ADVANCE SOCIAL SCIENCE ARCHIVE JOURNAL
Available Online: https://assajournal.com
Vol. 04 No. 01. July-September 2025.Page#.3446-3454
Print ISSN: 3006-2497 Online ISSN: 3006-2500
Platform & Workflow by: Open Journal Systems

The Effect of Resistance Training on the Development of Upper Limb Explosive Power in Amateur Male Volleyball Players

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Abstract
This study aimed to examine the impact of resistance training on the explosive power of the upper limbs in amateur male volleyball players. A pre-test and post-test research design was employed with a total of 30 college-level athletes, divided equally into experimental (n = 15) and control (n = 15) groups. The experimental group followed a structured 10-week resistance training program, conducted three times per week, while the control group continued with their routine activities. The training sessions included a six-minute warm-up and five resistance exercises (medicine ball overhead throws, push-ups, plyometric push-ups, push press, and medicine ball chest pass), specifically targeting upper limb explosive power. Pre-test results indicated no significant difference between groups, confirming baseline equivalence. However, post-test analysis revealed a significant improvement in explosive power among the experimental group compared to the control group. Paired samples tests further confirmed that only the experimental group demonstrated meaningful progress. These findings highlight the effectiveness of resistance training in enhancing upper limb explosive power, which plays a critical role in improving volleyball performance.

Keywords: *Resistance training, explosive power, upper limbs, volleyball players, experimental study*

Introduction

Volleyball is inherently a high-intensity, anaerobic sport that demands repetitive, powerful actions executed in short bursts such as spiking, serving, blocking, and rapid directional changes.

These actions rely heavily on the explosive strength the ability to generate maximal force in minimal time—of both the lower and upper limbs (Silva et al., 2019). Athletic power, defined as the product of force and velocity, is fundamental across all dynamic movements within volleyball (Silva et al., 2019).

Plyometric training, characterized by rapid eccentric-to-concentric muscle actions utilizing the stretch–shortening cycle (SSC), effectively enhances explosive power (Silva et al., 2019). These adaptations are crucial for volleyball athletes, improving vertical jump performance, agility, and speed abilities that directly translate to better on-court performance in offensive and defensive plays (Silva et al., 2019)

Moreover, volleyball-specific actions such as spiking and serving require powerful upper-limb movements. In young female players, spiking speed combined with vertical jump reach was identified as the most influential factor affecting situational efficiency on court, even surpassing general jumping and sprinting measures (Krzysztofik et al., 2013).

Research involving combined training protocols also supports the role of explosive power in upper-limb performance. An 8-week training program integrating plyometric jumps and ball-throwing exercises significantly improved upper-body explosive strength in young female players, while the control group engaged only in regular training showed no such improvements (PubMed, 2015). Similarly, batting (hitting) training among volleyball athletes produced significantly greater enhancements in upper-limb strength in the experimental group than the control group, further validating the effectiveness of targeted power training for hitting performance (Esposito et al., 2024).

In addition to performance enhancement, explosive power training including plyometrics has implications for injury prevention. Plyometric training enhances the body's capacity to absorb and generate force efficiently, improving neuromuscular coordination and reducing injury risk through better proprioception and shock absorption (Silva et al., 2019; MDPI, 2024).

Finally, integrating technical skills with explosive training modalities shows promising benefits. A recent study compared plyometric training with and without the inclusion of the ball and found that both protocols enhanced jump performance, with the ball-inclusive protocol specifically eliciting greater improvements in countermovement jumps with arm swing—suggesting a motivational and technical advantage to combining power drills with sport-specific context (Esposito et al., 2024).

Upper-limb strength and explosive power underpin several volleyball skills most notably the spike and serve where athletes must rapidly accelerate the arm and transfer force efficiently through the kinetic chain. Resistance training (RT) is widely recognized as a primary method to develop these qualities, as it provokes neuromuscular adaptations that increase maximal force, rate of force development, and movement velocity in sport-specific actions (Stockbrugger & Haennel, 2001). In volleyball, where ball velocity and terminal arm speed are decisive, structured RT that targets pressing, pulling, and overhead patterns can enhance both general and skill-specific performance indicators such as spike speed and serve velocity (Soylu & Altundağ, 2024).

RT improves upper-limb performance through hypertrophic changes (increased muscle cross-sectional area), neural drive (greater motor-unit recruitment and firing rates), and improved intermuscular coordination across the shoulder and trunk (García-Ramos et al., 2015). These adaptations translate to higher force and power in pressing and throwing tasks that resemble spiking mechanics. The backward-overhead medicine-ball throw, validated in competitive volleyball players, correlates strongly with vertical-jump power and demonstrates excellent reliability (Stockbrugger & Haennel, 2001). Likewise, ballistic push-ups and bench-press throws have been shown to be reliable indicators of explosive upper-body power (García-Ramos et al., 2015).

