



## Effectiveness of post isometric relaxation versus jack knife technique on flexibility, agility, and dynamic balance in young adults with hamstring tightness: A randomized experimental study

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### Abstract

**Background:** Hamstring tightness impairs flexibility, agility, and dynamic balance, increasing the risk of musculoskeletal injury. While Post-Isometric Relaxation (PIR) and the Jack Knife Technique (JKT) are common interventions, their comparative effectiveness remains unclear.

**Objective:** To compare the effects of PIR and JKT on hamstring flexibility, agility, and dynamic balance in healthy young adults with bilateral hamstring tightness.

**Methods:** Forty-six participants aged 18–25 with asymptomatic bilateral hamstring tightness were randomly allocated into two groups: PIR (n=23) and JKT (n=23). Interventions were administered thrice weekly over four weeks. Outcome measures included the Back Saver Sit and Reach (BSSR) for flexibility, T-Test for agility, and Y-Balance Test (YBT) for dynamic balance. Paired t-test, Wilcoxon test, independent t-test, and Mann-Whitney U test were used for analysis at  $\alpha=0.05$ .

**Results:** Both groups showed significant within-group improvements ( $p<0.001$ ). PIR showed greater improvement in flexibility ( $2.98\pm0.74$  cm vs  $2.34\pm0.59$  cm;  $p=0.003$ ), agility ( $1.18\pm0.18$  sec vs  $0.99\pm0.13$  sec;  $p<0.001$ ), and dynamic balance ( $1.83\pm0.29\%$  vs  $1.46\pm0.21\%$ ;  $p<0.001$ ) compared to JKT.

**Conclusion:** Both techniques effectively improve flexibility, agility, and dynamic balance in young adults with hamstring tightness. PIR demonstrated superior efficacy across all parameters.

**Keywords:** Hamstring tightness, post-isometric relaxation, jack knife technique, flexibility, agility, dynamic balance, young adults

### Introduction

Hamstring tightness is a commonly encountered musculoskeletal issue, especially among young adults, and it is frequently associated with decreased flexibility, compromised movement patterns, and increased risk of lower limb and spinal injuries. The hamstring muscle group plays a vital role in maintaining optimal biomechanics of the pelvis, hip, and knee. Tightness in these muscles can adversely affect postural control, dynamic balance, and athletic performance. Hamstring tightness is prevalent among youth and may impair flexibility, agility, and dynamic balance, increasing injury risk. Stretching techniques like PIR and JKT are commonly used in physiotherapy but lack comparative studies, particularly in the Indian population<sup>[1]</sup>.

This study investigates the comparative effectiveness of PIR and JKT in improving functional outcomes in young adults with bilateral hamstring tightness. Modern sedentary lifestyles, prolonged sitting, and lack of regular physical activity contribute significantly to reduced hamstring extensibility. Prolonged muscle shortening leads to alterations in the muscle-tendon unit, increasing the risk of strains and functional limitations. Therefore, early identification and management of hamstring tightness are essential to maintain mobility and prevent future musculoskeletal complications<sup>[2, 3]</sup>.

A variety of stretching techniques are utilized in physiotherapy to manage muscle tightness, including static stretching, proprioceptive neuromuscular facilitation (PNF),

and muscle energy techniques (MET). Among MET approaches, Post-Isometric Relaxation (PIR) uses gentle isometric contractions followed by passive stretching, enhancing muscle length and decreasing tone via autogenic inhibition mediated by Golgi tendon organ stimulation. Conversely, the Jack Knife Technique (JKT), a blend of dynamic and static self-stretching movements, is commonly used in athletic settings and physical education programs, especially in Japan. While individual studies have examined these techniques, there is limited comparative evidence on their relative efficacy, particularly in the Indian context<sup>[3, 4]</sup>. This study aims to compare the effectiveness of PIR and JKT on hamstring flexibility, agility, and dynamic balance among healthy young adults with bilateral hamstring tightness. The findings may guide clinicians and educators in selecting effective interventions for improving lower limb function and preventing injuries. The prevalence of hamstring tightness is high (68%) and its prevalence rate is increasing day by day due to inactive-sedentary lifestyle. The hamstrings serve as the primary knee joint flexors and having tight hamstrings can lead to changes in biomechanics. This, in turn, can result in altered joint reaction forces during regular daily activities. Taut hamstrings not only disrupt the biomechanics of the knee joint but also impact joint reaction forces and the mechanics of the hip and ankle joints. This disturbance leads to irregular gait patterns and abnormal loading on the feet. The plantar fascia undergoes repetitive trauma, potentially culminating in conditions like plantar fasciitis and heel pain.

