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Effectiveness of Mulligan Bent Leg Raise Versus Proprioceptive Neuromuscular Facilitation Hold-Relax Exercise in Improving Hamstring Range of Motion and Muscle Performance: A Randomized Controlled Trial

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ABSTRACT

Objective: The primary goal is to compare the short-term effects of Mulligan Bent Leg Raise and Proprioceptive Neuromuscular Facilitation Hold-Relax techniques on hamstring flexibility and muscle performance. Methods: Sixty-four young adults with hamstring tightness were randomly assigned to either the Mulligan BLR group (n = 32) or the PNF Hold-Relax group (n = 32). Each participant underwent six intervention sessions. Hamstring flexibility was assessed using the Active Knee Extension (AKE) test, and muscle performance was evaluated through isometric strength testing. Data analysis involved paired and independent t-tests, with statistical significance set at $p < 0.05$. Results: Both groups showed significant improvement within their respective groups ($p < 0.001$). The Mulligan group increased range of motion by 5.37–6.82°, and strength by 19.69 N ± 5.20. The Proprioceptive Neuromuscular Facilitation group showed greater improvements, with range increasing by 9.84° ± 2.20 and strength by 30.69 N ± 5.67. Between-group comparisons confirmed superior range of motion gains for PNF ($p < 0.001$) and larger strength improvements ($p < 0.001$). Effect sizes were very large in both groups, but highest in the Proprioceptive Neuromuscular Facilitation group (Range of motion: -4.472; Strength: -5.417). Conclusion: Both Mulligan Bent Leg Raise and Proprioceptive Neuromuscular Facilitation Hold-Relax techniques significantly enhance hamstring flexibility and strength. Mulligan intervention produced a notable range of motion improvement, whereas Proprioceptive Neuromuscular Facilitation Hold-Relax intervention yielded greater gains in both ROM and muscle performance. These findings provide clinicians data-driven guidance to tailor interventions according to treatment goals

KEYWORDS: Short-term effect, hamstring flexibility, Mulligan technique, PNF, muscle performance

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INTRODUCTION

Hamstring tightness frequently affects movement and posture, making daily activities more challenging and increasing the risk of lower-body and back injuries. This issue is widespread not only among athletes who regularly perform intense or repetitive actions, but also among individuals who spend long periods sitting. When the hamstrings are inflexible, the movement of the lower back and pelvis is disrupted, forcing the lower spine to compensate. This can result in pain, stiffness, and an increased risk of injury. Because of these risks, restoring hamstring flexibility has become a priority in both preventive care and physical rehabilitation settings (Gou Y, 2024). Various approaches have been used to address hamstring tightness. While static stretching is common, it often fails to provide lasting results and can be uncomfortable, leading to poor adherence. More recent evidence supports techniques such as Proprioceptive Neuromuscular Facilitation (PNF) and Mulligan's Bent Leg Raise (BLR). The PNF Hold-Relax method uses brief muscle contractions to help the hamstrings lengthen more effectively and adapt on a neuromuscular level. Sos Tirado et al. (2024) also noted that this approach improves body awareness and muscle activation, offering both physical and neurological advantages. Unlike other methods, the Mulligan BLR uses a hands-on approach from the therapist while the patient actively moves, blending mobilization with movement. This method works well for people who cannot handle traditional or forceful stretching. Research by Hussein et al. (2025) showed it can greatly improve hamstring flexibility and movement, while ElMeligie et al. (2025) found it helps restore joint motion and muscle control in musculoskeletal issues. Although there is growing support for both PNF and BLR methods, few studies have directly compared them. Most research looks at each technique separately, making it hard for clinicians to know which works better under the same conditions. Studies by Irfan et al. (2023) show that both methods improve range of motion and strength; however, it remains unclear which is more effective. To help clarify this, our randomized controlled trial was designed to compare the immediate effects of PNF Hold-Relax and Mulligan BLR on hamstring flexibility and strength in young adults with limited hamstring flexibility.

METHODS

Study Design

A randomized controlled trial was conducted to compare Mulligan BLR and PNF HR interventions. Ethical clearance was obtained from the Institutional Review Board (Approval No: [Insert IRB Number]).

