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EFFECT OF MUSCLE ENERGY TECHNIQUE VERSUS JACK- KNIFE STRETCHING ON HAMSTRING FLEXIBILITY TO ENHANCE VERTICAL JUMP AND BALANCE PERFORMANCE IN RECREATIONAL MALE BASKETBALL PLAYERS: A COMPARATIVE STUDY

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ABSTRACT

Background: Basketball is one of the most popular physical activities in the world. Eleven percent of world's population plays recreational basketball. Basketball requires complex movements, including jumping, turning, twisting and rapid direction changes. Therefore, players need adequate balance and flexibility to perform high-intensity movements. Hamstring muscle is the most common group of muscles to get tightened, which affects dynamic balance and vertical jump. MET has been demonstrated to be more effective in improving the extensibility of shortened muscles. Jack-knife stretching is an effective dynamic self-stretching technique for the hamstrings.

Methodology: A comparative study was conducted on 50 basketball players aged 14–18 years from sports academies in Ahmedabad, selected based on inclusion and exclusion criteria. Participants were randomly divided into two groups (n=25 each). Group A received Muscle Energy Technique (post-isometric relaxation), while Group B received Jack-Knife Stretching. Outcomes were assessed using the AKE Test, Sargent Jump Test, and SEBT. Interventions were performed three times per week for four Weeks.

Result: Between group A and B, the AKE test, Sargent jump test, and SEBT showed statistically significant improvement in their mean scores between the baseline and the fourth week. Statistically, muscle energy technique was found to be more effective compared to jack knife stretching.

Conclusion: In this research, there is significant difference found between muscle energy technique in comparison with jack knife stretching.

Keywords: Muscle energy technique (post isometric relaxation technique), Jack knife stretching, Active knee extension test, Sargent jump test, Star excursion balance test, Hamstring flexibility, Basketball

INTRODUCTION

Sports have a huge impact on people of all ages' career development, social cohesion, mental health, and physical fitness, making them essential to modern society **[1]**. Among team-based sports, basketball has emerged as one of the most widely played and observed disciplines worldwide. Since its invention by Dr James Naismith in 1891, basketball has progressed from an indoor recreational activity to a highly competitive, fast-paced global sport, practiced at recreational, amateur, collegiate, and professional levels **[2]**. Estimates suggest that approximately 10–11% of the global population participates in recreational basketball activities, underscoring its substantial cultural and social impact **[3]**.

The structure and duration of basketball games vary depending on the governing authority and the level of competition. Under National Basketball Association (NBA) regulations, games are played in four 12-minute quarters, whereas National Collegiate Athletic Association (NCAA) competitions are typically contested in two 20-minute halves. In contrast, international competitions governed by FIBA adopt a four-quarter format, with each quarter lasting 10 minutes **[4]**. Under FIBA regulations, basketball is played on a rectangular court measuring 28 m × 15 m. A team is authorised to have a maximum roster of 12 players, with five players participating on the court at any one time. Players in basketball are typically assigned to one of five main positions: point guard, shooting guard, small forward, power forward, and centre **[5]**.

Basketball involves complex multi-joint movements that are executed across the sagittal, frontal, and transverse planes **[6]**. Jumping actions, such as rebounding and jump shooting, rely on a coordinated proximal-to-distal sequencing of the hip, knee, and ankle joints, enabling maximisation of vertical impulse and jump height **[7]**. Efficient jumping performance depends on sufficient joint range of motion, muscle flexibility, and optimal utilisation of the stretch–shortening cycle. Restrictions in mobility or altered muscle extensibility may disrupt force transmission along the kinetic chain, thereby reducing performance efficiency **[8]**.

Flexibility refers to the ability of a muscle–tendon unit to stretch adequately, allowing a joint to move through its full range of motion without pain. When this ability decreases due to shortening of muscles and connective tissues, it is termed muscle tightness **[9, 10]**. The hamstring muscle group, comprising the biceps femoris, semitendinosus, and semimembranosus, spans both the hip and knee joints. Because of this biarticular arrangement, these muscles are particularly susceptible to adaptive shortening under repetitive sport-specific loading **[11-13]**. During activities, the hamstrings are exposed to repeated eccentric and concentric contractions, which may contribute to increased muscle stiffness and reduced extensibility **[14]**. Reduced hamstring extensibility disrupts the normal length–tension relationship of the muscle, increases passive resistance to movement, and alters neuromuscular activation patterns during functional tasks **[15]**.

