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RESEARCH ARTICLE

The Effects of Plyometrics and Asanas on Flexibility and Strength Endurance of Adolescent Volleyball Players

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Abstract

Background: Athletes' flexibility and strength endurance improve through regular yoga practice. If plyometric exercises combine with yoga asanas in training programs, it may enhance performance in sports that demand these fitness components. **Objectives:** To determine the effect of eight weeks of plyometric training alone and in combination with asanas on adolescent volleyball players' flexibility and strength endurance. **Methods:** Forty-five male adolescent volleyball players were randomly selected for two experimental groups and a control group for eight weeks. An ANCOVA was used to compare the modified post-test means to the initial test means. **Findings:** The study's findings indicate that plyometric exercise, both alone and in combination with asanas, has a substantial effect on flexibility (F = 15.90, p = 0.00) and strength endurance (F = 2.366, p = 0.0027). Furthermore, the paired means of plyometric combined with asanas and plyometric (0.743, p = 0.03), plyometric combined with asanas and control (1.268, p = 0.00), and plyometric and control (0.525, p = 0.029) had a statistically significant mean difference in flexibility. Among the paired means, the differences in strength endurance between plyometric combined with asanas and plyometric (0.276, p = 0.853); plyometric combined with asanas and control (2.911, p = 0.055); and plyometric and control (2.635, p = 0.082) were not statistically significant. **Novelty:** Plyometric training alone improved the players' flexibility by 14.25%, and plyometric training combined with asanas improved it by 28.64% compared to the control group. The combined exercise was 16.78% more effective than plyometric training alone. Post-testing data on strength endurance demonstrate an improved trend, despite the absence of statistically significant differences.

Keywords: Adolescent; Asanas; Flexibility; Plyometric; Strength Endurance

1 Introduction

Athletes undertake various physical activities to strengthen their technical and physical potential [(1)].In this regard, plyometric exercises positively affect physical fitness

indicators such as muscular power, strength endurance, speed, and flexibility while being safe (with no documented injuries)[2–8] These exercises can help improve muscle function by allowing muscles to stretch quickly while making an explosive muscle movement[9]. Plyometrics use the stretch-shortening cycle, which involves two quick, alternating movements. Until the 1980s, only track and field athletes were known to reap the benefits of plyometrics. Later, other sports adopted it as well[10,11].Research has shown positive outcomes of plyometric training in both athletes and non-athletes. Its advantages include improved muscle strength, joint function, stability, reduced chances of significant knee problems, and improved running economy[12,13].Similarly, yoga asanas are physical positions or postures mainly focused on enhancing steadiness, comfort, and a joyful spirit[14]. Asanas (static postures) are designed to engage all targeted and supporting muscle groups while maintaining a regular and steady breathing rhythm[15]. Yoga has been demonstrated to significantly increase the flexibility of the lower extremities and lower back compared to static stretching exercises[16]. The body's muscles are stretched and strengthened through yoga, which calms the mind and soul. The muscles in the back, calves, hands, shoulders, hamstrings, ankles and feet greatly benefit from yoga activities[17–24].

Volleyball requires the culmination of many physical attributes, such as strength, speed, flexibility, and agility[25,26]. Throughout the game, a volleyball player must make various moves, including jumping, digging, setting, blocking, hitting, and so forth, and has to be prepared to initiate motion in any direction[27–29].Previous studies on the fitness components of volleyball players have demonstrated the value of plyometric training. In an exhaustive meta-analysis of studies performed on male and female volleyball players, Ramirez-Campillo et al.[30] showed that plyometric jump training is safe and effective in improving physical fitness. Khan et al.[31] examined the effect of plyometric training on various physical aspects of university students and reported significant development in their improving motor ability. Extensive research has also proven the positive effects of yoga in multiple sports, including volleyball. However, it has yet to be fully known whether combining plyometrics with yoga can enhance players' physical benefits. It is assumed that young volleyball athletes may benefit more from specific stretching exercises mixed with plyometrics than conventional training methods. Hence, this study examines the integrated effects of yoga and plyometric training on two critical volleyball fitness needs for young adolescent volleyball players.

