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Effect of Stretch and Hold, Ballistic, and PNF Stretching on Hamstring and Lower Back Flexibility in Cricket Players.

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Abstract: This study evaluates the effectiveness of three stretching techniques, which includes Stretch and Hold training, Ballistic Training, and Proprioceptive Neuromuscular Facilitation (PNF) training in Improving hamstring and lower back flexibility among cricket players. A total of 100 participants (25 per group) were assessed, with the Shapiro-Wilk test confirming data normality. Paired t-tests and ANCOVA were conducted to determine training effectiveness. The results indicated significant flexibility improvements across all methods, with PNF training demonstrating the greatest increase (40.75%), followed by Ballistic Training (31.50%) and Stretch and Hold (28.37%). Post-hoc analysis further confirmed PNF's superiority over the other techniques. These findings highlight the effectiveness of dynamic and neuromuscular stretching in improving flexibility, with important implications for athletic training and injury prevention.

Keywords: Cricket Training, Hamstring Flexibility, Lower back Flexibility, PNF Training, Ballistic Training, Stretch and Hold Training, Flexibility Enhancement, Sports Performance.

I. INTRODUCTION

Flexibility is a crucial component of athletic performance, particularly in sports requiring dynamic movements, agility, and strength. Cricket, a sport characterized by frequent bending, lunging, and rapid directional changes, places significant stress on the hamstring and lower back muscles (Draper et al., 2009). Insufficient flexibility in these areas can increase injury risk and hinder overall performance. Therefore, effective training methods to enhance flexibility are essential for cricket players to improve mobility, reduce injury susceptibility, and optimize athletic performance (Gleim & McHugh, 1997).

The hamstrings play a vital role in cricket, particularly during sprinting and quick directional changes (Orchard et al., 2017). Increased hamstring flexibility contributes to enhanced stride length and efficient sprint mechanics. By allowing greater leg extension and range of motion, flexible hamstrings enable players to move faster, which is essential for running between the wickets, chasing balls in the outfield, and executing rapid fielding maneuvers. Conversely, tight hamstrings restrict movement, increasing the likelihood of muscle strains and impairing a player's ability to react swiftly and effectively.

Similarly, lower back flexibility is fundamental in cricket due to the sport's heavy reliance on rotational movements. Batting requires significant torso rotation to generate power and control, while bowlers depend on spinal flexibility to achieve the range of motion necessary for delivering fast, accurate balls (Vijayanand, 2012). Fielders also rely on trunk rotation when throwing and lunging for catches. Limited lower back flexibility can restrict these movements, reducing power output and increasing the risk of discomfort or injury. Given these demands, flexibility training is indispensable for cricket players seeking to enhance performance, maintain agility, and minimize injury risk (Elahi, 2024). Developing flexible hamstrings and a supple lower back allows players to execute the high-intensity, complex movements required in cricket more effectively and efficiently.

Incorporating targeted stretching techniques into cricket training programs is essential for improving flexibility. Dynamic stretching before practice or matches prepares muscles for high-intensity activity, while static stretching post-exercise aids in muscle recovery and long-term flexibility gains. Specific techniques such as hamstring stretches, lumbar mobility exercises, and yoga-based routines can be particularly beneficial for cricket players (Chaouachi et al., 2010).

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The biomechanics of stretching techniques involve muscle elongation, neural adaptation, and motor control. Muscle elongation refers to the mechanical lengthening of muscle fibers and connective tissues, enhancing their capacity to tolerate greater ranges of motion, reducing stiffness, and improving flexibility. Neural adaptation plays a key role, as the nervous system gradually reduces its protective tension responses, allowing muscles to relax and extend further. Motor control improvements arise from enhanced proprioception and neuromuscular coordination, enabling more efficient movement patterns and optimized flexibility gains.

Extensive research has examined the effectiveness of various stretching techniques in sports and rehabilitation. Stretch and Hold stretching, commonly known as static stretching, improves muscle flexibility when performed consistently. Studies indicate that holding a stretch for 15–30 seconds effectively increases range of motion and reduces muscle tightness. Ballistic stretching, characterized by rapid, bouncing movements, has demonstrated benefits for athletes requiring explosive power and agility (Weerapong et al., 2004), though it carries a higher risk of muscle strain, making it less suitable for beginners. Proprioceptive Neuromuscular Facilitation (PNF) stretching is widely recognized for its superior ability to enhance flexibility. By combining passive stretching with isometric contractions, PNF techniques promote deeper muscle relaxation and elongation, making them particularly effective for sports requiring extensive joint mobility and flexibility control.