Adolescents aged 14–18 years are particularly vulnerable, owing to the combined effects of growth-related changes, prolonged sitting associated with academic demands, and sport-specific loading **[16]**. Males typically demonstrate reduced anterior pelvic tilt and greater posterior-chain stiffness, which increases resting tension within the hamstring muscle–tendon unit[17].Hamstring muscle tightness commonly results in restricted knee extension and altered lower-limb biomechanics, making accurate assessment clinically important. The Active Knee Extension test is commonly used to assess hamstring flexibility under conditions of active neuromuscular control **[18-20]**.

A key element of basketball performance is explosive upward propulsion ability, which plays a major role. Vertical jump performance depends on coordinated activation of the hip, knee, and ankle extensors, with the hamstrings playing an important role in hip extension and movement efficiency. Hamstring tightness can disturb this coordination by limiting hip range of motion and altering the muscle length–tension relationship **[7]**. The sargent jump test, originally devised by Dr Dudley Allen Sargent, is often performed to measure explosive strength and power of the lower limbs **[21-23]**.

"Due to the high prevalence of hamstring tightness and its impact on performance and injury risk, effective interventions are necessary to improve flexibility and neuromuscular control. According to Philip E. Greenman (1996), early osteopathic treatments included soft-tissue procedures aimed at muscle relaxation. Muscle Energy Technique (MET) is one such approach that targets soft tissues and also assists in joint mobilisation **[24]**.

Fred Mitchell Sr. developed Muscle Energy Technique (MET), a manual therapy method in which the patient actively contracts specific muscles against controlled resistance applied by the therapist. This interaction promotes muscle relaxation, improves joint mobility, and increases range of motion through neurophysiological mechanisms such as Golgi tendon organ activation **[25-27]**. Jack-knife stretching is a simple self-stretching technique performed in a squat while holding the ankles, combining static and dynamic elements to enhance hamstring flexibility through reciprocal inhibition and improved blood circulation **[28-32]**.

MATERIAL AND METHODOLOGY

- Study design: A Comparative study
- Sampling technique: Simple random sampling
- Study setting: Various sports academy in Ahmedabad
- Sample size: 50
- Study duration: 1 year
- Duration of the intervention: 3 days/week for 4 weeks
- Study population: Male Recreational Basketball Players
- Material required: pen, paper, consent form, measure tape, weight scale, goniometer.

SELECTION CRITERIA

- **INCLUSION CRITERIA [33, 34]:**
  - Patient willing to participate in the study.
  - Age: 14- 18 years
  - Gender – Male
  - Recreational basketball players – should be playing for ½ -3 hours per session and at least 3 times a week.
  - Active knee extension test >20 degree.
- **EXCLUSION CRITERIA [33, 34]:**

- Short-term or persistent lumbar pain
- Acute hamstring injury
- Having complaints of pain or injury in back, knee or hip joint or stiffness in the knee joint.
- The study excluded participants having a history of lower limb or spinal diseases, knee or lumbar spine surgery, or complaints of pain or discomfort within the previous six months.
- Presence of any underlying traumatic or non- traumatic lower

limb orthopaedic, neurological and cardiovascular condition.

- **OUTCOME MEASURES [20-23]:**
  - For hamstring flexibility: Active knee extension test
  - For vertical jump: Sargent jump test
  - For balance: star excursion balance test

PROCEDURE: Each participant was informed about the study methodology, and a written consent form was filled out by all the participants. A detailed assessment was then taken, the procedure was explained properly than was filled out by the participants, and confidentiality of the data was assured.

STATISTICAL ANALYSIS

- Normalative data was found using Shapiro-Wilk test.
- Paired t-test was used to analyse intra-group differences.
- Independent t-test compared inter-group differences.
- Version 26.0 of SPSS software was used for the statistical analysis. P<0.05 was considered significant for all measurements. P>0.05 was considered non-significant.
- Value of confidence interval was set at 95%.
- P< 0.001 was considered highly significant.
- P<0.001 was considered highly significant.

RESULT

The current study involved fifty individuals diagnosed with hamstring tightness. The participants were divided into two groups. There were 25 patients in group A and 25 in group B, meeting 3 days a week for 4 weeks. Before and after analyses of data were calculated via SPSS 26 version.

The study analysed the pre- and post-intervention AKE values, Sargent jump and SEBT values.

