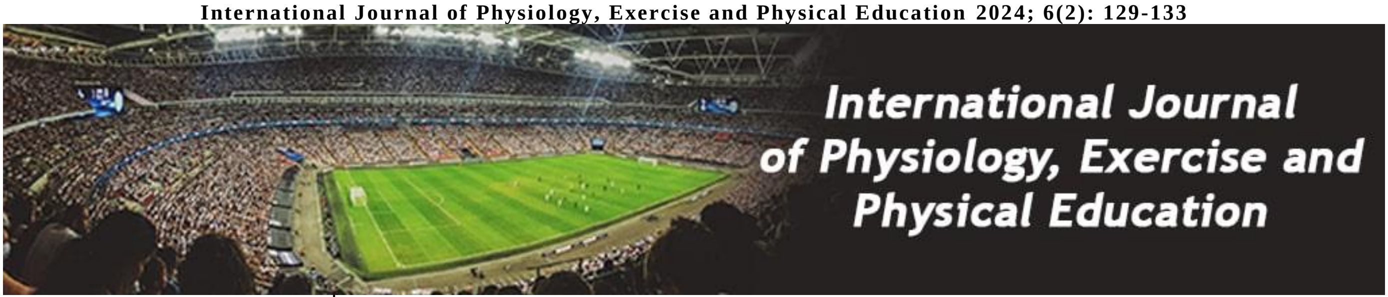

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Comparative effects of land based and water based plyometric training on selected physiological variables

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Abstract
The purpose of this review is to compare the effects of water-based and land-based plyometric training on various physiological variables, including Vital Capacity, aerobic capacity (VO2 max), and body composition. This review synthesizes findings from studies examining the impact of water-based and land-based plyometric exercises on physiological markers. For this study total 30 male athletes were selected as subjects, 10 for each group (land based plyometric training, water based plyometric training and control group). The subjects were randomly selected having age ranged 18 to 25 years. The dependentsample t-tests were used to identify any significant differences between the groups at the pre and post-testsfor the dependent variables. Two-way mixed analyses of variance (ANOVA) and Scheffes' post hoc testing were used to determine significant differences. Both types of plyometric training effectively improve Vital capacity and aerobic capacity. Land-based plyometrics are generally more intense, leading to quicker improvements in VO2 max. The explosive nature of land-based exercises increases oxygen consumption and accelerates metabolic rate, contributing to faster adaptations in aerobic capacity. In contrast, water-based plyometrics, though slightly less intense, offer the advantage of reduced joint impact, making them suitable for individuals with injuries or those requiring lower-intensity training. Water's resistance also provides a unique challenge to muscle groups, contributing to muscle toning, fat loss, and cardiovascular endurance. Both water-based and land-based plyometric training are effective for enhancing physiological variables such as cardiovascular fitness, muscle power, and VO2 max. Land-based plyometrics tend to lead to quicker and more pronounced improvements in aerobic capacity and strength due to their higher intensity, while water-based plyometrics offer a safer, lower-impact alternative that still provides substantial benefits for cardiovascular fitness, muscle endurance, and fat reduction. The choice between the two should depend on individual needs, fitness goals, and injury considerations. Combining both methods can provide a comprehensive training regimen to enhance overall fitness and health.

Keywords: Vital capacity, body composition, plyometric training, VO2 Max

Introduction

Plyometrics is a traditional training method composed of exercises that use the elastic potential of the muscle stretched by an eccentric action followed immediately by aconcentric action. Widely used in sports training, it causes positive effects on strength, speed, agility, and vertical jump performance, among others [1].

In athletics the use of plyometrics is recommended for developing the capacities related to jumping and speed performance [2]. A recent systematic review that included twenty-one studies showed that plyometric training improves vertical and horizontal jump performance, flexibility, and agility/speed in athletes [3]. In asystematic review with the metanalysis of fourteen studies, Ramirez-Campillo *et al.* concluded that different plyometric training protocols caused improvement in vertical jump height (with large effect sizes) of volleyball players of different ages and genders [4]. Under the prerogative of reducing the considerable mechanical overload that occurs while performing plyometric jumps, training in an aquatic environment has been proposed as an alternative. In water, this load reduction occurs due to buoyancy, which attenuates the ground reaction force (i.e. the impact) during the execution of different types of jumps in comparison to land [5]. Held *et al.* compared the effects of plyometrics on land and water in a systematic review that included eight studies. The participants in these studies were healthy men and women (physically active and inactive) and athletemen (basketball and wrestling), and the results showedthat the effect of plyometric training in water on the force of lower limbs, running speed, and the vertical jump performance on land is like that observed when the training is carried out on the land [6]. The physical properties of water make movements slower and attenuate the reaction forces during jumps [7]. Thus, individuals submitted to jump training in water report less subjective pain perception and less muscle damage is observed after APT sessions/programs when compared to land-based training. This may be particularly relevant for training athletes who are exposed torepetitive impactsin training routines and competition [8]. Plyometric studies have played an important role in many studies applied to developthe muscle groups used especially when performing movements that require high speed and strength with and without ball. Studies have shown that plyometric workout improvesphysical performance characteristics such as speed, agility and anaerobic capacity and strengthened muscle groups decrease the risk of injury [9].