This study investigates the impact of three popular stretching techniques-Stretch and Hold, Ballistic, and PNF on hamstring and lower back flexibility. Each method employs distinct physiological mechanisms to enhance muscle elasticity and range of motion. Stretch and Hold (static stretching) involves maintaining a fixed muscle position for an extended duration to promote gradual elongation. Ballistic Training utilizes rapid, bouncing movements to extend the muscle beyond its typical range, aiming to improve dynamic flexibility. PNF stretching combines muscle contraction and relaxation phases to achieve deeper muscle stretching and improved flexibility.

To evaluate the effectiveness of these methods, this study employed statistical analyses, including the Shapiro-Wilk normality test, paired t-tests, and Analysis of Covariance (ANCOVA). Pre- and post-test flexibility scores were compared across the three training methods to assess their impact on flexibility outcomes. Additionally, post-hoc analysis was conducted to determine significant differences among the techniques, providing insights into the most effective approach for cricket players. By identifying the most effective stretching technique, this research aims to inform athletes, coaches, and sports therapists about evidence-based flexibility training strategies. The findings are expected to contribute valuable insights into enhancing cricket players' performance while reducing the risk of hamstring and lower back injuries.

II. METHODOLOGY

This study aimed to evaluate the effectiveness of different stretching methods in enhancing Hamstring and lower back flexibility among cricketers in Kashmir. For this purpose, the researcher randomly selected 100 male cricket players from Government Higher Secondary School Pinglena and Skylight Higher Secondary School Pampore in the Kashmir region. The subjects were aged between 15 and 18 years.

The selected subjects were randomly assigned to four groups (I-IV), with each group containing 25 participants. Group I served as the control group, while Groups II-IV comprised experimental subjects undergoing different stretching methods: the Stretch-and-Hold method, the Ballistic Stretching method, and the Proprioceptive Neuromuscular Facilitation (PNF) method, respectively. All groups (I-IV) underwent a pre-test; however, only the experimental groups (II-IV) participated in a 12-week training program, with six training sessions per week. Each morning workout lasted approximately 45 to 60 minutes, including warm-up and cool-down exercises. In this study, the Sit and Reach test was used to evaluate hamstring and lower back flexibility.

A pre-test and post-test design was implemented, utilizing the Sit and Reach Test to measure flexibility of Hamstring and Lower back. The primary objective was to determine which stretching technique resulted in the most significant improvement in Hamstring and Lower back flexibility. A multi-stage statistical analysis was conducted to ensure a comprehensive evaluation of the interventions.

Statistical Analysis

The collected data will be analyzed using the Shapiro-Wilk test to assess normality (Yazici&Yolacan, 2007). Paired t-tests will be used to compare pre- and post-intervention flexibility scores within each group (Grindem et al., 2012). ANCOVA will be employed to evaluate differences between groups while controlling for baseline flexibility levels (Federolf et al., 2014). Additionally, post-hoc analysis will be conducted to identify the most effective stretching method for improving flexibility in cricket players.

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III. RESULT AND ANALYSIS

3.1 Normality Test

The Shapiro-Wilk test is a statistical method used to assess whether a dataset follows a normal distribution. It calculates a test statistic (W), where values closer to 1 indicate normality. Additionally, the p-value helps determine if deviations from normality are statistically significant. If the p-value is less than 0.05, the null hypothesis (H_0) of normality is rejected; otherwise, normality is assumed.

Null Hypothesis (H_0):

- The test assumes that the data is normally distributed.
- If the p-value is greater than the significance level (α), we fail to reject H_0, meaning there is no strong evidence against normality.

Table 1: Shapiro-Wilk test for Stretch and Hold, Ballistic and PNF training

	Control Group	Stretch and Hold	Ballistic	PNF
Parameter	Value	Value	Value	Value
P-value	0.7989	0.1349	0.126	0.5143
W	0.9761	0..9383	0.937	0.9646
N	25	25	25	25
Mean	8.92	11.04	11.16	11.88
S.D	4.654	2.83	3.1316	3.0865

The table 1 presents the results of a Shapiro-Wilk normality test for three different techniques: Stretch and Hold, Ballistic, and PNF. The probability value from the Shapiro-Wilk test, indicating whether the data follows a normal distribution. Since all p-values (0.1349, 0.126, and 0.5143) are greater than 0.05, the normality assumption is not rejected for any technique. The test statistic from the Shapiro-Wilk test, where values closer to 1 suggest the data is normally distributed.

3.2 Paired t-Test

The paired t-test was performed to analyze the differences between pre-test and post-test mean values for the three training methods—Stretch and Hold, Ballistic Training, and PNF Training—used to improve hamstring and lower back flexibility in cricket players. This test helps determine whether the changes observed in post-test scores are statistically significant by comparing the means of the same group before and after the intervention.