Training strategies that combine heavy and ballistic methods appear particularly effective. Heavy loads elevate maximal force capacity, while ballistic movements train velocity-specific adaptations. In recreationally trained men, adding ballistic exercises to a conventional heavy program produced superior gains in upper- and lower-body maximal strength compared with heavy training alone (Mangine et al., 2008). Similarly, the use of accommodating resistance (e.g., chains) has been shown to acutely enhance upper-body power output in trained athletes, making it a useful tool during phases aimed at maximizing concentric velocity (Godwin et al., 2018).

Complex and contrast training also play an important role in optimizing explosive power. Bench-press variations used as preload activities can acutely enhance subsequent plyometric push-up performance due to post-activation performance enhancement (PAPE) effects (McErlain-Naylor et al., 2019). For overhead athletes specifically, elastic-band programs improve shoulder internal/external rotator strength and throwing velocity (Hermassi et al., 2022). Similarly, in youth volleyball players, an eight-week Thera-Band intervention improved spike speed and upper-limb power, highlighting the ecological validity of band-based RT in volleyball (Uzor et al., 2018).

Finally, resistance training not only improves power output but also contributes to technical skill efficiency in volleyball. A randomized controlled trial with elite players demonstrated that neuromuscular training significantly enhanced serve speed and upper-limb stability (Soylu & Altundağ, 2024). Additionally, survey-based research shows that volleyball coaches and athletes widely integrate RT into their training plans to improve technical and tactical outcomes (Suchomel et al., 2021).

Volleyball research has traditionally emphasized elite and professional athletes, often overlooking the unique physiological and performance characteristics of amateur male players. Amateur athletes constitute the majority of participants worldwide, yet their training environments, resources, and physical preparation strategies differ significantly from professional settings (Borges et al., 2017). Unlike elite players who follow periodized training with access to strength and conditioning professionals, amateur male players often rely on limited training structures, which may affect their development in explosive strength, agility, and sport-specific skills (Palao et al., 2014).

Research on amateur male volleyball players is especially important because this group often competes in school, collegiate, and recreational leagues where systematic conditioning is absent. Studies have shown that insufficient physical preparation increases the risk of overuse injuries, particularly in the shoulders and knees, which are highly active during spiking and jumping actions (Ziv & Lidor, 2010). Tailored research can help identify appropriate resistance and plyometric training methods suitable for this population, ensuring performance gains without overloading unconditioned athletes (Marques et al., 2008).

Furthermore, amateur players often demonstrate greater variability in technical skills and physical performance compared to professionals (Gabbett & Georgieff, 2007). Understanding how training interventions—such as resistance training, plyometrics, or combined modalities—affect explosive power, endurance, and injury resilience in this group can provide coaches with evidence-based strategies. Recent findings suggest that even relatively short-term training programs can produce meaningful improvements in amateur players' vertical jump and spiking ability, highlighting their capacity for rapid adaptation when guided by structured interventions (Trajkovic et al., 2016).

Objectives of the Study

1) To assess the explosive power of the upper limbs of volleyball players before the exercise.
2) To evaluate the explosive power of the upper limbs of volleyball players after the exercise.
3) To compare the pre- and post test (Experimental group and Control Group) of explosive power of the upper limbs of volleyball players.

Hypotheses of the study

H_0 1: There is no significant difference in the explosive power of the upper limbs of volleyball players between the experimental group and the control group before the exercise.

H_A 2: There is a significant difference in the explosive power of the upper limbs of volleyball players between the experimental group and the control group after the exercise.

H_0 3: There is no significant difference between the pre-test and post-test measurements of the control group in the explosive power of the upper limbs of volleyball players.

H_A 4: There is a significant difference between the pre-test and post-test measurements of the experimental group in the explosive power of the upper limbs of volleyball players.

Methodology

Research design

This study consisted of a pre-test and post-test research design. The participants were assessed on upper limb explosive power before the intervention. An experimental group received resistance training, while a control group did not. After the training period, both groups were tested again under the same conditions.

Participants

The study included a total of 30 male college-level volleyball athletes Distract, Dera Ismail Khan, KP, Pakistan. Participants were divided equally into two groups: 15 in the experimental group and 15 in the control group. The experimental group underwent resistance training, while the control group continued with their routine activities.

