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Isolated And Combined Effects Of Saq And Ladder Training On Biomotor Abilities And Skill Performance Among Adolescent Volleyball Players

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Abstract

The present study investigated the isolated and combined effects of Speed–Agility–Quickness (SAQ) training and agility ladder training on selected biomotor abilities and volleyball skill performance among adolescent volleyball players. Sixty male players aged 13–17 years from Mahe, India were randomly assigned into four groups (n = 15 each): SAQ training group, ladder training group, combined SAQ+ladder training group, and control group. Training was administered three sessions per week for twelve weeks, while the control group continued routine activity without any specialised intervention. The dependent variables included speed, agility, abdominal muscular endurance, leg explosive power, balance, and volleyball skill performance (passing, serving, and spiking). Pre- and post-intervention data were statistically analysed using Analysis of Covariance (ANCOVA) to determine group differences, with the significance level fixed at $p < 0.05$. Results showed significant improvements in all selected biomotor and skill variables in the experimental groups compared to the control group. Further, the combined SAQ+ladder training group demonstrated superior improvements compared to isolated training groups. The findings indicate that integrating SAQ and ladder training is more effective for improving performance-related fitness and volleyball-specific skills among adolescent players.

Keywords: SAQ training; agility ladder; biomotor abilities; volleyball skills; adolescent athletes.

1. INRODUCTION

Volleyball is a high-intensity intermittent sport characterized by repeated bouts of acceleration, deceleration, jumping, landing, and rapid directional changes. The game requires athletes to possess well-developed bio motor abilities, particularly speed, agility, muscular endurance, balance, and explosive power, along with consistent execution of technical skills such as passing, serving, and spiking. In volleyball, a player's ability to respond rapidly to game stimuli and execute skills under time pressure is a strong determinant of competitive performance.

Adolescence is a crucial phase for long-term athletic development because of rapid biological and neuromuscular maturation. Training interventions during this period can yield significant improvements in movement efficiency, coordination, and sport-specific fitness capacities. Therefore, it is essential to implement scientifically structured training programmes that enhance both physical fitness and volleyball-specific technical performance during the adolescent stage.

Speed, Agility Quickness (SAQ) training is widely adopted in sports conditioning programmes due to its emphasis on acceleration, rapid footwork, change-of-direction ability, and neuromuscular responsiveness. SAQ drills improve the efficiency of movement patterns and support the development of explosive sport-specific actions. Similarly, agility ladder training is commonly used as a coordination-based conditioning method to enhance foot speed, rhythm, balance, and movement control through patterned locomotion drills. Ladder training may improve neural activation and intermuscular coordination, thereby improving movement precision and readiness during competitive play.

Although evidence supports the independent benefits of SAQ and ladder training, research examining their comparative and combined effects on both bio motor variables and volleyball skill performance is limited, particularly among adolescent volleyball players. Since SAQ and ladder drills target complementary neuromuscular and movement components, an integrated training programme may produce greater improvements than either method performed in isolation. Establishing the effectiveness of combined training has direct practical relevance for coaches and physical educators seeking to optimise training outcomes.

Hence, the present study aimed to examine the isolated and combined effects of SAQ training and agility ladder training on selected bio motor abilities and volleyball skill performance among adolescent volleyball players.

2. METHODOLOGY

2.1. Study Design

The study adopted an experimental research design using a pre-test and post-test randomised control group design to determine the isolated and combined effects of SAQ training and agility ladder training on selected bio motor abilities and volleyball skill performance among adolescent volleyball players.

2.2. Participants

Sixty (N = 60) male adolescent volleyball players aged 13–17 years were selected from schools and volleyball training centres in and around Mahe, India. All participants had prior experience in volleyball coaching and competitive participation.

2.2.1. Inclusion criteria

Participants were included if they:

- were male volleyball players aged 13–17 years,
- had minimum regular volleyball training experience,
- were medically fit and free from injury at the time of participation.

2.2.2. Exclusion criteria

Participants were excluded if they:

- had musculoskeletal injury in the last 3 months,
- had any medical condition restricting vigorous training,
- failed to attend the training programme consistently.

2.3. Group Allocation and Randomisation

After baseline testing, the participants were randomly assigned into four equal groups (n = 15 each):

- Group I – SAQ Training Group (STG)
- Group II – Ladder Training Group (LTG)
- Group III – Combined SAQ + Ladder Training Group (CTG)
- Group IV – Control Group (CG)

The control group did not receive any specialised intervention and continued their routine physical activity and regular volleyball training only.