Different Stretching techniques can be used for preventing tightness of hamstrings and complications associated with it. Since there are less evidence for PIR as well as jack knife individually, while there are no studies comparing the both PIR and jack knife technique hence this is significant to evaluate the effect of it. The purpose of this study is to compare out the effect of PIR and jack knife stretching technique on flexibility, agility and dynamic postural control in asymptomatic individuals with hamstring tightness.

## Methodology

### Sample Size

was estimated in G Power 3.1.9.7 version with effect size 0.94 and  $\alpha=0.05$  at 80% power. Sample size calculated was 38, with a drop out chances of 20% the total sample size was  $n=46$ . So, 46 participants were included in this study i.e. 23 in each group. 6.7 Study Setting: SPB Physiotherapy College and other OPDs of Surat.

### Study Design and Setting

This was a randomized, pre-post experimental study conducted at SPB Physiotherapy College, Surat. Ethical clearance was obtained from the institutional ethics committee.

### Participants

A total of 46 healthy male and female participants aged 18–25 years with asymptomatic bilateral hamstring tightness were recruited. Participants were included if their flexibility score fell within or below 'average' as per YMCA's normative values. Individuals with a history of musculoskeletal injury, surgery, back pain, or neurological symptoms were excluded.

### The Sample Size

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### Selection Criteria

#### Inclusion criteria

- Those who are willing to participate in the study [2].
- Age group between 18-25 years [5].
- Both male and female participants will be included [5].
- Subjects with asymptomatic bilateral hamstring tightness and in category  $\leq$  "average" according YMCA's normative value for sit and reach test [6].

#### Exclusion criteria

- Subjects unwilling to participate [5].
- History of any trauma, fractures or other soft tissue injury (past 1 year) of pelvis/hip/knee [5].
- surgical history of hip or knee in past 1 year [7].
- Radiating symptoms in the lower limb [7].
- Past history of any contusion or strain on either quadriceps or hamstring muscle in last 1 year [7].
- Subject having back pain [23].
- Subject with presence of any bleeding disorders [7].
- Inflammatory condition of hip or knee [7].

### Sampling and Randomization

Convenience sampling was used. Participants were

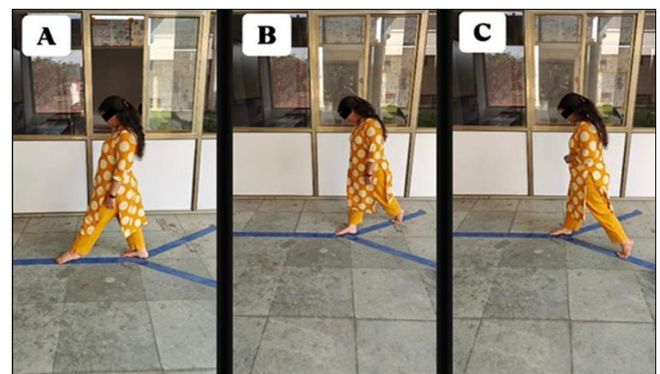
randomly allocated into two intervention groups using a chit-based randomization method.

