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IMMEDIATE EFFECT OF BLOOD FLOW RESTRICTIONS THERAPY (BFRT) ON HAMSTRING FLEXIBILITY: A RANDOMIZED CLINICAL TRIAL

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ABSTRACT

Background: Muscular flexibility is an important aspect of normal human function. The hamstring muscles are most commonly having decreased flexibility. BFRT is a technique used to help improve muscle strength and recovery that involves using cuff to partially restrict blood flow to the affected muscle while exercising. Aim is to find the effectiveness of Blood flow restriction therapy (BFRT), stretching and combination (BFRT + stretching) for improving hamstring flexibility.

Method: This was a double-blinded randomized controlled trial (RCT). Students with hamstring tightness were recruited from the university campus. Thirty-three students were randomly and equally divided into Group A (BFRT), Group B (stretching), and Group C (combined). Hamstring tightness was measured at baseline and immediately after the intervention, using active knee extension and the sit-and-reach test. The data were analyzed with ANOVA.

Result & conclusion: All the three groups showed significant p value of <0.01 in within group. It can be concluded from the study that passive stretching and BFRT were effective to release hamstring tightness. But combined was more effective than BFRT, stretching.

Clinical Implication: To release the tightness of muscle, agonist should be relax and antagonist muscle should be strengthened. This study focuses on the immediate effect of combination of passive stretching and BFRT on hamstring tightness.

Keywords: Blood flow restrictions therapy, Hamstring tightness, stretching, active knee extension test

INTRODUCTION

Being flexible is essential to fitness, since it plays a big role in the musculoskeletal system's growth and the optimization of muscle performance. A muscle's ability to extend by fully extending the range of motion of a single joint is referred to as its flexibility, according to existing research. Reduced flexibility is one of the most often reported reasons of hamstring muscle injury. Those who engage in physical activity frequently experience hamstring tightness **[1]**.

The conventional methods for increasing flexibility have frequently focused on static stretching, which is the widely used technique of gradually lengthening muscles. While static stretching has long been a mainstay of flexibility training, some researches have cast doubton its ability to produce the needed acute alterations, raising questions about its immediate consequences. The way to execute stretching exercises is to arrange the body's parts in the proper positions and hold them there for a predetermined amount of time. These exercises promote flexibility and range of motion by stretching the appropriate soft tissues and muscular groups. They also build stretched tolerance **[2]**.

The need for quick and effective ways to improve flexibility has led to the quest for substitute procedures. Within the field of musculoskeletal health and performance enhancement, one such new strategy that is gaining traction is antagonist strengthening with Blood Flow Restriction therapy (BFRT). The literature was the first to report on the advantages of blood flow restriction for skeletal muscle **[3]**. In BFRT, a tourniquet-like device is applied to the limb's proximal region in order to restrict blood flow while exercising. Because of this restriction, a hypoxic environment is created, which sets off special physiological reactions and antagonist strengthening is based on reciprocal inhibition, which states that when antagonistic muscles contract, the target muscles relax that could lead to increases in muscle mass, strength, and flexibility **[4, 5]**.

In order to fully reflect the complex nature of hamstring flexibility, various outcome metrics may be utilized. Both static and dynamic evaluations, such as the Sit and Reach test and the Active Knee Extension (AKE) test. These tests offer a comprehensive evaluation of hamstring flexibility. The AKE test reveals how well the hamstrings function during dynamic activities, mirroring movements required in daily life or sports. On the other hand, the Sit andReach test provides a snapshot of static flexibility, which is essential for understanding an

individual's ability to maintain elongated positions. Integrating both tests into assessments provides a well-rounded understanding of hamstring flexibility, aiding in the development of targeted flexibility training programs for various needs, from sports performance to injury prevention and rehabilitation **[6, 7]**.

There is lack of evidence which describe the relation of antagonist muscle strengthening with the use of BFRT and flexibility of agonist muscle in hamstring tightness. The main goal of this randomized clinical experiment is to comparing the immediate benefits of BFRT, static stretching, and the combination of BFRT and static stretching on hamstring flexibility.

We hypothesize that BFRT and combination of BFRT and static stretching will demonstrate superior immediate effects on hamstring flexibility compared to static stretching. This hypothesis is grounded in the potential synergistic effects of BFRT - induced hypoxia on muscle tissue and its ability to stimulate acute changes in flexibility.

METHODOLOGY:

Participants: A convenience sample of 33 healthy college students (age = 21.51 ± 2.68 years) agreed to participate in the study. A questionnaire was administered to all subjects to collect their relevant medical history and to quantify physical activity levels. The inclusion criteria were healthy subjects aged 18 to 25 years, both male and female. During the active knee extension test, a lag of 20 degrees was considered normal from full extension; anything less than 20 degrees was considered hamstring tightness. Exclusion criteria included individuals already undertaking a regular exercise program, those with contraindications to Blood Flow Restriction Training (BFRT), pre-existing cardiovascular conditions, a history of trauma within the past 1 year, a history of impairment to the knee, hip, or lower back within the past 2 years, and a history of sprain and strain within the past 3 months or any medical conditions affecting hamstring flexibility.