By concluding all these reviews and thoughts emerged from the reviews the researcher decided to select the current problem and work over it. The study may show the physiological changes after the plyometric workout at different environmental conditions and contribute a sound knowledge in the field of plyometric training.

Methodology

Subjects

For this study total 30 male athletes were selected as subjects, 10 for each group (land based plyometric training, water based plyometric training and control group). The subjects were randomly selected having age ranged 18 to 25 years. Subjects were informed about the aims, nature, benefits and potential risks the study and provided written informed consent to take apart prior to the investigation. The subjects were healthy, free of lower extremity injuries, and they had no medical or orthopedic that comprehensive their participation in this study. Subjects were matched and randomly assigned to three groups; aquatic plyometric training group (n=10), land plyometric training group (n=10), and control group (n=10).

Selected Variables

The selected physiological variables for the study were Vo2 Max, Vital Capacity and Body Composition. The selected variables for the study

- Dependent variables: Vo2 max, Vital capacity and Body composition.
- Independent variables: Land Plyometric Training (LPT), Water Plyometric Training (WPT).

Criterion measure

S no.	Variable	Test	Unit
1.	Vo2 max	Step Test	ml/kg-1/min-1
2.	Vital capacity	Spirometer	Liters
3.	Body composition	Skin Fold Caliper	Mm

Experimental design

All study procedures took place at gymnasium at Laxmi Bai National Institute of Physical Education, Gwalior (M.P). Both groups trained for 6 weeks, two days per week. They performed a plyometric exercise designed in mat and water for the lower extremity, while the control group had not participated in any type of plyometric exercises. Subjects continued their routine athletic training, during experimental period. Subjects not participated in any type of plyometric training at the last six months and not permitted to use weight training along the plyometric training protocol. Both groups trained two days a week (Monday and Thursday) with 72-hoursrecovery [11], continued for 6 weeks. The subjects in the plyometric groups performed following plyometric drills - the Squat jump, Double leg lateral hop, Split Squat jump, Tuck Jump and Lunge jump. The training protocol of this study was step loading that comprised; fatigue, adaptation, jump, peak adaptation and reduction load. The plyometric exercise lasted from 03.30 PM to 05.30 PM for APT group. In contrast, plyometric exercise lasted from 05.30 PM to 07 00 PM for LPT group. Aquatic plyometric group trained in a swimming pool, while approximately 70% of their body was floating down the water. The temperature of the swimming pool was kept consistent at 27 ˚C or 28 ˚C [11]. Land plyometric group trained on mat of 3 cm at gymnastic club. Each exercise session lasted 40 min. Every session started with a 5-min Jogging, a 5-min stretching and ballistic movements to warm-up and a 5-min of stretch movements to cool down. The sufficient recovery was 60 sec rest between the sets and 3 min between each jump on per session. Subjects performed the plyometric exercises with a maximum ability and capacity in per session.

Statistical analysis

All data are presented as Mean ± SD. The dependent sample t-tests were used to identify any significant differences between the groups at the pre and post-tests for the dependent variables. Statistical analysis was performed using SPSS version 2.0 software. Two-way mixed analyses of variance (ANOVA) and Scheffes' post hoc testing were used to determine significant differences among the APT, LPT, and control groups. The level of significance was set at 0.05.