### Outcome Measures

- Flexibility:** Back Saver Sit and Reach (BSSR) Test
- Agility:** T Agility Test
- Dynamic Balance:** Y Balance Test (YBT)

### Y balance test

- The Y Balance Test was employed as a valid and reliable measure to assess dynamic balance. The procedure involved a grid with three lines extending outward at 120° angles.
- Participants stood on one leg, placing their first toe at the centre of the grid line, and were instructed to raise the opposite leg.
- They then stretched the raised leg as far as possible along each of the three lines, touched the line, and returned to the starting position while maintaining a single leg stance at the grid's centre.
- Three consecutive trials were conducted for each reach direction: right anterior, left anterior, right posteromedial, left posteromedial, right posterolateral, and left posterolateral. Trials were excluded if participants touched the ground for support or shifted their stance limb during the movement.
- The scoring was determined by measuring the distance reached in centimetres. This distance was then divided by the participant's leg length and multiplied by 100 to calculate the final score using the formula: (reach distance in cm/leg length  $\times$  100) [8].
- YBT has Interrater test-retest reliability of the of 0.80 to 0.85 and intraclass correlation coefficients of 0.85 to 0.93 [9].



### T agility test

#### Equipment

- Four cones
- A measurement with minimum length of 5 yards (4.6m)
- Stop watch

#### Flat surface Procedure

- Four cones (A, B, C, and D) were arranged as illustrated in the figure. Prior to the test, participants were instructed to warm up and perform stretching exercises.
- They were allowed to practice the course with submaximal effort before the actual test began.
- The test started with participants positioned at point A. Upon an auditory signal, they sprinted forward to point B and touched the base of the cone with their right

hand. While maintaining a forward-facing stance and avoiding crossing their feet, participants shuffled to the left for a distance of 5 yards (4.6 m) and touched the base of the cone at point C with their left hand. They then shuffled to the right for a distance of 10 yards (9.1 m) and touched the base of the cone at point D with their right hand.

- Following this, participants shuffled back to the left for 5 yards and touched the base of the cone at point B with their left hand.
- Finally, they ran backward, passing point A, at which point the stopwatch was stopped.
- The best time from two trials was recorded, rounded to the nearest 0.1 second.
- Trials were disqualified if participants failed to touch the base of any cone, crossed one foot in front of the other instead of shuffling their feet, or did not face forward throughout the test<sup>[10]</sup>.



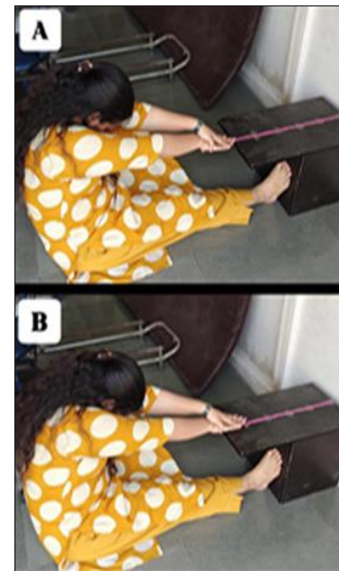
- In a previous study, the intraclass reliability of the T-test was reported to be 0.98 across three trials. Regression analyses demonstrated that 48% of the variability in T-test scores for men and 62% for women could be predicted from measures of leg power, leg speed, and agility. The criterion validity of the T-test as a measure of agility, leg power, and leg speed was assessed using partial correlations<sup>[11]</sup>.

### Back Saver Sit & Reach Test

- The Back Saver Sit and Reach test was utilized as a practical assessment to evaluate the flexibility of the hamstrings.
- This test has been widely recognized and included in various health-related fitness evaluations due to its association with preventing acute and chronic musculoskeletal injuries, low back problems, postural deviations, gait limitations, and the risk of falls.
- In the BSSR test, participants were seated at the sit-and-reach box with one leg fully extended, ensuring the sole of the foot was flat against the end of the box. The other leg was bent, with the sole of the foot flat on the floor, positioned 7-10 cm to the side of the straight knee.
- Participants were instructed to keep the extended leg as straight as possible while placing their hands on top of

each other, aligning the tips of their middle fingers, and keeping their palms facing downward. They were then asked to reach forward slowly, sliding their hands along the scale of the box and aiming to reach as far as possible.

- The physiotherapist recorded the average of three trials for each leg. Based on the findings of a previous study, the BSSR test for the left leg ( $p < 0.01$ ) and the right leg ( $p < 0.05$ ) demonstrated significant associations with hamstring flexibility. These results indicated that the BSSR test provided accurate and reliable measures of hamstring flexibility<sup>[12]</sup>.



