

Effect of Plyometric Training on Muscular Endurance and Flexibility among Football Players

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Abstract: The purpose of the present study was to investigate the effect of a twelve-week plyometric training programme on muscular endurance and flexibility among football players. Sixty male football players aged 18–23 years from football academies of the Marathwada region were selected using a randomized sampling technique. The subjects were divided into an experimental group (n = 30) and a control group (n = 30). The experimental group participated in a structured plyometric training programme for twelve weeks, six days per week, while the control group continued their regular training activities.

Muscular endurance and flexibility were assessed using the Bent Knee Sit-ups Test and Sit and Reach Test, respectively. The data were analyzed using descriptive statistics, paired t-test, and Analysis of Covariance (ANCOVA). The results of the paired t-test revealed significant improvements in muscular endurance ($t = -36.970$, $p < 0.001$) and flexibility ($t = -9.009$, $p < 0.001$). ANCOVA results further showed significant differences between the experimental and control groups in muscular endurance ($F = 326.83$, $p < 0.001$) and flexibility ($F = 164.74$, $p < 0.001$). The findings indicate that plyometric training is effective in improving muscular endurance and flexibility among football players.

Keywords: Plyometric Training, Football Players, Muscular Endurance, Flexibility, Motor Fitness, Physical Conditioning.

I. INTRODUCTION

Football is a physically demanding sport that requires a combination of technical skill, tactical awareness, and high levels of physical fitness. Players are required to perform repeated bouts of running, jumping, kicking, turning, and other dynamic movements throughout the duration of a match. To meet these demands, football players must possess adequate muscular endurance and flexibility.

Muscular endurance is the ability of a muscle or muscle group to perform repeated contractions over an extended period without fatigue. It enables football players to sustain performance throughout the match and recover efficiently between high-intensity efforts. Flexibility, on the other hand, refers to the ability of a joint or series of joints to move through an unrestricted and pain-free range of motion. Adequate flexibility contributes to efficient movement patterns, improved performance, and reduced risk of injury.

Plyometric training has become one of the most widely used conditioning methods in modern sports. It involves explosive movements that utilize the stretch-shortening cycle of muscles, thereby improving neuromuscular efficiency and athletic performance. Although plyometric training is traditionally associated with improvements in speed, agility, and power, emerging evidence suggests that it may also positively influence muscular endurance and flexibility when implemented systematically.

Despite the growing popularity of plyometric training, limited studies have examined its influence on muscular endurance and flexibility among football players from the Marathwada region. Therefore, the present study was undertaken to determine the effectiveness of a structured plyometric training programme on these selected motor fitness variables.



Objectives of the Study

1. To determine the effect of plyometric training on muscular endurance among football players.
2. To determine the effect of plyometric training on flexibility among football players.

Hypotheses

H₁: There will be no significant effect of plyometric training on the muscular endurance of football players of the Marathwada region.

H₂: There will be no significant effect of plyometric training on the flexibility of football players of the Marathwada region.

II. METHODOLOGY

Participants

The study consisted of sixty football players aged between 18 and 23 years selected from football academies of the Marathwada region. The subjects were randomly assigned into two groups:

- Experimental Group (n = 30)
- Control Group (n = 30)

Research Design

A randomized pre-test and post-test control group design was employed for the study. Measurements were recorded before and after the twelve-week training period.

Training Programme

The experimental group participated in a structured plyometric training programme for twelve weeks. Training sessions were conducted six days per week under the supervision of the investigator. Each session lasted approximately 45–60 minutes and included warm-up exercises, plyometric drills, and cool-down activities. The control group continued their regular football training without additional plyometric intervention.

Criterion Measures

The following standardized tests were selected:

- Muscular Endurance – Bent Knee Sit-Ups Test
- Flexibility – Sit and Reach Test

Statistical Analysis

Descriptive statistics such as mean and standard deviation were calculated for all variables. The Shapiro–Wilk Test was used to assess normality of data distribution. An Independent t-test was applied to establish baseline equivalence between the groups. Paired t-tests were used to determine significant differences between pre-test and post-test scores within groups. Analysis of Covariance (ANCOVA) was employed to compare adjusted post-test means while controlling for pre-test differences. The level of significance was set at 0.05.