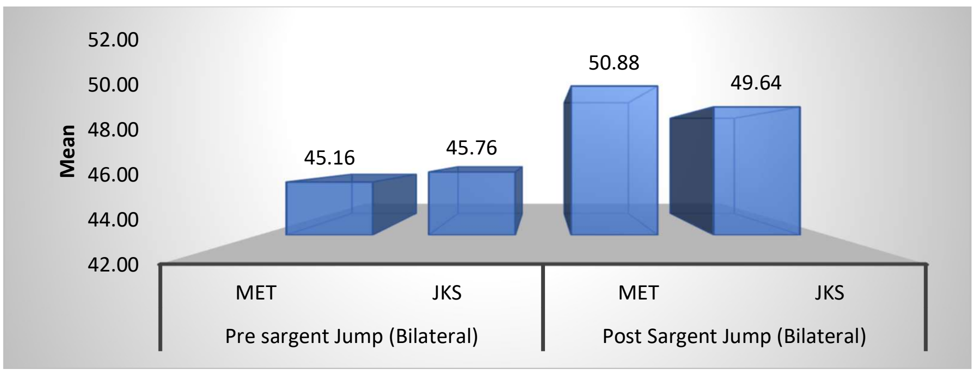
Table 1 and Graph 1 present the between-group comparison of pre- and post-test Sargent Jump Test scores for Group A and Group B. The post-test mean of Group A is marginally higher than that of Group B, suggesting a slightly greater improvement following the intervention. However, both groups demonstrated comparable gains in Sargent Jump performance.

Table 2 and Graph 2 compare hamstring flexibility between the groups using the AKE test. Group A showed greater improvement than Group B, with a larger mean difference. The results were statistically significant, indicating that Group A's intervention was more effective in reducing hamstring tightness.

Table 3 and Graph 3 present the between-group analysis of SEBT performance across all directions. Group A demonstrated greater mean improvements than Group B in most reach directions, particularly anterior, posteromedial, and anterolateral. These findings indicate superior balance enhancement in Group A following the intervention.

Table 1: Between-Group Analysis Of Pre- And Post-Test Of Group A And Group B By Using Sargent Test

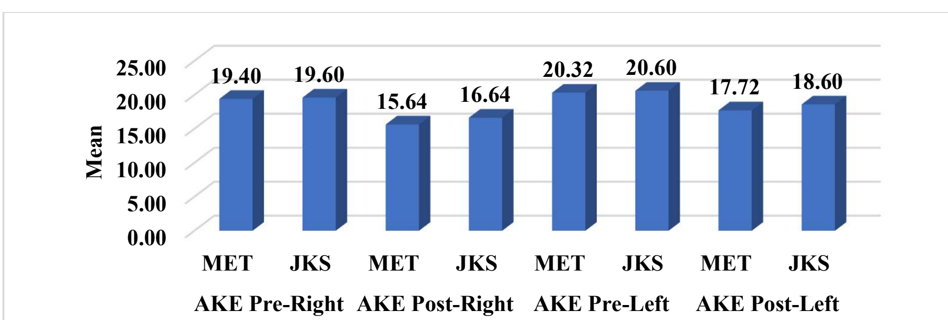
GROUP		Mean	Std. Deviation	t test	P Value
Pre Sargent Jump	MET	45.16	1.70	1.517	0.136
	JKS	45.76	1.01		
Post Sargent Jump	MET	50.88	1.90	2.477	0.017
	JKS	49.64	1.63		



Graph 1: between group analysis of pre and post test of group A and group B by using sargent jump test

Table 2: Between-Group Analysis Of Pre- And Post-Test Of Group A And Group B By Using Active Knee Extension Test

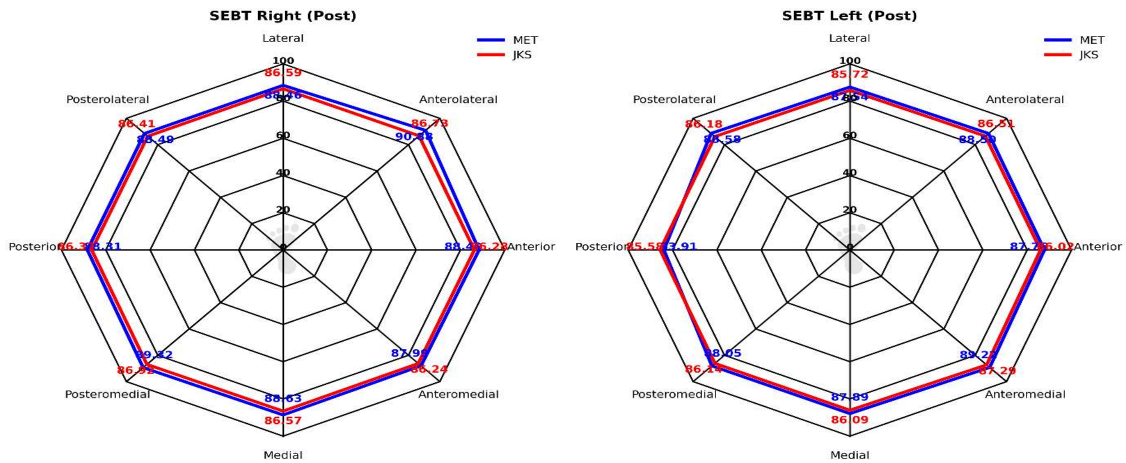
Group		Mean	Std. Deviation	t test	P Value
AKE Pre-Right	MET	19.40	1.32	0.548	0.586
	JKS	19.60	1.26		
AKE Post-Right	MET	15.64	1.44	2.341	0.023
	JKS	16.64	1.58		
AKE Pre-Left	MET	20.32	1.25	0.79	0.434
	JKS	20.60	1.26		
AKE Post-Left	MET	17.72	1.31	2.425	0.019
	JKS	18.60	1.26		