**Procedure:** Ethical clearance was taken from the Institutional Ethical Committee of SPB Physiotherapy College. Reference number of IEC approval letter is EC/SPB/093. The participants were screened on the basis of inclusion and exclusion criteria and their demographic data was taken by an assessment Performa. Prior to the commencement of the study, detailed procedure of the study was explained to the participants and a signed informed consent form was collected from them. Then the participants were randomly assigned to a 4-week intervention protocol and allocated randomly to Group A and Group B. The subjects were allocated to any of the two groups by random allocation using chit method. The therapist assessed for Sit and reach test, Y balance test and t agility test before the intervention on the first day of the treatment. Description of the groups is given below: Group A = Post isometric relaxation Group B = Jack knife technique on the first day of the first week, baseline measurements of sit and reach test, Y-balance test and t agility test were taken. Total treatment was of 4 weeks with 3 sessions per week. Post assessment data of SR test, YBT, t agility test was taken at the end of 4 week.

### Intervention

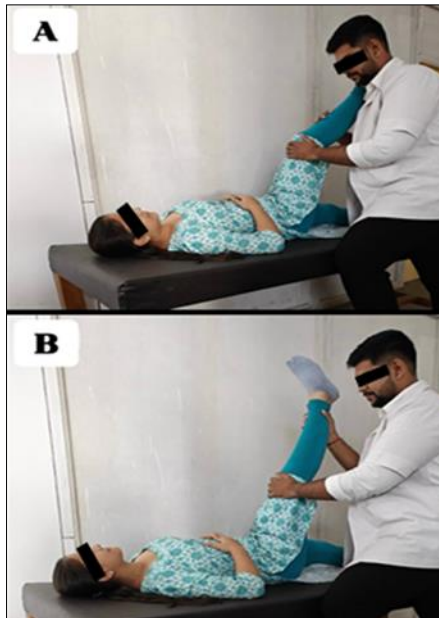
**Intervention for Group A:** Post isometric relaxation for hamstring muscle was performed by therapist for 3 days per week for 4 weeks.

### Post Isometric Relaxation

- Subject was asked to lie down in supine position with contralateral hip and knee semi flexed position.

Therapist standing on the intervention side of the subject, facing the head end of the plinth.

- The leg to be treated flexed fully at hip and knee, and then was extended until the restriction barrier is identified.
- The leg of the treated side is placed on the therapist’s shoulder, for e.g. right leg on right shoulder. The subject then instructed to gently bend the knee against the resistance (the counterforce was given by the therapist’s shoulder) starting slowly and using only sub maximal strength (20%-30%).



- Subjects were instructed to Inhale, and slowly build up an isometric contraction; breath was held during the 7-10 sec of contraction. Release the breath as slowly cease the contraction.
- Inhale and exhale fully once more following cessation of all efforts. During the second exhalation leg was straightened at the knee towards its new barrier. Procedure is repeated two-three more times and three time per week for four weeks. • If appropriate, visual synkinesis (i.e. looking in the direction of contraction and then the direction of release) was added. Also, respiratory synkinesis (inhale during most contractions and exhale during release) was also used along with visual synkinesis [5, 13].

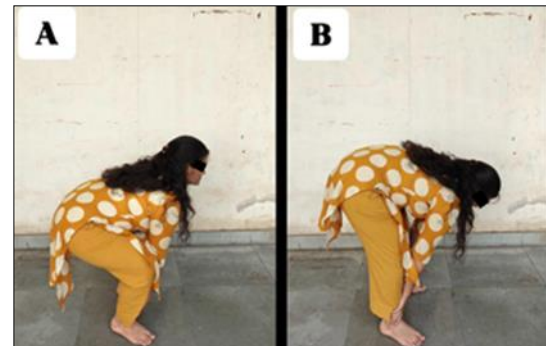
**Intervention for Group B**

After familiarization with technique, participants were asked to perform jack knife technique for three times per week for four weeks.