Forty-five male adolescent volleyball players participated in this study for eight weeks. Participants were initially provided plyometric and yoga training, followed by assessments of their physical attributes through sit and reach test and bent knee sit-ups. Statistical analysis was used to compare the results. The study's objectives were as follows:

1. To determine the effect of eight weeks of plyometric training alone and in combination with yoga asanas on adolescent volleyball players' flexibility and strength endurance.
2. To evaluate the effectiveness of experimental training groups on adolescent volleyball players' flexibility and strength endurance.

The following hypotheses were tested in the study:

1. There would be no significant impact of plyometric training alone and in combination with asanas on flexibility and strength endurance of adolescent male volleyball players.
2. There would be no significant difference in flexibility and strength endurance of adolescent male volleyball players across different experimental training groups.

2 Methodology

2.1 Participants

The participants in this study were specifically identified trainees enrolled in a volleyball sports hostel in the Narsinghpur district, Madhya Pradesh, India. Thus, a purposeful sampling method was employed to select participants for this investigation. As an outcome, 45 male volleyball players between the ages of 14 and 20 were chosen to participate in this study. These 45 participants were randomly assigned to one of three groups: the Experimental Group-1 (plyometric training), the Experimental Group-2 (plyometric training in combination with asanas), and the Control Group (no specific training).

The inclusion criteria were (i) adolescent volleyball players, (ii) male volleyball players, and (iii) enrolled in a sports hostel in Madhya Pradesh's Narsinghpur district. The exclusion criteria were: (i) players who had been injured in the previous three months; (ii) any psychological health concern; (iii) non-adolescent age group; and (iv) players with the condition that prohibits physical activity. A signed informed consent form was obtained from the participants. The research degree committee of MGCG Vishwavidyalaya, Chitrakoot, Satna, Madhya Pradesh, approved the study (R.D./17/4633, dated August 30, 2017).

2.2 Experimental Design

This study aimed to see if there was a probable cause-effect link between yoga practice and plyometric training in adolescent volleyball players for up to eight weeks. The investigators adopted a pre- and post-trial-controlled group design in this study. The participants were divided into three groups to meet the study's goals. Two of the three groups were experimental, while the third was a control group.

2.3 Training Protocol (Plyometric and Plyometric with Asanas)

Participants in both experimental groups received training five days a week and two days' rest during the training period. Only one session was held each day, with each session lasting 50 minutes. After the plyometric training, the participants in the second experimental group followed a 40-minute yoga session in which they practiced selected asanas. During these eight weeks, the participants in the control group received no special training. The details of treatment for experimental groups are shown in Table 1.

Table 1. Description of the 8 Week Plyometric Training alone and in combination with asanas

Weeks	Plyometric Training	Plyometric Training in combined with asanas		Repetitions and Sets
Week 1st to 3rd	1.Clapping push ups	1.Clapping push ups	1. Trikonasana	10 × 2
	2.Tuck jump	2.Tuck jump	2. Padmasana	10 × 2
	3.Alternate leg diagonal	3.Alternate leg diagonal	3.Paschimottasana	10 × 2
	4.Double leg jump	4.Double leg jump	4. Vajrasana	10 × 2
	5.Arrow cone drill	5.Arrow cone drill	5. Swastikasana	10 × 2
	6.Squat jump	6.Squat jump	6. Bhujangasana	10 × 2
	7.Vertical jump	7.Vertical jump	7. Dhanurasana	10 × 2
	8.Box skip	8.Box skip	8. Halasana	10 × 2
Week 3rd to 6th	1.Shock push ups	1.Shock push ups	1. Trikonasana	10 × 2
	2.Ankle jump	2.Ankle jump	2. Padmasana	10 × 2
	3.bound lateral cone hops	3.bound lateral cone hops	3.Paschimottasana	10 × 2
	4.Forward double leg butt	4.Forward double leg butt	4. Vajrasana	10 × 2
	5.T-drill	5.T-drill	5. Swastikasana	10 × 2
	6.Split jump	6.Split jump	6. Bhujangasana	10 × 2
	7.Long-jump & sprint	7.Long-jump & sprint	7. Dhanurasana	10 × 2
	8.Front box jump	8.Front box jump	8. Halasana	10 × 2
Week 6th to 8th	1.Decline push ups	1.Decline push ups	1. Trikonasana	10 × 2
	2.Depth jump leap	2.Depth jump leap	2. Padmasana	10 × 2
	3.Standing broad jumps	3.Standing broad jumps	3.Paschimottasana	10 × 2
	4.Kick fast skipping	4.Kick fast skipping	4. Vajrasana	10 × 2
	5.X-drill	5.X-drill	5. Swastikasana	10 × 2
	6.Split	6.Split	6. Bhujangasana	10 × 2
	7.Jump & turn 900	7.Jump & turn 900	7. Dhanurasana	10 × 2
	8.Box jump	8.Box jump	8. Halasana	10 × 2