Table 2: t-Test: Paired Two Sample for Means

	Stretch and Hold Training		**Ballistic Training**		**PNF Training**	
Parameters	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
Mean	8.6	11.04	8.76	11.52	8.44	11.88
Variance	15.83333	8.04	18.69	8.676667	17.92333	9.526667
Observations	25	25	25	25	25	25
Pearson Correlation	0.898866		0.932901		0.979941	
Hypothesized Mean Difference	0		0		0	
df	24		24		24	
t Stat	-6.43891		-7.26651		-12.68	
P(T<=t) one-tail	5.85E-07		8.29E-08		1.98E-12	
t Critical one-tail	1.710882		1.710882		1.710882	
P(T<=t) two-tail	1.17E-06		1.66E-07		3.96E-12	
t Critical two-tail	2.063899		2.063899		2.063899	

The statistical results comparing the effectiveness of three stretching techniques — Stretch and Hold, Ballistic, and PNF training — demonstrate significant improvements in flexibility across all groups. The mean flexibility scores

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improved notably for each method, increasing from 8.6 to 11.04 for Stretch and Hold, 8.76 to 11.52 for Ballistic, and 8.44 to 11.88 for PNF stretching. Variance values decreased across all groups, indicating greater consistency in post-test results. Pearson correlation values were strong in each case (0.898866 for Stretch and Hold, 0.932901 for Ballistic, and 0.979941 for PNF), reflecting a high correlation between pre- and post-test scores. The low p-values (e.g., 1.17E-06 for Stretch and Hold) demonstrate that these improvements are statistically significant, with t-values exceeding their respective critical thresholds. Overall, the data highlights that while all three methods improved flexibility, PNF stretching showed the most significant gains, making it the most effective intervention for enhancing cricket players' flexibility as shown in Table 2.

3.3 Comparison between Stretch and Hold, Ballistic and PNF Training (Sit and Reach Test)

The comparison of the three methods—Stretch and Hold, Ballistic Training, and PNF—in terms of hamstring and lower back flexibility among cricket players reveals significant differences in their effectiveness. PNF showed the greatest improvement, with a mean increase from 8.44 to 11.88, followed by Ballistic Training (8.76 to 11.52) and Stretch and Hold (8.6 to 11.04) as shown in Figure 1. The variance reduction was most pronounced in stretch and hold (from 15.833 to 8.04), indicating greater consistency in post-test scores, whereas PNF Training also showed variance reduction (17.9233 to 9.526), but Ballistic Training had the least variance (18.69 to 8.676) as shown in Figure 2. However, the strongest impact on flexibility was observed with PNF, making it the most effective method, while Ballistic Training showed moderate effectiveness, and Stretch and Hold had the least impact among the three.