III. RESULT AND ANALYSIS

3.1: Muscular Endurance (Bent Knee Sit-ups Test)

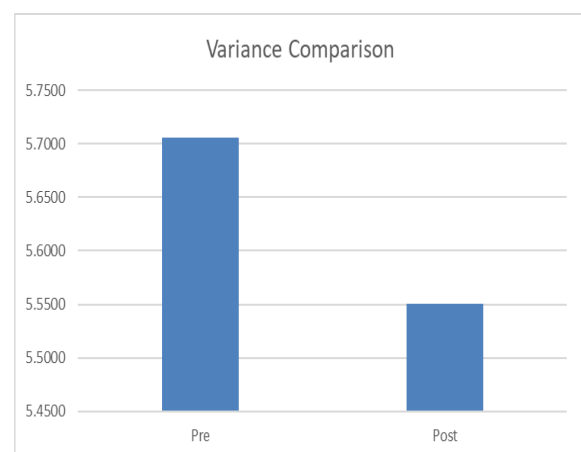
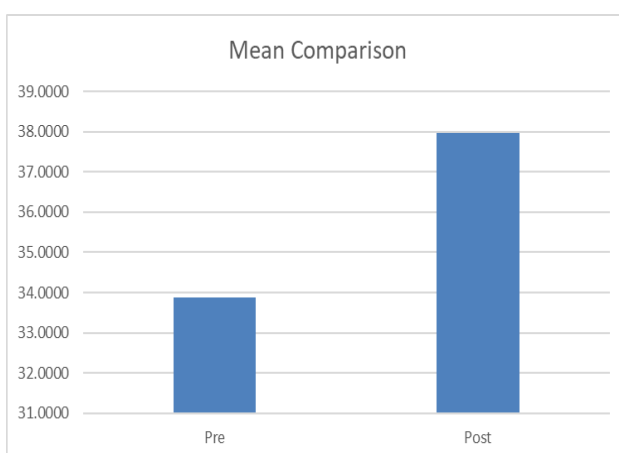
3.1.1: Paired t-Test Analysis of Pre-Test and Post-Test Scores for Muscular Endurance (Bent Knee Sit-ups Test)

	Pre-Test	Post-Test
Mean	33.86667	37.96667
Variance	5.705747	5.550575
Observations	30	30
Pearson Correlation	0.967313	
Hypothesized Mean Difference	0	
df	29	
t Stat	-36.9702	
P(T<=t) one-tail	2.99E-26	
t Critical one-tail	1.699127	
P(T<=t) two-tail	5.97E-26	
t Critical two-tail	2.04523	

The mean value of the pre-test is 33.8667 repetitions per minute, whereas the mean value of the post-test is 37.9667 repetitions per minute. Since the number of sit-ups performed has increased, it indicates an improvement in muscular endurance after the plyometric training programme. The calculated t -value is -36.970 (absolute value = 36.970), which is much greater than the critical t -value of 2.045 at the 0.05 level of significance with 29 degrees of freedom. The obtained p -value (5.97201×10^{-26}) is extremely small and far less than 0.05, indicating a highly significant difference between pre-test and post-test scores.

The Pearson correlation value (0.9673) indicates a strong relationship between pre-test and post-test scores, reflecting consistency in measurement. Since the calculated t -value is greater than the critical value and the p -value is less than 0.05, the null hypothesis is rejected and the alternative hypothesis is accepted. It is therefore concluded that the plyometric training programme has a significant effect on improving muscular endurance, as measured by the Bent Knee Sit-ups Test (repetitions per minute), among football players of the Marathwada region.

3.1.2: Bar Diagram Showing Comparison of Mean and Variance Scores of Pre-Test and Post- Test for Muscular Endurance (Bent Knee Sit-ups Test)



The bar diagram representing the mean scores clearly shows an increase in the number of sit-ups performed from pre-test to post-test, which indicates an improvement in muscular endurance. Similarly, the bar diagram representing variance shows a slight decrease in variability in post-test scores, suggesting that the performances of the subjects became more consistent after plyometric training.