2.4 Assessment

The key outcome measures were (i) the sit and reach test, which was first described in 1952 by Wells and Dillon and is perhaps the most widely used flexibility test [32].(ii) the bent knee sit-up test- is a typical athletic activity that improves abdominal and hip flexor endurance while maintaining core muscle stability [33,34].

2.5 Sit and Reach Test

The test measures spine and hamstring flexibility. The equipment required to complete the test is a sit-and-reach box, a ruler, and recording sheets. The subject begins the test by sitting on the floor with their legs outstretched and their feet flat against the flexible bench (the box attached to the ruler). The participant then tries to flex the trunk to its maximum possible extent and extend the fingers along the scale for three seconds. The legs should be stretched out from the knees throughout the test. The participant's score was recorded by measuring the distance between the middle toe and the toe, or the distance forward from the toe, in inches [35].

2.6 Bent Knee Sit-Ups

The test assesses abdominal muscle endurance. A floor mat or yoga mat and a timer are necessary for this test. Participants were asked to lie on their backs. Afterward, the knees are bent, both feet should remain close to the ground, and the heels should not be more than 12 inches from the hips. The knee should be bent to a maximum of 90 degrees. The fingers of both hands of the participant should be behind his neck, and his elbows should be square on the mat. An assistant holds onto the participant's feet to make contact with the surface. The subject was instructed to contract his abdominal muscles and bring his head and elbows forward until his elbows came to his knees in the final pose [36].

2.7 Statistical Analysis

Statistical software for the social sciences (SPSS) version 23.0 was used to examine the data for each variable. The data were analysed using descriptive statistics. Additionally, analysis of co-variance (ANCOVA) was used to adjust the initial test means and compare the corrected post-test means to determine differences. The least significant difference test was performed to identify which matched means differed significantly; a critical difference was determined using this test [37].

3 Results and Discussion

The descriptive statistics of the means for the variable were calculated for the actual post-test situation. These were presented together with the adjusted post-test mean by ANCOVA, one for each variable, for comparison. Table 2 depicts the original means, standard deviation, adjusted means, and standard error of two experimental groups and the control group for flexibility and strength endurance respectively. Figure 1 shows the comparison between the means of flexibility and strength endurance between the treatment and control groups.

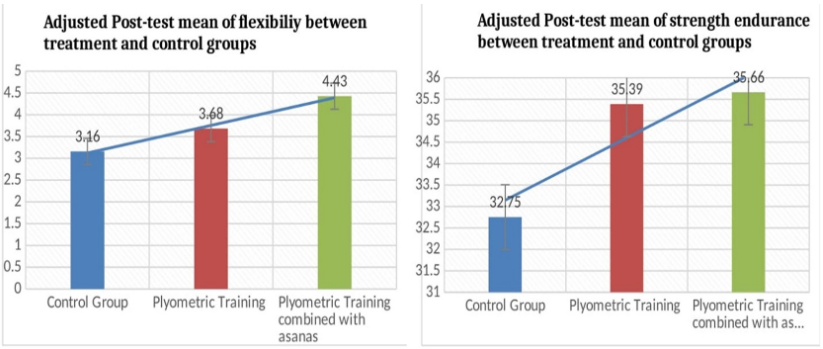

Fig 1. Mean comparison of flexibility and strength endurance between treatment and control groups

Table 2. Descriptive Statistics of post-test and adjusted post-test means of flexibility and strength endurance of treatment groups in volleyball players

Variable	Treatment Group	Post-test mean	SD	Adjusted post-test mean	SE	N
Flexibility	Plyometric Training	3.40	0.870	3.683[a]	0.164	15
	Plyometric Training combined with Asanas	4.60	0.967	4.426[a]	0.161	15
	Control Group	3.26	0.979	3.158[a]	0.160	15
Strength Endurance	Plyometric Training	35.60	5.44	35.387[b]	1.043	15
	Plyometric Training combined with Asanas	35.73	4.67	35.662[b]	1.042	15
	Control Group	32.46	4.24	32.751[b]	1.044	15

N=45; SD, Standard deviation; SE, Standard error
a) The following values are used to assess covariates in the model: pre-testing score of sit and reach test = 3.4667
b) The following values are used to assess covariates in the model: pre-testing score of bent-knee sit-up test = 33.9333.