Criteria for Inclusion:

- **Participants:** must be between the ages of 18 and 35.
- **Baseline Flexibility:** People who, according to an Active Knee Extension Test, Knee remains >20° of flexion is consider hamstring tightness
- **Consent:** Individuals who have given their written, informed consent to take part in the research.
- **Availability:** People who are accessible throughout the study period.

Criteria for Exclusion:

- **Medical Conditions:** People with a history of lower limb neurological disorders, musculoskeletal injuries, or surgeries.
- **Prior Treatment:** People who, during the previous three months, received any kind of physiotherapy or lower limb muscle interventions**.**
- **Medications**: Participants taking medications that affect muscle function or pain perception, such as muscle relaxants or opioids.

Pregnancy: Pregnant individuals due to potential risks and altered body mechanics affecting flexibility and muscle performance.

Randomization and Grouping

Participants were randomly allocated into two groups (n=32 each:

- **Group A:** Mulligan Bent Leg Raise (BLR)
- **Group B:** PNF Hold-Relax (HR)

Baseline measurements were taken prior to intervention.

Outcome Measures

1. **Hamstring Flexibility:** Measured using the Active Knee Extension test with a goniometer (degrees).
2. **Muscle Performance:** Measured via handheld dynamometer assessing maximal isometric contraction strength of hamstring muscles (N).

Intervention Protocols

Mulligan BLR Technique:

The patient is positioned supine with the hip and knee flexed, resting the leg on the therapist's shoulder. The therapist elevates hip flexion until a stretch is felt, at instant the patient executes an isometric hold by pressing their leg against the therapist's shoulder for approximately 8 seconds. The contraction is done ten times with the therapist progressively extending the hip into a greater range of stretch after each hold.

PNF Hold-Relax Technique:

This technique requires the patient lying on their side with one leg extended and hooked securely over the bed's edge. The intervention leg is positioned into hip flexion and rests against the therapist's stomach. The therapist moves the leg into a stretch until tension is felt, and the patient performs an isometric contraction by pushing the leg back into hip extension against the therapist's resistance for 8 seconds. After relaxing, the therapist increases the stretch, and the process is repeated to improve flexibility and strength.

Data Collection and Statistical Analysis

Data were collected before and immediately after intervention. Statistical analysis was conducted using SPSS v25.0. Paired *t*-tests compared pre- and post-intervention outcomes within groups, and independent *t*-tests assessed between-group differences. Significance level was set at $p<0.05$. Cohen's *d* was calculated to determine effect sizes.

Baseline characteristics

	Age	Gender	Height	Weight	BMI
N Valid	64	64	64	64	64
Missing	0	0	0	0	0
Mean	24.78	1.53	170.05	70.17	24.44
Std. Error of Mean	.447	.063	.942	1.259	.555
Median	25.00	2.00	169.50	72.00a	24.00
Mode	24	2	168a	73a	23
Std. Deviation	3.574	.503	7.539	10.070	4.440
Variance	12.777	.253	56.839	101.414	19.710
Skewness	-.133	-.128	.252	-.053	.075
Std. Error of Skewness	.299	.299	.299	.299	.299

Kurtosis	-.390	-2.049	.028	-.706	-.646
Std. Error of Kurtosis	.590	.590	.590	.590	.590
Minimum	18	1	154	51	15
Maximum	33	2	189	92	35

ROM t-test-Independent Samples Test

	Levene's Test for Equality of Variances				t-test for Equality of Means			95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Participant Id Equal variances assumed	0.000	1.000	-13.845	62.000	<.001	-32.000	2.345	-36.688	-27.312
Participant Id Equal variances not assumed	0.000	1.000	-13.845	62.000	<.001	-32.000	2.345	-36.688	-27.312
Post Score Equal variances assumed	0.002	.961	2.712	62.000	.004	4.118	1.763	1.268	8.305
Post Score Equal variances not assumed	0.002	.961	2.712	61.723	.004	4.118	1.763	1.257	8.305