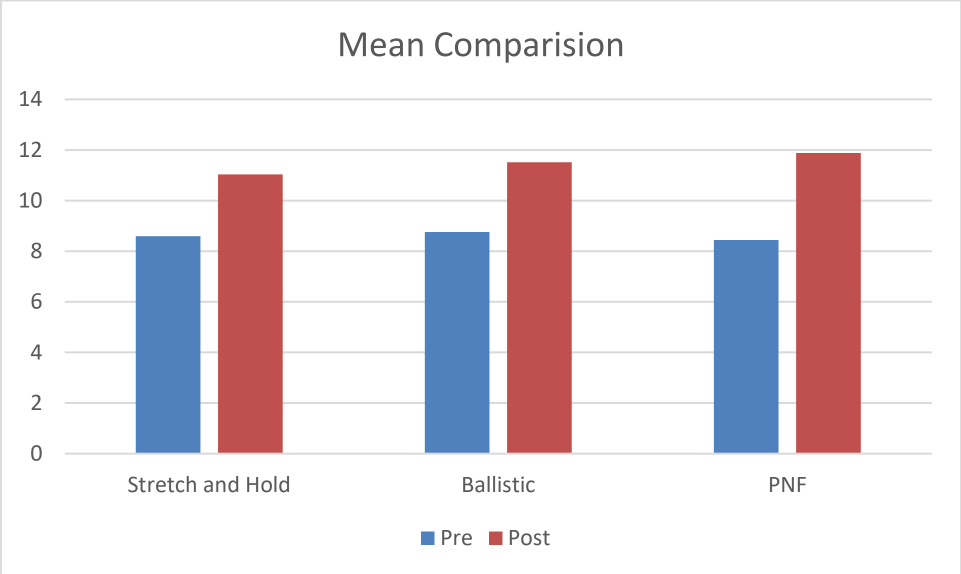

Figure 1: Mean Comparison between Stretch and Hold, Ballistic and PNF

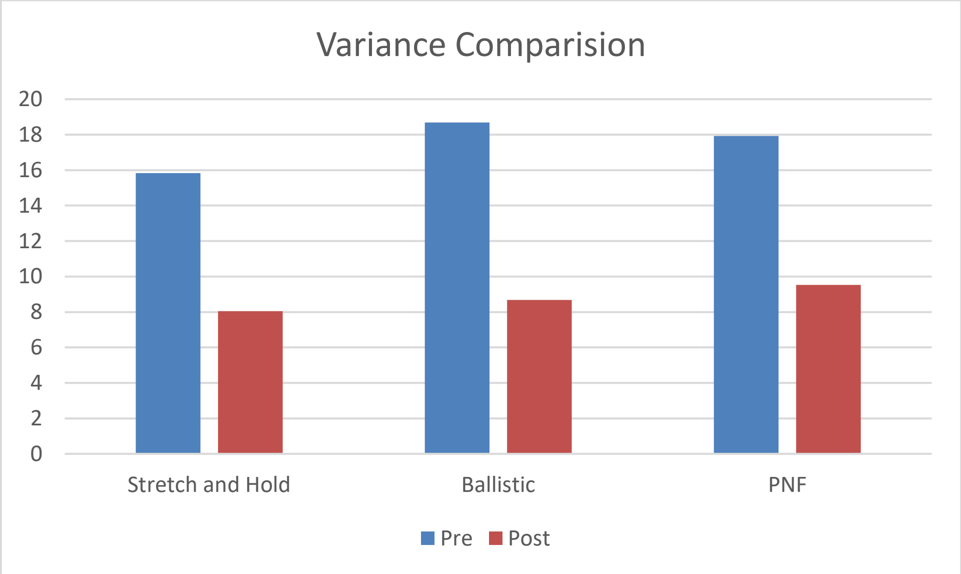

Figure 2: Variance Comparison between Stretch and Hold, Ballistic and PNF

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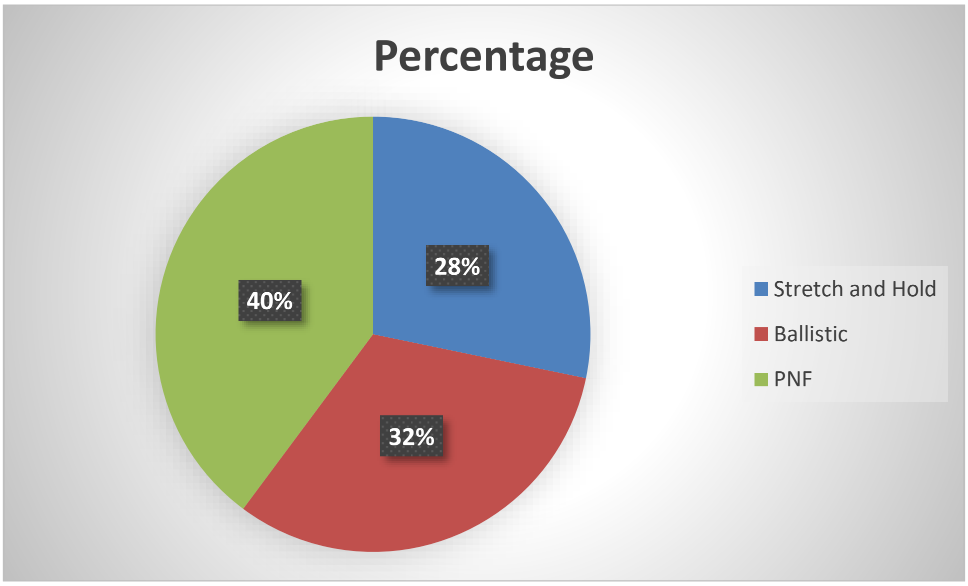

Figure 3: Percentage Improvement in Hamstring and Lower Back Flexibility across Different Training Methods

The PNF technique resulted in the highest improvement (40%), suggesting it is the most effective method for enhancing flexibility among cricket players. Ballistic Training showed a moderate improvement of 32%, while the Stretch and Hold method had the lowest impact (28%). These findings highlight the effectiveness of dynamic and neuromuscular stretching techniques over static stretching as shown in Figure 3.