2.4. Training Intervention

The training intervention period was 12 weeks, conducted three sessions per week, with each session lasting approximately 60 minutes (including warm-up and cool-down). All experimental groups trained under supervision and followed progressive overload principles.

General structure of each session (for all experimental groups)

- Warm-up: 10–15 minutes (jogging, dynamic stretching, mobility drills)
- Main training: 35–40 minutes (SAQ / ladder / combined)
- Cool-down: 5–10 minutes (light movement + stretching)

2.4.1. SAQ Training Protocol

The SAQ training programme included drills designed to enhance:

- acceleration,
- multi-directional speed,
- quickness and reaction,
- change-of-direction ability.

Typical SAQ drills included: short sprints (10 - 30 m), shuttle runs, cone drills, reaction-based sprint starts and COD drills. Training load and complexity were progressively increased across 12 weeks.

2.4.2. Ladder Training Protocol

The ladder training group performed structured agility ladder drills focusing on:

- footwork rhythm,
- coordination,
- balance,
- quick stepping patterns,
- movement control.

Typical drills included single-step, double-step, lateral step, in–in/out–out, crossover, and diagonal ladder patterns. Progression was achieved through increased drill complexity, speed, and reduction in rest intervals.

2.4.3. Combined Training Protocol

The combined training group performed both SAQ drills and ladder drills within the same session. Ladder drills were used as neuromuscular activation/coordination components, followed by SAQ drills emphasising speed and change-of-direction. Adequate rest was provided between drills to maintain quality of movement performance.

2.5.Variables and Testing

The dependent variables were divided into bio motor and volleyball skill performance variables.

Bio motor variables

- Speed
- Agility
- Abdominal muscular endurance
- Leg explosive power
- Balance

Skill performance variables

- Passing ability
- Serving ability
- Spiking ability

2.6. Testing Procedure

Pre-test measurements were recorded prior to the start of the training programme and post-test measurements were recorded immediately after the 12-week intervention. Standard test administration procedures were maintained for all groups. To ensure reliability, the same sequence of testing, similar environmental conditions, and uniform instructions were followed during both test sessions. Two trials were given and the best score was recorded.

2.7. Statistical Analysis

Data were analysed using descriptive statistics (mean and standard deviation). To determine differences among groups, Analysis of Covariance (ANCOVA) was used by adjusting the post-test values using pre-test scores as covariates. Scheffe's post hoc test was applied to locate specific group differences when the F-ratio was significant. Statistical significance was fixed at $p < 0.05$.

2.8. Ethical Considerations

Participation was voluntary. Prior to data collection, informed consent was obtained from participants and/or guardians, and the study procedures were explained clearly.

3. RESULTS AND DISCUSSION

3.1.Leg Explosive Power

The results of the paired 't' test indicated that all experimental groups demonstrated significant improvement in leg explosive power following the twelve-week training intervention. The STG recorded a significant improvement ($t = 9.93$, $p < 0.05$) with a 7.78% increase, while the LTG showed significant improvement ($t = 7.64$, $p < 0.05$) with a 5.32% increase. The CTG achieved the highest improvement ($t = 20.37$, $p < 0.05$), with a substantial 16.71% increase. In contrast, the CG exhibited comparatively minimal change ($t = 4.40$) and only a 4.59% improvement. These findings indicate that structured SAQ and ladder-based interventions produce superior improvements in lower limb explosive capacity compared to routine activity alone. The paired 't' test values and percentage changes are presented in Table I.

To determine whether the observed improvements differed significantly between groups after adjusting for baseline differences, ANCOVA was applied. The ANCOVA results showed that the adjusted post-test means differed significantly among groups ($F = 43.04$, $p < 0.05$). This confirms that the training interventions produced statistically significant effects beyond chance variation. The ANCOVA computation of pre-test, post-test, and adjusted post-test means is shown in Table II.

Post-hoc comparisons using Scheffe's test further revealed that CTG demonstrated significantly superior improvements compared with STG, LTG, and CG. The findings clearly establish that while both SAQ and ladder training independently improved explosive power, the combined programme produced a stronger training stimulus, likely due to synergistic neuromuscular adaptation, improved force production, enhanced stretch–shortening cycle efficiency, and reduced ground contact time during explosive actions. The Scheffe's confidence interval results are presented in Table III.