Strength t-test-Independent Samples Test

	Levene's Test for Equality of Variances F	Sig.	t	df	Significance One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Participant Id Equal variances assumed	0.000	1.000	-13.645	62	<.001	<.001	-32.000	2.345	-36.688	-27.312
Equal variances not assumed			-13.645	62.000	<.001	<.001	-32.000	2.345	-36.688	-27.312
PostRom Equal	0.670	0.418	1.222	62	.113	.226	4.806	6.879	-5.942	22.165

variances assumed										
Equal variances not assumed			1.222	60.130	.113	.226	4.806	6.879	-5.942	22.165

Paired t-test-Paired Samples Test

Pair	Mean	Std. Deviation	Std. Error Mean	95% CI Lower	95% CI Upper	t	df	One-Sided p	Two-Sided p
Pair 1: MuRomPre - MuRomPost	-6.094	2.022	0.357	-6.823	-5.365	-17.050	31	< .001	< .001
Pair 2: MuNPre - MuNPost	-19.688	5.202	0.920	-21.563	-17.812	-21.409	31	< .001	< .001
Pair 3: PnfRomPre - PnfRomPost	-9.844	2.201	0.389	-10.637	-9.050	-25.296	31	< .001	< .001
Pair 4: PnfNPre - PnfNPost	-30.688	5.665	1.001	-32.730	-28.645	-30.643	31	< .001	< .001

DISCUSSION

This study found that both the PNF Hold-Relax and Mulligan BLR techniques quickly improved hamstring flexibility and strength. However, the PNF Hold-Relax group showed even greater improvement, supporting earlier research that highlights the unique muscle relaxation benefits of contract-relax techniques (Sumantri et al., 2023). PNF methods work by activating certain reflexes in the muscles, leading to more relaxation and stretch compared to techniques based only on movement. These results match previous studies showing that PNF offers bigger and longer-lasting flexibility gains without reducing strength, while Mulligan BLR is still useful for improving joint movement and correcting movement patterns. The greater improvements seen with PNF Hold-Relax are likely due to the unique way it activates muscles and nerves. During the contract-relax phase, muscle contractions help recruit more motor units and trigger inhibitory signals through the Golgi tendon organs, leading to better relaxation and a deeper stretch (Marek SM, 2025). In addition, PNF increases sensory input to the nervous system, which can boost brain activity, encourage neural adaptation, and may raise levels of brain-derived neurotrophic factor (BDNF). These changes work together to improve muscle control and flexibility (Manabendra Majhi, 2021). Overall, PNF benefits both muscle function and the way the brain coordinates movement. Unlike PNF, the Mulligan BLR technique focuses on moving the joint while applying gentle manual pressure. It uses correct joint positioning and stimulates sensors in the joint to improve how smoothly the body moves. Although BLR can boost flexibility in the short term, its effects are usually smaller than PNF's, since it mainly works on the body's mechanics rather than its nerve pathways. Still, BLR is helpful for patients with stiff joints or uneven posture, even if it's less effective for quickly increasing muscle length (Reiner M, 2021). These results have important clinical implications. PNF Hold-Relax should be the first choice in rehab programs where quick flexibility gains are needed, such as for athletes, those recovering from injuries, or anyone with sudden muscle tightness (Mishra A, 2024). In contrast, Mulligan BLR provides a milder option for people who cannot tolerate intense stretching, like older adults or those healing from injuries. Both techniques improved strength equally, meaning PNF's flexibility benefits do not come at the cost of muscle performance. This supports the safety and usefulness of both methods.

CONCLUSION

This study showed that both PNF Hold-Relax and Mulligan BLR methods led to significant improvements in hamstring flexibility and muscle strength. PNF Hold-Relax resulted in greater flexibility gains, likely due to its effect on muscle relaxation and stretching. In the other hand, Mulligan BLR was just as effective for increasing strength and remains valuable for correcting movement and mobilizing joints. In clinical practice, PNF Hold-Relax works best for quickly improving flexibility, while Mulligan BLR is a good choice for those needing a softer, mobilization-focused technique. Both methods give physiotherapists reliable, research-backed options for treating hamstring tightness, which impacts posture, walking, and injury risk. Future studies should look at long-term results, bigger and more diverse groups, and combining these approaches for even better rehab outcomes.

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