Results

Table 1: Descriptive statistics (Mean +Standard Deviation) of dependent variables

Variables	LPT		WPT		Control Group	
	Pre test	Post test	Pre test	Post test	Pre test	Post test
Vo_2 max	46.88±3.85	48.13±4.32	42.87±3.02	49.79±3.45	45.06±3.56	45.93±2.95
Vital Capacity	3.89±0.26	4.02±0.26	3.75±0.16	4.65±0.38	3.81±0.21	3.88±0.29
Body Composition	10.64±1.29	9.35±1.25	11.08±1.34	9.71±0.94	11.53±1.08	11.20±1.13

Table 2: Paired Difference of VO_2 Max

	Mean	SD	t	df	Sig. (p-value)
LBPT _Pre – LBPT _Post	-1.251	0.730	-5.417	9	0.000
WBPT _Pre – WBPT _PoIst	-6.921	1.019	-6.191	9	0.000
CG_Pre – CG_Post	-0.439	0.648	0.025	9	0.061

Table 2 shows the paired t-test analysis of the pre and post-test performance of the vertical jump for all groups. As shown in the table, there is a significant difference in the pre-test and post-test performance of the vertical jump in LBPT and WBPT as the p-value is less than 0.05 (p = 0.000); while no significant difference was observed for Control Group's pre-test and post-test scores as the p-value is more than 0.05 (p = 0.653). It means that vertical jump performance improved for LBPT and WBPT; while there was no change in the performance of the Control Group.

Table 3: Pairwise Comparison of VO_2max among groups

(I) Groups	(J) Groups	Mean Difference (I - J)	Std. Error	Sig. (p-value)
LBPT	WBPT	1.1750	1.52988	.007
	CG	1.8460	1.52988	.046
WBPT	LBPT	-1.1750	1.52988	.007
	CG	.6710	1.52988	.000
CG	LBPT	-1.8460	1.52988	.046
	WBPT	-.6710	1.52988	.000

Vital Capacity

Table 4: Paired t-test analysis for Vital capacity performance

	Paired Differences				
	Mean	SD	t	df	Sig. (p-value)
LBPT _Pre – LBPT _Post	-0.130	0.125	-3.284	9	0.009
WBPT _Pre – WBPT _Post	-0.900	0.244	-11.619	9	0.000
CG_Pre – CG_Post	-0.070	0.067	-1.280	9	0.055

Table 4shows the paired t-test analysis of the pre and post-test performance of the Vital capacity for all groups. As shown in the table, there is a significant difference in the pre-test and post-test performance of the Vital capacity in LBPT and WBPT as the p-value is less than 0.05 (p = 0.000); while no significant difference was observed for Control Group's pre-test and post-test scores as the p-value is more than 0.05 (p = 0.653). It means that vertical jump performance improved for LBPT and WBPT; while there was no change in the performance of the Control Group.

Table 5: Pairwise Comparison of Vital capacity among groups

(I) Groups	(J) Groups	Mean Difference (I - J)	Std. Error	Sig. (p-value)
LBPT	WBPT	-.3150*	.12133	.039
	CG	.0450	.12133	.049
WBPT	LBPT	.3150*	.12133	.039
	CG	.3600*	.12133	.017
CG	LBPT	-.0450	.12133	.049
	WBPT	-.3600*	.12133	.017

Table 6 Paired t-test analysis for Body Fat Percentage

	Paired Differences				
	Mean	SD	t	df	Sig. (p-value)
LBPT _Pre – LBPT _Post	1.282	0.645	6.283	9	0.000
WBPT _Pre – WBPT _Post	1.376	0.495	8.777	9	0.000
CG_Pre – CG_Post	0.269	0.440	1.929	9	0.086

Table 6 shows the paired t-test analysis of the pre and post-test performance of the Body Fat Percentage for all groups. As shown in the table, there is a significant difference in the pre-test and post-test performance of the Body Fat Percentage in LBPT and WBPT as the p-value is less than 0.05 (p = 0.000); while no significant difference was observed for Control Group's pre-test and post-test scores as the p-value is more than 0.05 (p = 0.653). It means that Body Fat Percentage performance improved for LBPT and WBPT; while there was no change in the performance of the Control Group.

Table 7: Pairwise Comparison of Body Fat Percentage among groups

(I) Groups	(J) Groups	Mean Difference (I - J)	Std. Error	Sig. (p-value)
LBPT	WBPT	-.360	.52272	.838
	CG	-1.670	.52272	.000
WBPT	LBPT	0.360	.52272	.838
	CG	-1.310	.52272	.001
CG	LBPT	1.670	.52272	.000
	WBPT	1.310	.52272	.001