Scheffe's post hoc test revealed significant mean differences between STG and LTG, STG and CTG, STG and CG, LTG and CTG, LTG and CG, and CTG and CG, as the observed mean differences were greater than the confidence interval value (CI = 0.99) at the 0.05 level. This indicates that the CTG resulted in superior improvement in leg explosive power compared with isolated SAQ training, isolated ladder training, and routine activity."

The graphical representation of pre-test, post-test and adjusted post-test means is provided in Figure 1, which visually confirms the superior gains in CTG relative to other groups. Overall, the present results demonstrate that an integrated SAQ and ladder training programme is highly effective for enhancing leg explosive power in adolescent volleyball players. This improvement is practically meaningful because leg explosive power is a key determinant for volleyball-specific actions such as jumping, blocking, and spiking.

3.2. Spiking Ability

The paired ‘t’ test analysis revealed statistically significant improvements in spiking ability for all experimental groups after twelve weeks of training. The STG improved significantly ($t = 26.00$, $p < 0.05$) with 56.66% improvement. Similarly, the LTG showed significant improvement ($t = 42.56$, $p < 0.05$) with 56.26% improvement. The CTG demonstrated the greatest improvement ($t = 34.39$, $p < 0.05$), achieving a 61.85% increase. In contrast, the CG showed negligible improvement ($t = 0.67$), confirming that skill development requires structured and targeted training interventions. The detailed pre-test and post-test spiking results are presented in Table IV.

To examine the training effect while controlling for baseline differences, ANCOVA was employed. The results indicated significant group differences in adjusted post-test means of spiking ability ($F = 59.55$, $p < 0.05$). This confirms that the training interventions had a statistically significant influence on spiking performance. ANCOVA results are shown in Table V.

Further, Scheffe’s post hoc test established that CTG demonstrated superior improvement compared with both isolated groups and the control group. The combined training approach likely improved spiking performance through enhanced approach speed, improved jump take-off force, coordination, rhythm, and timing all essential components for efficient spike execution. Since spiking is a complex skill requiring explosive power plus footwork accuracy and motor sequencing, a combined SAQ + ladder programme provides more comprehensive training transfer than isolated interventions. Scheffe’s results are provided in Table VI.

Scheffe’s post hoc test showed that the combined training group differed significantly from the control group and demonstrated better improvements compared with isolated training groups. Significant mean differences were observed where the mean difference exceeded the confidence interval value at the 0.05 level, indicating that combined SAQ and ladder training produced superior gains in spiking ability.”

The bar diagram representation of pre-test, post-test, and adjusted post-test mean values is presented in Figure 2, clearly illustrating that CTG attained the highest performance outcomes in spiking ability. Collectively, these findings confirm that both SAQ training and ladder training are effective in improving spiking performance; however, the combined method provides enhanced improvement by simultaneously developing explosive strength, neuromuscular responsiveness, and technical movement coordination necessary for volleyball spiking.

Tables and Figures

Table I

Paired ‘t’ test and % of changes on volleyball players’ leg explosive power of STG, LTG, CTG and CG

Groups Name	Assessment Periods	Subjects	Mean Value	SD Value	mean Difference	DM Value	‘t’ – test Value	Percentage
STG	Pre test	15	46.26	2.21	3.60	.36	9.93	7.78
	Post test		49.86	2.09				
LTG	Pre test	15	27.40	3.50	1.46	.19	7.64	5.32
	Post test		28.86	3.46				
CTG	Pre test	15	42.66	2.12	7.13	.35	20.37	16.71
	Post test		49.80	2.93				
CG	Pre test	15	40.46	1.95	1.86	.42	4.40	4.59
	Post test		42.33	1.98				

df 14 =2.15 (table value) (*significant)

Table II

ANCOVA of pre-test, post-test and adjusted post-test means on leg explosive power for experimental and control groups

	STG	LTG	CTG	CG	Source of Variance	Sum of Squares	df	Means Squares	F-ratio
Pre-test Means	46.26	27.40	42.66	40.46	BG	3042.00	3	1014.00	158.79
SD	2.21	3.50	2.12	1.95	WG	357.60	56	6.38	
Post-Test Means	49.86	28.86	49.80	42.71	BG	4398.98	3	1466.32	202.65
SD	2.09	3.46	2.93	1.98	WG	405.20	56	7.236	
Adjusted Post-Test Means	43.30	39.82	46.58	41.15	BG	227.65	3	75.88	43.04
					WG	96.96	55	1.763	

Required F (0.05), (df 3,56) = 2.76, (df 3,55) = 2.77 at 0.05, significance.