Graph 2: between-group analysis of pre- and post-test of group A and group B by using active knee extension test

Table 3: between-group analysis of pre and post-test Sebt of group A and group B

Group		Mean	Std. Deviation	t test	P Value
Pre Anterior Left	MET	80.28	2.25	0.335	0.739
	JKS	80.51	2.44		
Post Anterior Left	MET	87.76	2.59	2.306	0.025
	JKS	86.02	2.73		
Pre Anterior Right	MET	82.14	2.07	1.298	0.201
	JKS	81.13	3.29		
Post Anterior Right	MET	88.40	2.62	2.254	0.029
	JKS	86.28	3.90		
Pre Anteromedial Left	MET	81.22	2.10	1.617	0.113
	JKS	80.12	2.67		
Post Anteromedial Left	MET	89.22	2.48	2.6	0.012
	JKS	87.29	2.76		
Pre Anteromedial Right	MET	81.84	2.06	1.391	0.171
	JKS	80.91	2.64		
Post Anteromedial Right	MET	87.99	2.61	2.218	0.031
	JKS	86.24	2.96		
Pre Medial Left	MET	81.63	2.50	1.796	0.079
	JKS	80.30	2.71		
Post Medial Left	MET	87.89	2.55	2.217	0.031
	JKS	86.09	3.18		
Pre Medial Right	MET	82.35	2.27	1.57	0.123
	JKS	81.16	3.02		
Post Medial Right	MET	88.63	2.80	2.356	0.023
	JKS	86.57	3.36		
Pre Posteromedial Left	MET	81.55	2.01	1.439	0.157
	JKS	80.52	2.97		
Post Posteromedial Left	MET	88.05	2.21	2.366	0.022
	JKS	86.14	3.38		
Pre Posteromedial Right	MET	81.71	2.29	0.312	0.757
	JKS	81.50	2.51		
Post Posteromedial Right	MET	89.32	4.08	2.365	0.022
	JKS	86.92	3.02		
Pre Posterior Left	MET	79.57	2.23	0.524	0.603
	JKS	79.95	2.85		
Post Posterior Left	MET	83.91	2.36	2.152	0.037
	JKS	85.58	3.07		
Pre Posterior Right	MET	82.40	2.24	1.694	0.097
	JKS	81.27	2.48		
Post Posterior Right	MET	88.31	2.63	2.339	0.024
	JKS	86.37	3.22		
Pre Posterolateral Left	MET	81.24	2.34	0.877	0.385
	JKS	80.59	2.91		
Post Posterolateral Left	MET	88.58	3.10	2.585	0.013
	JKS	86.18	3.47		
Pre Posterolateral Right	MET	81.49	2.24	0.592	0.556
	JKS	81.05	2.94		
Post Posterolateral Right	MET	88.49	2.72	2.447	0.018
	JKS	86.41	3.28		
Pre Lateral Left	MET	81.48	2.74	1.565	0.124
	JKS	80.20	3.02		
Post Lateral Left	MET	87.54	2.74	2.17	0.035
	JKS	85.72	3.16		
Pre Lateral Right	MET	82.21	2.00	1.611	0.114
	JKS	81.15	2.61		
Post Lateral Right	MET	88.46	3.11	2.176	0.034
	JKS	86.59	2.95		
Pre Anterolateral Left	MET	82.00	2.18	1.665	0.103
	JKS	80.82	2.77		
Post Anterolateral Left	MET	88.50	2.16	2.621	0.012
	JKS	86.51	3.14		
Pre Anterolateral Right	MET	82.50	2.21	1.566	0.124
	JKS	81.42	2.66		
Post Anterolateral Right	MET	90.88	2.78	4.979	<0.001
	JKS	86.73	3.12		



Graph 3: Between-Group Analysis of Pre and Post-Test Sebt of Group A and Group B

DISCUSSION

The present study aimed to compare the effects of Muscle Energy Technique (MET) and Jack-Knife Stretching on hamstring flexibility, vertical jump performance, and dynamic balance in recreational male basketball players. The findings indicate that both interventions significantly improved all measured outcomes. However, the magnitude of improvement was greater in the MET group, suggesting that MET may be a more effective intervention for enhancing lower-limb functional performance.