Discussion

VO_2 max

The result of the study indicates that water based and land based plyometric training both plays major role in improvement of vo2 max. Plyometric training, whether land-based or water-based, primarily improves power, speed, and muscle efficiency, which can indirectly enhance VO2 max. However, plyometrics are often more focused on anaerobic conditioning than aerobic conditioning, and improvements in VO2 max may not be as pronounced as in traditional endurance training. Bishop *et al*. (2008) [14] found that land-based plyometric exercises can increase cardiovascular efficiency, but these results are generally not as significant as those from steady-state aerobic training. An article by Tschakert *et al*. (2010) [15] explored the cardiovascular benefits of aquatic exercise and noted that water-based workouts could be beneficial for improving VO2 max when structured correctly. Some studies suggest that aquatic exercise can improve cardiovascular fitness similarly to land-based training, though the effects may be less pronounced for VO2 max. For example, a study by Miyamoto *et al*. (2001) [12] found that water-based exercise improved VO2 max in older adults, while another study by Cochrane *et al*. (2011) [13] showed that water aerobics improved cardiovascular fitness in postmenopausal women. Studies on aquatic training have shown that it can lead to improvements in cardiovascular function, with some research indicating that water-based exercises can elevate heart rate and oxygen consumption, potentially improving VO2 max over time. The cooling effect of water during exercise may also allow for sustained high-intensity training.

Vital capacity

As per the result of the study both water-based and land-based plyometric training can contribute significantly to improving vital capacity, though they do so in different ways. Water-based plyometrics provide a gentler, lower-impact approach that still offers significant resistance training for the respiratory muscles, making it a good choice for individuals with joint issues or those seeking a less stressful training environment.

Land-based plyometrics are typically more intense and can result in quicker improvements in vital capacity because of the higher impact and more challenging nature of the exercises. However, the risk of injury is higher, and recovery might be more demanding. A study published in European Journal of Applied Physiology (2007) found that water-based exercise, particularly swimming and water aerobics, significantly improved lung volumes, including vital capacity, due to the increased resistance and respiratory effort required in water. Research published in Journal of Applied Physiology (2016) found that plyometric exercises, particularly those involving explosive movements like jump squats and box jumps, increased both heart rate and breathing rate, leading to enhanced pulmonary function and increased vital capacity.

A study in Sports Medicine (2013) showed that high-intensity plyometric training on land improves cardiovascular endurance and lung function by challenging both the aerobic and anaerobic systems. A study in Journal of Strength and Conditioning Research (2014) showed that water-based resistance training, which would include plyometric movements, helped increase lung capacity through enhanced diaphragmatic and accessory muscle activity.

Body Fats Percentage

Water-based plyometrics use the resistance of water to add an extra challenge, making movements more strenuous while reducing the impact on joints. This type of training provides a low-impact alternative to land-based plyometrics, which can be particularly useful for individuals with joint issues or those who want a less intense form of exercise. Despite the lower impact, water resistance ensures the body burns calories effectively. Water resistance provides a unique cardiovascular challenge, which helps improve fat metabolism. The buoyancy and resistance of water engage different muscle groups, contributing to overall muscle toning and fat reduction. Land-based plyometrics, such as jump squats, box jumps, and lunge jumps, are high-intensity exercises that can significantly raise the heart rate and metabolism. These exercises involve high-impact movements that are more intense than water-based plyometrics, potentially leading to faster results in terms of fat loss. Plyometric exercises on land tend to elevate heart rate quickly, promoting fat loss through intense cardiovascular and metabolic activity. Muscle Building and Fat Loss: Plyometrics enhance muscle power and hypertrophy, which increases resting metabolic rate and promotes long-term fat loss through increased lean muscle mass. The intense nature of land-based plyometrics can lead to a significant post-exercise oxygen consumption (EPOC) effect, meaning the body continues to burn calories at an elevated rate after the workout.

Conclusion

The water-based and land-based plyometric training are equally effective for lowering body fat percentage, but land-based plyometrics may yield faster results due to their higher intensity and the greater metabolic demand they place on the body. Water-based plyometrics provide a safer, lower-impact option that still promotes fat loss, especially for individuals with joint issues or those seeking less intensity. Combining both approaches may provide a well-rounded fitness program for fat loss and overall health. Both water-based and land-based plyometric training can play an equal role in improving vital capacity, with each offering unique benefits. Water-based exercises provide a lower-impact, resistance-based environment that is gentler on the joints but still effective for lung function improvement. On the other hand, land-based plyometrics tend to be more intense, providing a greater overall cardiovascular and pulmonary challenge, which may lead to quicker improvements in vital capacity. The choice between the two will depend on the individual’s preferences, injury history, and fitness goals. Similarly, Both water-based and land-based plyometric training are effective for lowering body fat percentage, but land-based plyometrics may yield faster results due to their higher intensity and the greater metabolic demand they place on the body. Water-based plyometrics provide a safer, lower-impact option that still promotes fat loss, especially for individuals with joint issues or those seeking less intensity. Combining both approaches may provide a well-rounded fitness program for fat loss and overall health.

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