BG - Between Groups, WG - Within Groups, df – Degrees of Freedom

Table III

Scheffe's confidence interval test – leg explosive power

STG	LTG	CTG	CG	MD	CI
43.30	39.82			3.48*	0.99
43.30		46.58		3.28*	
43.30			41.15	2.15*	
	39.82	46.58		6.76*	
	39.82		41.15	1.33*	
		46.58	41.15	5.67*	

Required C.I Value 0.10 at 0.05 level

Table IV.

Paired 't' test and % of changes on volleyball players' spiking performance of STG, LTG, CTG and CG

Groups Name	Assessment Periods	Subjects	Mean Value	SD Value	mean Difference	DM Value	't' – test Value	Percentage
STG	Pre test	15	6.33	0.81	3.46	.13	26	56.66
	Post test		9.80	1.14				
LTG	Pre test	15	6.86	1.18	3.86	.09	42.56	56.26
	Post test		10.73	1.22				
CTG	Pre test	15	7	0.75	4.33	.12	34.39	61.85
	Post test		11.33	1.04				
CG	Pre test	15	4.46	0.91	0.20	.29	0.67	4.48
	Post test		4.26	1.75				

df 14 =2.15 (table value) (*significant)

Table V.

ANCOVA of pre-test, post-test and adjusted post-test means on spiking performance for experimental and control groups

	STG	LTG	CTG	CG	Source of Variance	Sum of Squares	df	Means Squares	F-ratio
Pre-test Means	6.33	6.86	7	4.46	BG	61.53	3	20.51	23.53
SD	.81	1.18	.75	.91	WG	48.80	56	.87	
Post-Test Means	9.80	10.73	11.33	4.26	BG	472.33	3	157.44	90.33
SD	1.14	1.22	1.04	1.75	WG	97.60	56	1.74	
Adjusted Post-Test Means	9.59	9.87	10.31	6.34	BG	67.05	3	22.35	59.55
					WG	24.81	55	.45	

Required F (0.05), (df 3,56) = 2.76, (df 3,55) = 2.77 at 0.05, significance.

BG - Between Groups, WG - Within Groups, df – Degrees of Freedom

Table VI.

Scheffe's confidence interval test – spiking performance (adjusted post-test means)

STG	LTG	CTG	CG	MD	CI
9.29	9.87			.28	0.50
9.29		10.31		.72*	
9.29			6.34	3.25*	
	9.87	10.31		.44	
	9.87		6.34	3.53*	
		10.31	6.34	3.97*	