As shown in Table 3, the F-values are 15.90 and 2.366 for comparing the adjusted means of the three treatment groups (plyometric, plyometric training combined with asanas, and control) during post-test scoring of dependent variables flexibility and strength endurance, respectively. Since the p-value for the F-statistic is 0.00 for flexibility and 0.0027 for strength endurance,

it was found to be significant. Thus, the null hypothesis was rejected at a significance level of 0.005. Partial ETA squared for flexibility was 0.4368, which shows a substantial difference, whereas for strength endurance, it was 0.1034, indicating a moderate difference. Since the F-value is significant, a pair-wise comparison of the adjusted means of the three groups was made for flexibility and strength endurance (Table 4). It revealed that the p-value for the mean difference between plyometric and plyometric combined with asanas, plyometric and control, and plyometric combined with asanas and control is less than 0.05 for flexibility and greater than 0.05 for strength endurance; hence the post-hoc test was done for flexibility. Table 5 shows that there was a significant difference between the paired mean of flexibility at different methods of training: plyometric combined with asanas and plyometric (0.743), plyometric combined with asanas and control (1.268), and plyometric and control (0.525).

Table 3. Analysis of Covariance for between subject effect of Experimental groups on flexibility and strength endurance

Variable	Source	Type III Sum of Squares	df	Mean Square	F	Sig. (p-value)	Partial Eta Squared
Flexibility	Group	12.127	2	6.064	15.90*	.000	0.4368
	Error	15.635	41	.381			
	Total	688.000	45				
	Corrected Total	53.311	44				
Strength Endurance	Group	77.043	2	38.522	2.366*	0.0027	0.1034
	Error	667.580	41	16.282			
	Total	54945.000	45				
	Corrected Total	1072.800	44				

Table 4. Pair wise comparison of mean of flexibility and strength endurance with least significant difference among treatment groups

(I) Treatment Group	(J) Treatment Group	Mean Difference (I-J)	SE	Sig. (p-value)	95% Confidence Interval for Difference	
FLEXIBILITY					**Upper Bound**	**Lower Bound**
Plyometric Training	Plyometric Training combined with Asanas	.743(*)	.234	.003	-1.215	-.271
	Control	.525(*)	.231	.029	.058	.993
Plyometric Training combined with Asanas	Plyometric Training	.743(*)	.234	.003	.271	1.215
	Control	1.268(*)	.226	.000	.812	1.724
Control	Plyometric	.525(*)	231	.029	-.993	-.058
	Plyometric Training combined with Asanas	1.268(*)	.226	.000	-1.724	-.812
STRENGTH ENDURANCE						
Plyometric Training	Plyometric Training combined with Asanas	.276	1.474	.853	-3.252	2.701
	Control	2.635	1.478	.082	-.349	5.620
Plyometric Training combined with Asanas	Plyometric Training	.276	1.474	.853	-2.701	3.252
	Control	2.911	1.476	.055	-.069	5.891
Control	Plyometric	2.635	1.478	.082	-5.620	.349
	Plyometric Training combined with Asanas	2.911	1.476	.055	-5.891	.069

*The mean difference is significant at the 0.05 level; SE: Standard error

These findings indicate that an 8-week plyometric training program, either alone or in conjunction with asanas, significantly improved flexibility and strength endurance in adolescent male volleyball players. Therefore, the first hypothesis was not accepted (Table 3). The result demonstrated that there was a significant mean difference between the paired mean of flexibility at different methods of training: plyometric combined with asanas and plyometric (0.743); plyometric combined with asanas and control (1.268); and plyometric and control (0.525). It showed that there was no significant mean difference between the paired mean of strength endurance at different methods of training: plyometric combined with asanas and plyometric (0.276); plyometric combined with asanas and control (2.911); and plyometric and control (2.635); hence, the second hypothesis was

Table 5. Least significant difference post hoc test of the mean of flexibility at different methods of training in volleyball player

Plyometric Training combined with Asanas Group	Plyometric Training Group	Control Group	Mean Difference	Critical Difference at 5% level
4.426	3.683	-	0.743(*)	
4.426	-	3.158	1.268(*)	0.455
	3.683	3.158	0.525(*)	

*The mean difference is significant at the 0.05 level

not accepted in flexibility but accepted in strength endurance (Table 4).