IV. ANALYSIS OF COVARIANCE

Analysis of Covariance (ANCOVA) is a statistical technique that combines ANOVA and regression by adjusting the dependent variable for the effects of one or more covariates. In this study, ANCOVA was used to assess the effectiveness of different training methods—Stretch and Hold, Ballistic Training, and PNF—on hamstring and lower back flexibility in cricket players while controlling for potential confounding variables.

Table 3: ANCOVA result of Control, Stretch and Hold, Ballistic Training, and PNF Training after adjusting for pre-test scores on the Sit and Reach.

Source	Df	Sum Sq	Mean Sq	F Value	Pr(>F)
Pre-Test (Covariate)	1	1058.1	1058.1	1084.27	< 2e-16
Group (Training Method)	3	147.9	49.3	50.52	< 2e-16
Residuals	95	92.7	1.0		

The ANCOVA results as shown in Table 3 reveal that the pre-test scores significantly influence the post-test scores ($p < 2e-16$), justifying the use of ANCOVA over a simple ANOVA as it accounts for this covariate, improving the accuracy of group comparisons. Furthermore, the highly significant group effect ($p < 2e-16$) indicates that the different training methods — Control, Stretch, Ballistic, and PNF — have a notable impact on post-test scores even after adjusting for pre-test differences.

This finding suggests that at least one of these training methods leads to a statistically significant improvement in flexibility compared to the others. The residual sum of squares (92.7) and mean square (1.0) reflect the unexplained variance, while the high F-value (50.52) underscores the strong effect of the training method on the post-test scores.

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Table 4: Pairwise Comparisons between Groups

Contrast	Mean Difference	SE	t-value	p-value
Ballistic - Control	2.33356	0.279	8.351	< 0.0001
Ballistic - PNF	-0.9695	0.28	-3.469	0.0047
Ballistic - Stretch	-0.00475	0.279	-0.017	1.0000
Control - PNF	-3.30306	0.28	-11.813	< 0.0001
Control - Stretch	-2.33831	0.279	-8.366	< 0.0001
PNF - Stretch	0.96475	0.279	3.452	0.0050

The pairwise comparisons between groups reveal significant differences in post-test scores across training methods. The Ballistic group scored significantly higher than the Control group with a mean difference of 2.33 (SE = 0.279, $p< 0.0001$). However, the Ballistic group scored significantly lower than the PNF group by 0.97 points (SE = 0.28, $p = 0.0047$) and showed no meaningful difference compared to the Stretch group (mean difference = -0.00475, SE = 0.279, $p = 1.0000$).

The Control group scored significantly lower than both the PNF group (mean difference = -3.30, SE = 0.28, $p< 0.0001$) and the Stretch group (mean difference = -2.34, SE = 0.279, $p< 0.0001$). Lastly, the PNF group outperformed the Stretch group with a mean difference of 0.96 (SE = 0.279, $p = 0.0050$), indicating a notable advantage. These results highlight that the PNF method generally leads to the highest flexibility improvements, while the Control group shows the least improvement as shown in Table 4.

Result of Table 4

1. PNF Training resulted in the highest post-test flexibility scores (Mean = 12.06), significantly higher than all other groups.
2. Ballistic Training also showed significant improvements compared to the Control group but was significantly less effective than PNF.
3. The Control group had the lowest post-test flexibility scores, showing significantly lower improvements than all training methods.
4. Stretch and Hold Training was better than the Control group but did not significantly differ from Ballistic Training.

V. CONCLUSION

The findings of this study demonstrate that all three stretching techniques—Stretch and Hold, Ballistic Training, and Proprioceptive Neuromuscular Facilitation (PNF)—effectively improved hamstring and lower back flexibility in cricket players. Among these methods, PNF stretching proved to be the most effective, yielding the greatest improvement in flexibility (40.75%). Ballistic Training followed with moderate improvement (31.50%), while Stretch and Hold achieved the least impact (28.37%). These results emphasize the superior efficacy of dynamic and neuromuscular stretching techniques over static stretching in enhancing flexibility.

The results of ANCOVA further confirmed significant differences in flexibility outcomes between groups, with the PNF method outperforming all other techniques. The pairwise comparisons underscored this advantage, highlighting PNF's substantial contribution to post-test flexibility gains compared to the other methods.

Based on these findings, incorporating PNF stretching techniques into cricket training programs is strongly recommended to optimize flexibility gains, improve athletic performance, and reduce injury risks. While Ballistic and Stretch and Hold methods offer notable benefits, athletes, coaches, and sports therapists should prioritize PNF strategies to achieve superior flexibility outcomes. Future research could explore the long-term impact of these stretching methods and their influence on cricket-specific performance metrics such as sprinting, fielding efficiency, and injury prevention.

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