lower limb muscles, which have the potential to produce more power during jumping. Previous studies that showed significant increases in strength, speed 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; Robinson et al.,2004; Islam., 2006).

Depth jumps are considered very high-intensity exercises that require appropriate training and careful progressions for safe completion of the program (Holcomb et al). Our participants performed depth jumps from 0.19 m, which is lower than the recommended range because our participants did not have previous plyometric-training experience. In addition, aquatic boxes used for the depth jumps in the pool are manufactured differently to be lower in height and prevent floating and slipping. The aquatic boxes are lower in height because of the difficulty of jumping onto subsequent boxes caused by the water's resistance. Our plyometric program's intensity of was low based on using experience not great with volleyball training participants in order to allow them to become familiarized with the type of exercises. As a result, the medium intensity might explain why we found increases in the performance variables from pre- to posttesting. Other studies used participants with higher fitness levels who therefore could sustain a higher intensity program (Chimera et al., 2004; Gehri et al., 1998; Potteiger et al., 1999; Islam., 2006).

Researchers suggests Future studies should investigate using aquatic plyometric training with children less than 16 years old so it is safe and does not cause any pressure on joints and bones ends.

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 28 participants, but only 24 completed the study. In addition, several participants reported slight slipping while performing the aquatic plyometric exercises. Slipping during the movement can alter the mechanics of the movements and prevent the stretch-shortening cycle from working properly. Further research should investigate the use of aquatic footwear that might reduce the likelihood of slipping while performing plyometrics in the aquatic setting.

Conclusion

The present study demonstrated that after 10 weeks of plyometric training in an aquatic environment, because of the resistive and buoyant properties of water, might decrease forces on the joints compared with land plyometrics and limit the extent of joint and muscle injuries. The speed of movement is definitely slowed in the water. Finally, despite the lack of significant results associated with aquatic plyometrics, we still think that the aquatic setting can be a unique environment in which to motivate and train individuals and serve as a rehabilitative tool while patients are recuperating from injury or surgery.

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