**Jack Knife Technique**

- Participants were asked to stand with slightly wider stance than shoulder width.
- Then participants were asked to squat down while holding their ankle joint with their hands, participants were asked to hold this position for 5-7 sec.
- That is followed by a gradual extension of the knee joints, this position of maximum extension is achieved with the quadriceps femoris is at peak contraction. This position is then held for 5-7 s. • Participants were given a rest interval of 30-40 sec between each repetition if

required. • Procedure is followed for 5 time in total 1 set for 3 times per week for four weeks. • As the subject do not produce movement in the final position, the movement is classified as a static stretch. • However, contraction of the antagonist muscle (the quadriceps femoris) during the stretching period makes the movement a dynamic stretch. (14)



**Statistical Analysis**

Statistical analysis was done using JAMOVI version 2.3.28 Software. Microsoft® Word 2021 (Version 2108) and Microsoft® Excel® 2021 (Version 2108) was used to generate graphs and tables. This study included Age, Flexibility, Agility and Dynamic balance as quantitative variables. This study included Gender as a qualitative variable. The sample size of this study was small (0.05), so non-parametric tests were used for statistical analysis. Wilcoxon test was used for within group analysis. Shapiro wilk test was used to check normality of difference between pre and post score of all outcomes. As the difference shown normal distribution for flexibility and dynamic balance, independent t test was used for between group analysis. Hence the difference shown not normal distribution for agility, Mann Whitney U test was used for between group analysis. Confidence interval was kept 95% and the level of significance for all statistical data was set  $\alpha = 0.05$ .

A total of 46 participants (23 in each group) completed the 4-week intervention without any dropouts. The demographic characteristics of the participants are presented in Table 1. Both groups were similar in age and gender distribution.

**Table 1:** Demographic Data

Group	Mean Age (Years)	Male (n, %)	Female (n, %)	Total Participants
Group A	20.8	10 (43%)	13 (57%)	23
Group B	21.1	9 (39%)	14 (61%)	23

**Table 2:** Normality of Data of Group A

OUTCOME MEASURES	NORMALITY
	SHAPIRO-WILK TEST
	GROUP A
FLEXIBILITY PRE	0.004
AGILITY PRE	0.060
DYNAMIC BALANCE PRE	0.562

According to normality distribution of Pre-data of group A, agility pre-p value was 0.060 which was  $>0.05$ , dynamic balance pre-p value was 0.562 which was  $>0.05$ . It indicates

that there was no significant difference and data was normally distributed. So, further within group analysis of agility and dynamic balance were done by using parametric test i.e., paired t test. Hence flexibility pre-p value is 0.004 which is <0.05. It indicates that there was significant difference and data was not normally distributed. So, further within group analysis of flexibility was done by using non-parametric test i.e., Wilcoxon test.

**Table 3:** Within Group Comparison of Agility and Dynamic Balance (Group-A)

VARIABLE	GROUP A (Paired t test)		
	PRE-INTERVENTION	POST- INTERVENTION	P-VALUE
	(MEAN + SD)	(MEAN + SD)	
AGILITY	13.7±0.09	12.5±0.18	<0.001
DYNAMIC BALANCE	89.9±4.11	91.7±4.13	<0.001

Table-3 shows within group comparison of group A outcome agility and dynamic balance. Here is pre and post intervention mean value of both along with standard deviation (SD) also provided. Here, p value for both the outcome agility and dynamic balance is <0.001 indicate that there is significant difference between pre and post intervention in Group A.

**Table 4:** Within Group Comparison of Flexibility (Group-A)

VARIABLE	GROUP A (Wilcoxon test)		
	PRE-INTERVENTION	POST-INTERVENTION	P VALUE
	(MEAN + SD)	(MEAN + SD)	
FLEXIBILITY	14.5±1.74	17.5±1.67	<0.001

Table-4 shows within group comparison of outcome variable which was done by Wilcoxon test. Here pre-intervention and post intervention mean and standard deviation (SD) also provided. Here, p value for flexibility is <0.001 indicate that there is significant difference between pre and post intervention in Group A.