Training Protocol

A resistance training program was implemented for a duration of 10 weeks. The sessions were conducted three times per week, on Monday, Wednesday, and Friday. Each session began with a six-minute warm-up to prepare the athletes. The program included five resistance exercises (Medicine Ball Overhead Throws, Push Ups, Plyometric Push-Ups, Push Press (Barbell or Dumbbells), Medicine Ball Chest Pass) specifically targeting the upper limbs. These exercises were designed to enhance explosive power relevant to volleyball performance (Mocanu et al., 2024).

Results

H_0 1: There is no significant difference in the explosive power of the upper limbs of volleyball players between the experimental group and the control group before the exercise.

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
EPUL (Pre)	Control Group	15	17.800	1.612	.416
	Experimental Group	15	17.933	1.667	.430

EPUL (Explosive Power of Upper Limbs)

The pre-test results showed that the control group (M = 17.80, SD = 1.61) and the experimental group (M = 17.93, SD = 1.67) had nearly identical mean scores in upper limb explosive power. The small difference in means indicates both groups started with similar performance levels.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EPUL (Pre)	Equal variances assumed	.002	.961	-.223	28	.825	-.133	.598	-1.360	1.093
	Equal variances not assumed			-.223	27.968	.825	-.133	.598	-1.360	1.093

The independent samples t-test showed no significant difference in pre-test upper limb explosive power between the control and experimental groups, $t(28) = -0.223$, $p = .825$. This result confirms that both groups were statistically equivalent at baseline before the resistance training program.

H_A 2: There is a significant difference in the explosive power of the upper limbs of volleyball players between the experimental group and the control group after the exercise.

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
EPUL (Post)	Control Group	15	17.666	1.345	.347
	Experimental Group	15	26.933	2.120	.547

EPUL (Explosive Power of Upper Limbs)

The post-test results revealed a clear difference between the groups. The control group had a mean score of 17.67 (SD = 1.35), while the experimental group achieved a much higher mean score of 26.93 (SD = 2.12).

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EPUL (Post)	Equal variances assumed	3.305	.080	-14.293	28	.000	-9.266	.648	-10.594	-7.938
	Equal variances not assumed			-14.293	23.699	.000	-9.266	.648	-10.605	-7.927

The independent samples t-test showed a highly significant difference in post-test upper limb explosive power between the experimental and control groups, $t(28) = -14.293$, $p < .001$. The experimental group outperformed the control group by an average of 9.27 points, confirming the strong positive effect of the resistance training program.

H_0 3: There is no significant difference between the pre-test and post-test measurements of the control group in the explosive power of the upper limbs of volleyball players.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	EPUL Control Group (Pre)	17.800	15	1.612	.416
	EPUL Control Group (Post)	17.666	15	1.345	.347

EPUL (Explosive Power of Upper Limbs)

The paired samples statistics for the control group showed a slight decrease in mean upper limb explosive power from pre-test (M = 17.80, SD = 1.61) to post-test (M = 17.67, SD = 1.35).

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	EPUL Control Group (Pre) EPUL Control Group (Post)	.133	1.060	.273	-.453	.720	.487	14	.634

The paired samples t-test for the control group revealed no significant difference between pre-test and post-test upper limb explosive power, $t(14) = 0.487$, $p = .634$. This indicates that the control group showed no meaningful improvement over the training period without resistance training.

H_A 4: There is a significant difference between the pre-test and post-test measurements of the experimental group in the explosive power of the upper limbs of volleyball players.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	EPUL Experimental Group (Pre)	17.933	15	1.667	.430
	EPUL Experimental Group (Post)	26.933	15	2.120	.547

EPUL (Explosive Power of Upper Limbs)

The paired samples statistics for the experimental group showed a substantial increase in mean upper limb explosive power from pre-test (M = 17.93, SD = 1.67) to post-test (M = 26.93, SD = 2.12).

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	EPUL Experimental Group (Pre) - EPUL Experimental Group (Post)	-9.000	1.558	.402	-9.863	-8.136	-22.367	14	.000

The paired samples t-test for the experimental group showed a highly significant improvement in upper limb explosive power from pre-test to post-test, $t(14) = -22.367$, $p < .001$. The mean increase of 9.00 points demonstrates the strong positive effect of the resistance training program.

Conclusion

The results of the study clearly indicate that resistance training had a significant positive impact on the explosive power of the upper limbs in amateur male volleyball players. Both groups began with statistically equivalent performance levels at the pre-test stage, confirming baseline similarity. However, after the intervention, the experimental group demonstrated a substantial improvement in explosive power, while the control group showed no meaningful change. These findings confirm that a structured resistance training program is highly effective in enhancing upper limb explosive power, which is crucial for volleyball performance.

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