Required C.I Value 0.10 at 0.05 level

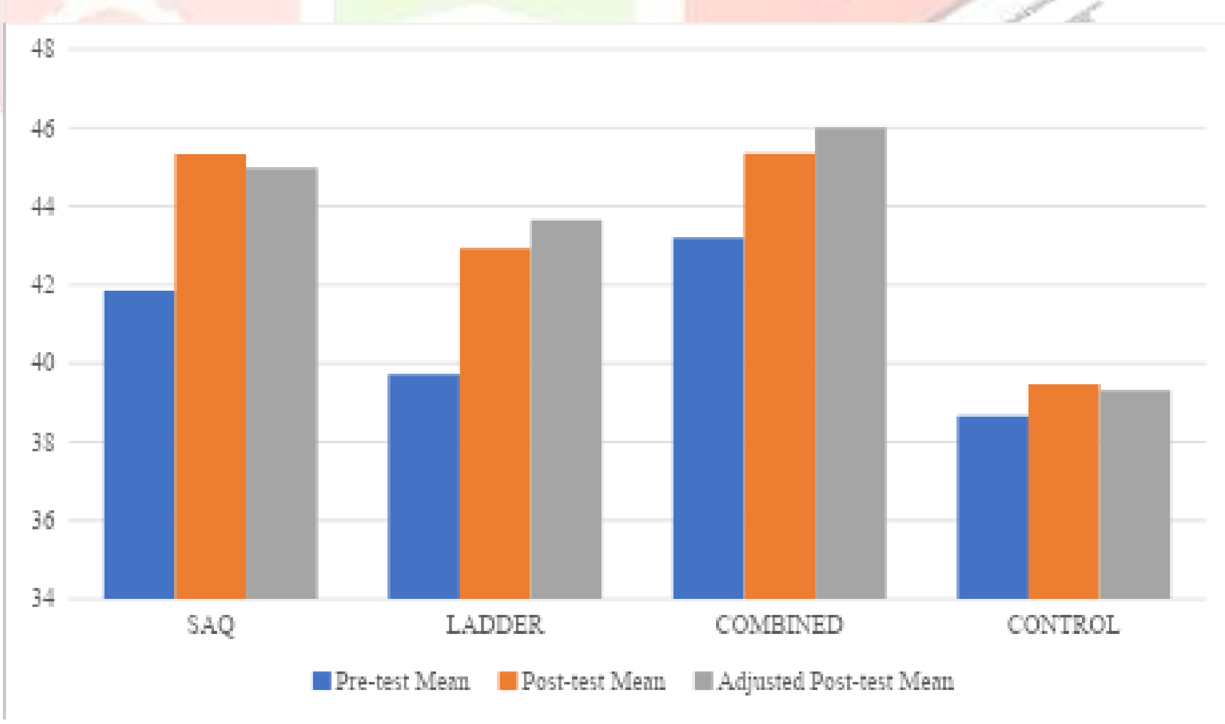

Figure 1. Bar diagram showing pre-test, post-test and adjusted post-test means on leg explosive power

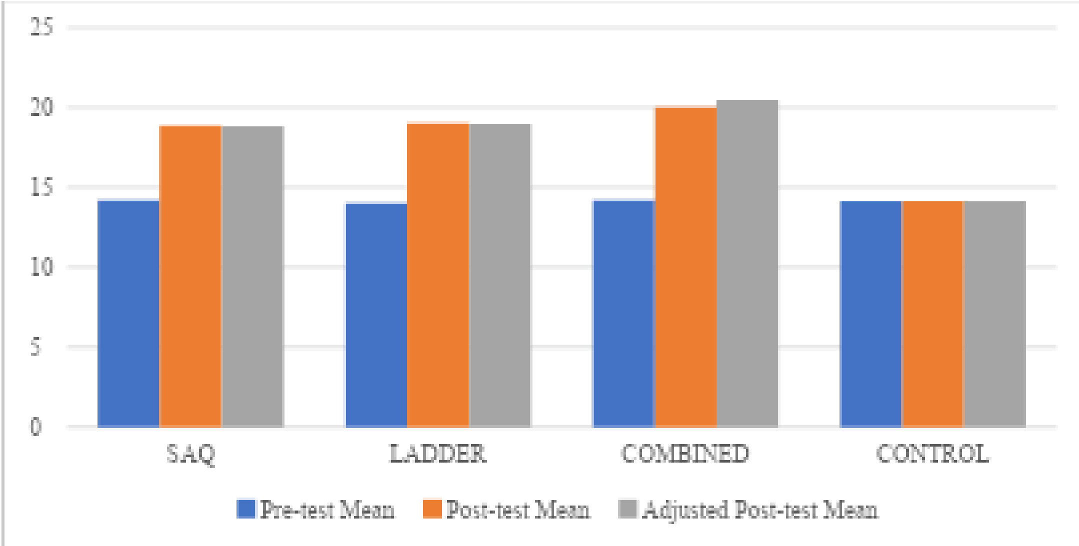

Figure 2. Bar diagram showing pre-test, post-test and adjusted post-test means on spiking ability

4. CONCLUSION

The present study examined the isolated and combined effects of SAQ training and agility ladder training on selected bio motor abilities and volleyball skill performance among adolescent volleyball players. The findings confirmed that both SAQ training and ladder training independently produced significant improvements in performance variables compared with the control group. However, the combined SAQ + ladder training programme demonstrated superior gains, particularly in leg explosive power and spiking ability, indicating that an integrated intervention is more effective than isolated training methods.

The enhanced outcomes observed in the combined group may be attributed to synergistic neuromuscular adaptations achieved through simultaneous development of acceleration capacity, change-of-direction efficiency, coordinated footwork, and explosive movement execution. From a practical perspective, these results support the inclusion of combined SAQ and agility ladder drills within regular volleyball conditioning programmes, as this approach is cost-effective, time-efficient, and directly relevant to volleyball actions such as approach movement and jump-based skills.

The study was limited to male adolescent players and a 12-week intervention duration; hence, generalization to other age groups and female athletes should be done cautiously. Future research may extend the intervention period, include female participants, and incorporate sport-specific reactive agility and match-performance indicators for broader applicability.

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