**Table 5:** Normality of Data of Group B

OUTCOME MEASURES	NORMALITY
	SHAPIRO-WILK TEST
	GROUP B
FLEXIBILITY PRE	<0.001
AGILITY PRE	0.060
DYNAMIC BALANCE PRE	0.662

According to normality distribution of Pre-data of group B, agility pre p value was 0.060 which was >0.05, dynamic balance pre p value was 0.662 which was >0.05. It indicates that there was no significant difference and data was

normally distributed. So, further within group analysis of agility and dynamic balance were done by using parametric test i.e., paired t test. Hence flexibility pre-p value is <0.001 which is <0.05, It indicates that there was significant difference and data was not normally distributed. So, further within group analysis of flexibility was done by using non-parametric test i.e., Wilcoxon test.

**Table 6:** Within Group Comparison of Agility and Dynamic Balance (Group-B)

VARIABLE	GROUP B (Paired t test)		
	PRE-INTERVENTION	POST-INTERVENTION	P-VALUE
	(MEAN + SD)	(MEAN + SD)	
AGILITY	13.7±0.08	12.74±0.13	<0.001
DYNAMMIC BALANCE	89.94±4.0	91.41±3.95	<0.001

TABLE 6 shows within group comparison of group B for agility and dynamic balance. Pre and post intervention mean as well as standard deviation (SD) is also given. Here, p value for both the outcome agility and dynamic balance is <0.001 indicate that there is significant difference between pre and post intervention in Group B.

**Table 7:** Within Group Comparison of Flexibility (Group-B)

VARIABLE	GROUP B (Wilcoxon test)		
	PRE-INTERVENTION	POST INTERVENTION	P-VALUE
	(MEAN + SD)	(MEAN + SD)	
FLEXIBILITY	14.04±2.34	16.39±2.20	<0.001

Table 7 shows within group comparison of group B for flexibility. Pre and post intervention mean as well as standard deviation is also given. Here, p value for flexibility is <0.001 indicate that there is significant difference between pre and post intervention in Group B.

**Table 8:** Normality of Post-Pre-data

VARIABLE	p value
FLEXIBILITY	0.174
AGILITY	0.019
DYNAMIC BALANCE	0.068

Table 8 shows normality of difference done by Shapiro wilk test. Here, p- value of flexibility is 0.174 and dynamic balance is 0.068, which is >0.05 that indicates normal distribution of data for flexibility and dynamic balance. p value of agility is 0.019 which is <0.05 that indicates data of agility is not normally distributed.

So independent t test was used for between group difference analysis of flexibility and dynamic balance. Mann Whitney u test was used for between group difference analysis for agility.

**Table 9:** Between group comparison of flexibility and dynamic balance by independent t test

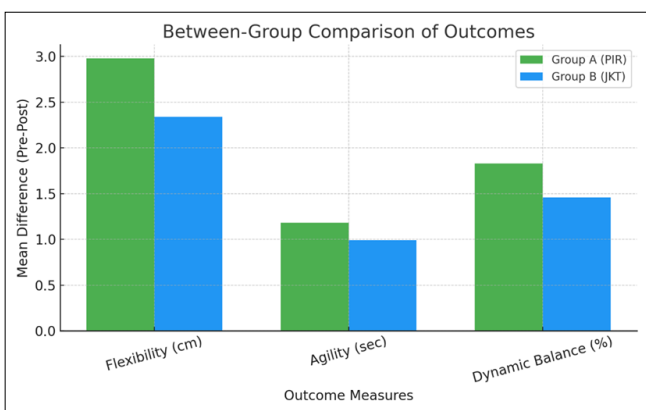
VARIABLES	GROUP A	GROUP B	p-value
	DIFFERENCE MEAN ±SD	DIFFERENCE MEAN± SD	
FLEXIBILITY	2.98±0.74	2.34±0.59	0.003
DYNAMIC BALANCE	1.83±0.29	1.46±0.21	<0.001

Table 9 shows the p value of flexibility is 0.003 which is <0.05. It indicates that there is significant difference in flexibility between both the groups. As the mean is more in group A it indicates group A is more effective in improving flexibility. Table 7.2.10 shows the p value of dynamic balance is <0.001 which is <0.05. It indicates that there is significant difference in dynamic balance between both the groups. As the mean is more in group A it indicates group A is more effective in improving dynamic balance.