By comparing the effects of experimental treatments on the flexibility variable during the sit and reach test and on strength endurance during the bent-knee sit-up test, it can be deduced that the Partial Eta Square for flexibility and strength were 0.4368 and 0.1034, respectively. This suggests that the treatments had a more significant effect on flexibility than endurance.

Idrizovic et al. [38] observed a similarly significant effect through the sit-and-reach test in plyometric-conditioned junior female volleyball players (F = 75.93, p 0.01; small ES). They demonstrated significant group time interactions (F = 11.70, p = 0.01; large ES) and post-hoc differences. They concluded that adding two plyometric sessions could improve the players' physical attributes. However, any additional conditioning did not lead to much improvement in the studied variables. In another study with 45 female collegiate volleyball players, it was shown that plyometric exercises improved several nervous system functions, increased muscle temperature, and enhanced muscle elasticity, resulting in increased flexibility. This study showed that both types of exercises positively affected both muscular strength and endurance [39].

One study compared the individual and combined effects of Proprioceptive Neuromuscular Facilitation (PNF) stretching and plyometric training on young volleyball players' muscular strength and flexibility [40], showed that flexibility increased more rapidly than muscular power in all experimental groups. Combined training improved muscular power variables at a faster rate than only plyometrics or only PNF. PNF improved flexibility much faster than other treatments. Yet another study compared the effects of yoga and burpee exercises in male college students [41]. It showed that regular asana and burpee workouts improved the participants' muscular endurance, flexibility, and balance. Reports have demonstrated improved volleyball and basketball performance after combined exercises and training [42,43]. Sehrawat and Raghav [44] compared the effects of plyometric and yogic practices on the blood pressure and pulse rates of young volleyball players and found that the experimental group showed improved characteristics than the control group. One study among tribal taekwondo players showed that the combined power yoga and plyometric training group showed enhanced speed compared to the power yoga and plyometric training group. [45] Racil et al [46] studied the effect of combined exercises in 34 male hurdlers and concluded that specific stretching exercises with plyometrics were more effective than conventional strategies in improving physical fitness.

Contradictorily, Bashir et al. [47] showed that there was no significant difference in muscular endurance between the groups who underwent only plyometrics and those who took weight training along with plyometrics. Hill et al. [48] suggested plyometric training regimen improves lower extremity force output in teenage female athletes but not reactive strength. More study is required to compare the intervention to a control group and identify optimal workout dosage to modify the reactive strength index. Similarly, Silva et al. [7] demonstrated that the stiffness test indicated no significant changes for any variables following ten weeks of plyometric training in research's investigating the degree of specific lower limb power and reactive force in young female volleyball players [49,50].

There are very few studies comparing the effects of yoga and plyometrics on the physical parameters of volleyball players. In this regard, the current study relevantly compares the individual and combined impact of both training types on the flexibility and strength endurance of adolescent volleyball players. This will not only help in assessing the applicability of both training and coaching in the sport but also help in designing more effective training programs to enhance the physical capability of the volleyball players.

4 Conclusion

This study reports a comparative analysis of the individual and combined effects of plyometric and yoga practices on adolescent male volleyball players' strength endurance and flexibility. A significant impact of plyometric training alone and in combination with asanas was observed on flexibility and strength endurance. While plyometrics combined with yoga asanas was most effective, players could achieve better muscular flexibility with plyometrics alone compared to the control group. Post-testing data on strength endurance demonstrate an improved trend, despite the absence of statistically significant differences between the experimental groups. The limitation of this study is that it was carried out on male volleyball players in the age group of 14–20 years only. However, we recommend that for the training of young volleyball players, a combination of plyometric and

yoga practices be considered to increase their flexibility and strength endurance. Combination exercises are known to have an enhanced effect on improving the physical fitness of athletes in various sports. Nonetheless, there is a significant dearth of research-supported training programs. Thus, further studies are required to explore the combined effect of different types of physical activities, which will help design more efficient training modules for athletes.

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