3.1.3: Analysis of Covariance (ANCOVA) for Muscular Endurance (Bent Knee Sit-ups Test)

Source	df	Sum of Squares	Mean Square	F-value	p-value
Pre-Test	1	43.51	43.51	26.39	< 0.001
Groups	1	538.90	538.90	326.83	< 0.001
Error	57	93.99	1.65		

The ANCOVA results reveal that the F-value for the pre-test is 26.39, which is statistically significant at the 0.05 level. This indicates that pre-test scores have a significant influence on post-test performance. More importantly, the F-value for the groups is 326.83, which is highly significant ($p < 0.001$). This clearly indicates that there is a statistically significant difference between the control and experimental groups after adjusting for pre-test scores.

3.1.4: Adjusted Post-Test Means for Muscular Endurance (Bent Knee Sit-ups Test)

Group	Adjusted Mean (repetitions/min)	Standard Error	95% Confidence Interval
Control	33.4	0.244	32.9 – 33.9
Experimental	39.8	0.244	39.3 – 40.3

The adjusted post-test mean for the experimental group is 39.8 repetitions per minute, whereas for the control group it is 33.4 repetitions per minute. Since a higher number of repetitions indicates better performance in the Bent Knee Sit-ups Test, the experimental group performed significantly better than the control group after undergoing the plyometric training programme. The confidence intervals are relatively narrow, indicating precision in the estimation of adjusted means.

Since the obtained p-value is less than 0.05, the null hypothesis is rejected and the alternative hypothesis is accepted. It is therefore concluded that the plyometric training programme has a significant effect on improving muscular endurance, even after adjusting for initial differences between groups. The results obtained from ANCOVA clearly indicate that plyometric training significantly improves muscular endurance (measured in repetitions per minute using the Bent Knee Sit-ups Test) among football players of the Marathwada region.

3.2: Flexibility (Sit and Reach Test)

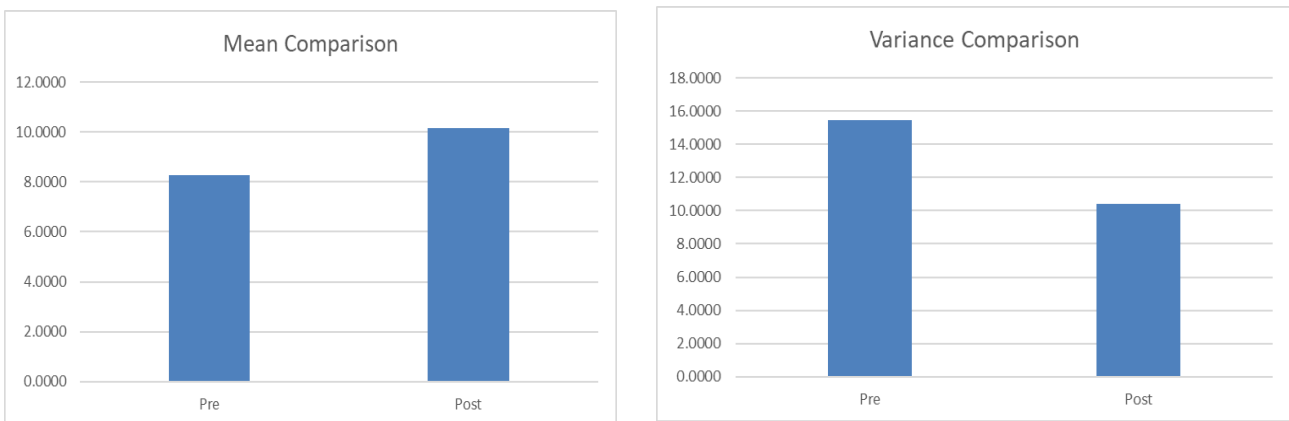
3.2.1: Paired t-Test Analysis of Pre-Test and Post-Test Scores for Flexibility (Sit and Reach Test)

t-Test: Paired Two Sample for Means		
	Pre-Test	Post-Test
Mean	8.266666667	10.16667
Variance	15.44367816	10.41954
Observations	30	30
Pearson Correlation	0.966819759	
Hypothesized Mean Difference	0	
df	29	
t Stat	-9.00860914	
P(T<=t) one-tail	3.33535E-10	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	6.6707E-10	
t Critical two-tail	2.045229642	

A paired sample t-test was conducted to examine the effect of the training programme on flexibility performance of the participants, assessed through the Sit and Reach Test. The results showed that the mean pre-test score was 8.27 (Variance = 15.44), whereas the mean post-test score increased to 10.17 (Variance = 10.42), indicating improvement in flexibility after the training programme.