Hamstring flexibility assessed using the Active Knee Extension (AKE) test improved significantly in both groups, with greater reduction in hamstring tightness observed in the MET group. This enhanced effect may be attributed to the neurophysiological mechanisms of MET, particularly post-isometric relaxation and autogenic inhibition, which facilitate temporary reduction in muscle tone and allow increased muscle elongation **[20, 27]**. Similar findings have been reported in previous studies. Kalanekar *et al*. (2020), "observed that MET was more effective than other mobilization techniques in improving hamstring flexibility **[20]**". Likewise, Varsha Tamang *et al*. (2022), "reported greater flexibility gains with MET compared to conventional stretching methods **[25]**". The findings of the present study are consistent with these reports and further support the effectiveness of MET in reducing hamstring tightness.

Vertical jump performance measured using the Sargent Jump Test also improved significantly in both groups, with greater improvement observed in the MET group. Improved hamstring flexibility may enhance the stretch-shortening cycle mechanism, which is essential for explosive movements such as jumping. Hazal Genç *et al*. (2024), "reported a positive association between hamstring flexibility and vertical jump performance in male basketball players **[22]**". Increased flexibility allows better force absorption and generation during dynamic movements, thereby contributing to improved power production. Additionally, MET may enhance neuromuscular coordination and muscle activation efficiency **[20]**, which could explain the greater improvement in jump performance observed in this group. Although Jack-Knife Stretching also improved jump performance, the relatively smaller mean difference suggests that dynamic stretching alone may produce comparatively limited neuromuscular adaptations **[31]**.

Dynamic balance assessed using the Star Excursion Balance Test (SEBT) improved significantly in both groups, with greater improvement in the MET group, particularly in the anterior, posteromedial, and anterolateral directions. These directions require adequate flexibility, proprioceptive control, and neuromuscular coordination. Previous literature highlights a strong relationship between muscle flexibility and dynamic balance performance **[32]**. Kang *et al*. (2021), "emphasized that increased muscle extensibility may positively influence proprioception and postural stability **[31]**". The results of the present study support these findings, as greater improvements in reach distance were observed in the MET group. The combination of active contraction followed by controlled passive stretching in MET may enhance neuromuscular responsiveness and improve balance control during dynamic tasks.

Although previous studies by Amruta Kabra *et al*. (2020) and Jae-Seop Oh *et al*. (2021) reported that Jack-Knife Stretching and PNF techniques can effectively improve hamstring flexibility, the present study demonstrates that MET produces greater overall functional improvements **[28, 31]**. Jack-Knife Stretching primarily improves flexibility through repeated active end-range movements and increased stretch tolerance, whereas MET addresses both mechanical stiffness and neural components of muscle tightness. The isometric contraction phase in MET promotes deeper neuromuscular relaxation, which may lead to more sustained improvements in flexibility and performance. Baseline characteristics such as age and Body Mass Index (BMI) were comparable between groups, indicating that the differences observed in outcome measures were primarily due to the intervention rather than demographic variations. This supports the internal validity of the study.

From a clinical and sports performance perspective, these findings are important because basketball requires explosive power, rapid directional changes, and effective dynamic balance. Hamstring tightness can negatively affect performance and increase injury risk in athletes. Therefore, interventions that simultaneously improve flexibility, power, and balance are highly beneficial. The results of the present study suggest that MET not only enhances hamstring flexibility but also contributes to improved vertical jump performance and dynamic balance. In conclusion, both Muscle Energy Technique and Jack-Knife Stretching are effective in improving hamstring flexibility, vertical jump performance, and dynamic balance. However, MET produced significantly greater improvements in all outcome measures. By combining active muscle contraction with controlled passive stretching, MET induces both mechanical and neurophysiological adaptations that contribute to superior functional outcomes. Therefore, MET may be considered a more effective intervention for improving lower-limb flexibility, explosive power, and dynamic balance in recreational male basketball players and may be beneficial for inclusion in sports training and rehabilitation programs.

CONCLUSION

The study concluded that both groups were individually effective in improving hamstring flexibility, vertical jump and balance in male recreational basketball players. However, Muscle Energy Technique (post-isometric relaxation technique), was more effective than the jack-knife stretching in improving hamstring flexibility, vertical jump and balance in male recreational basketball players.

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