**Table 10:** Between group comparison of Agility balance by Mann Whitney u test

VARIABLE	GROUP A (Paired t test)		
	PRE-INTERVENTION (MEAN + SD)	POST- INTERVENTION (MEAN + SD)	P-VALUE
AGILITY	13.7±0.09	12.5±0.18	<0.001
DYNAMIC BALANCE	89.9±4.11	91.7±4.13	<0.001

Table-10 shows the p value of agility is <0.001 which is <0.05. It indicates that there is significant difference in agility between both the groups. As the mean is more in group A it indicates group A is more effective in improving agility.



**Graph 1:** Comparison of Flexibility, Agility, and Dynamic Balance between Group A (PIR) and Group B (JKT).

**Discussion**

This study demonstrates that both Post-Isometric Relaxation (PIR) and the Jack Knife Technique (JKT) significantly improve flexibility, agility, and dynamic balance in young individuals with hamstring tightness. However, PIR showed superior results across all outcomes, suggesting it may be a

more effective therapeutic intervention for this population. The greater effectiveness of PIR can be attributed to its underlying neurophysiological mechanisms. PIR involves submaximal isometric contractions followed by passive stretching, which activates Golgi tendon organs and induces autogenic inhibition, thereby reducing muscle tone and promoting elongation of muscle fibers. This effect has been shown to improve tissue extensibility, increase joint range of motion, and reduce neuromuscular hyperactivity [5, 15]. In contrast, the Jack Knife Technique primarily involves static-dynamic self-stretching, relying on voluntary antagonist muscle contraction to elicit reciprocal inhibition [19]. Although JKT has been widely adopted in physical education programs and athletic settings due to its ease of implementation and effectiveness [20, 21], it does not engage the same reflexive inhibitory responses as PIR. Our findings are consistent with previous studies. Agrawal *et al.* found PIR to be more effective than reciprocal inhibition in improving hamstring flexibility in young adults [5]. D’Souza *et al.* also reported improvements in ROM with PIR in individuals with tight hamstrings [7]. Similarly, Esther Liyanage *et al.* noted superior immediate gains in flexibility with PIR over static stretching [22]. Additionally, the improvement in dynamic balance observed in this study is clinically significant. Hamstring flexibility directly influences postural control and lower limb alignment, which are critical for dynamic stability during movement [23, 24]. Enhanced agility in the PIR group may also reflect better neuromuscular coordination and muscle response timing following intervention. To the best of our knowledge, this is among the few studies comparing these two techniques in the Indian population. The results support the clinical utility of PIR as a preferred method to address hamstring tightness in healthy young adults.

**Conclusion**

This study concludes that both Post-Isometric Relaxation and Jack Knife Technique are effective in improving flexibility, agility, and dynamic balance in young healthy individuals with bilateral hamstring tightness. However, PIR showed superior efficacy across all outcome measures, likely due to its neurophysiological basis involving autogenic inhibition. These results suggest that PIR may be considered a more effective clinical intervention for managing hamstring tightness.

**Limitations**

- The study was limited to a small sample size and short intervention duration (4 weeks).
- Only young healthy individuals aged 18–25 years were included, limiting generalizability to older populations or clinical groups.
- No long-term follow-up was performed to assess sustained benefits of either intervention.
- Potential assessor bias could not be ruled out completely due to the nature of the interventions.

**Future Scope**

- Future studies should include a larger and more diverse population, including athletes and older adults.
- Long-term follow-up is needed to evaluate the sustainability of the improvements.

- Comparing these techniques with other stretching or strengthening approaches may provide further clinical insights.
- Objective tools like EMG and motion analysis could enhance understanding of neuromuscular adaptations.

### Ethical Approval

The study was approved by the Institutional Ethical Committee of SPB Physiotherapy College, Surat. Reference number of IEC letter is EC/SPB/093. All participants were informed about the study objectives, procedures, risks, and benefits, and written informed consent was obtained from each participant.

### Conflict OF Interest

The authors declare no conflict of interest.

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