The calculated t-value was -9.01 with 29 degrees of freedom (df = 29). The obtained two-tailed p-value was 6.67×10^{-10} , which is much lower than the commonly accepted significance level of 0.05. Therefore, the difference between pre-test and post-test scores was found to be statistically significant. This indicates that the training programme had a significant positive effect on the flexibility of the subjects. The high Pearson correlation ($r = 0.967$) also shows a strong relationship between pre-test and post-test scores of the participants. Since $p < 0.05$, the null hypothesis was rejected, and it was concluded that the training programme significantly improved flexibility performance.

3.2.2: Bar Diagram Showing Comparison of Mean and Variance Scores of Pre-Test and Post- Test for Flexibility (Sit and Reach Test)



The bar diagram representing the mean scores clearly shows an increase in the distance reached in the Sit and Reach Test from pre-test to post-test, which indicates an improvement in flexibility. Similarly, the bar diagram representing variance shows a decrease in variability in post-test scores, suggesting that the performances of the subjects became more consistent after plyometric training.

3.2.3: Analysis of Covariance (ANCOVA) for Flexibility (Sit and Reach Test)

Source	df	Sum of Squares	Mean Square	F-value	p-value
Pre-Test	1	762.86	762.86	558.77	< 0.001
Groups	1	224.92	224.92	164.74	< 0.001
Error	57	77.82	1.37		

The ANCOVA results reveal that the F-value for the pre-test is 558.77, which is statistically significant at the 0.05 level. This indicates that pre-test scores have a significant influence on post-test performance. More importantly, the F-value for the groups is 164.74, which is highly significant ($p < 0.001$). This clearly indicates that there is a statistically significant difference between the control and experimental groups after adjusting for pre-test scores.

3.2.4: Adjusted Post-Test Means for Flexibility (Sit and Reach Test)

Group	Adjusted Mean (cm)	Standard Error	95% Confidence Interval
Control	7.84	0.215	7.41 – 8.27
Experimental	11.76	0.215	11.33 – 12.19

The adjusted post-test mean for the experimental group is 11.76 cm, whereas for the control group it is 7.84 cm. Since a higher value indicates better performance in the Sit and Reach Test, the experimental group performed significantly better than the control group after undergoing the plyometric training programme.

The confidence intervals are reasonably narrow, indicating precision in the estimation of adjusted means. Since the obtained p-value is less than 0.05, the null hypothesis is rejected and the alternative hypothesis is accepted. It is therefore concluded that the plyometric training programme has a significant effect on improving flexibility, even after adjusting for initial differences between groups. The results obtained from ANCOVA clearly indicate that plyometric training significantly improves flexibility (measured in centimeters using the Sit and Reach Test) among football players of the Marathwada region.

DISCUSSION

The results of the present study indicate that a twelve-week plyometric training programme significantly improved muscular endurance and flexibility among football players. The improvement in muscular endurance may be attributed to repeated muscular contractions involved in plyometric exercises, which enhance fatigue resistance and neuromuscular efficiency.

The improvement in flexibility may be explained by the dynamic stretching and stretch-shortening cycle actions involved in plyometric movements, which increase joint mobility and muscle elasticity over time.

These findings are consistent with previous research by Wankhede and Painjane (2020), Bokkasam and Lillypushpam (2020), and Patir and Singh (2021), who reported significant improvements in flexibility and muscular endurance following plyometric training interventions in various sports populations.

CONCLUSION

It is concluded that a twelve-week plyometric training programme is effective in improving muscular endurance and flexibility among football players. Therefore, plyometric training can be recommended as a valuable component of conditioning programmes for football athletes.

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