Study Design: This research employs a 3-group randomized clinical trial design to compare the immediate effects of three interventions on hamstring flexibility. Participants were randomly assigned to one of the following groups: Group A: Blood Flow Restriction (BFRT) of antagonist strengthening, Group B: Static Stretching, Group C: Combination (BFRT + stretching) Informed consent was obtained from all participants.

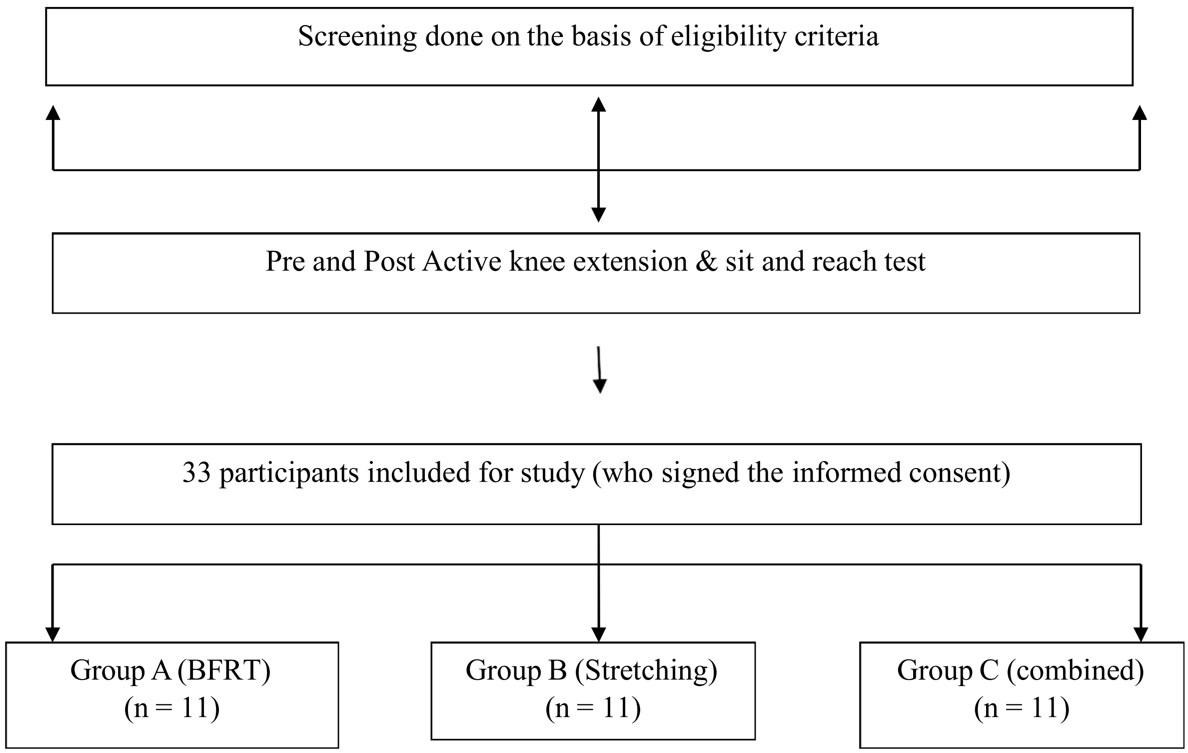
Blinding: Due to the nature of the interventions, it was challenging to blind participants and therapists.

Interventions: In Group A (BFRT), participants underwent BFRT using a validated protocol, involving the application of a tourniquet-like device to the proximal part of the thigh during a standardized quadriceps strengthening. In Group B (Static Stretching), participants engagedin a standardized static stretching routine targeting the hamstring muscles. The protocol involved controlled stretches held for a specific duration. In Group C (Combined), participants in this group received both BFRT and static stretching and rested quietly during the allocated time.

Outcome Measures: The primary outcome measure was hamstring flexibility, assessed usingestablished clinical measures such as the sit-and-reach test and active knee extension test before and after treatment.

Data Collection: Baseline measurements were taken before interventions. Immediate post- intervention measurements were recorded to capture acute changes. Outcome assessors were trained to ensure consistency and reliability in data collection.

Statistical Analysis: Statistical analysis was performed with SPSS program version 27.0 for the statistic. The one-sample Kolmogorov-Smirnov test was used to determine the homogeneity of the data in each group. Paired t – test was used to compare both the values of the sit-and-reach test and Active knee extension test before starting the exercise program and after the training program in each group. ANOVA test was used to compare the difference of outcome measures after the training program among the three groups. The significance level was set at $p \leq 0.05$.


Screening done on the basis of eligibility criteria
Pre and Post Active knee extension & sit and reach test
33 participants included for study (who signed the informed consent)
Group A (BFRT) (n = 11)
Group B (Stretching) (n = 11)
Group C (combined) (n = 11)

RESULTS

Descriptive Findings:

A total of 33 subjects completed the study and were included in the analysis. The subjects' baseline data (mean ± SD) were as follows: mean age 21.51 ± 2.68 years, and they were randomly divided into three groups. Group A consisted of 8 females and 3 males, Group B had 6 females and 5 males, and Group C included 6 females and 5 males. The baseline characteristics of subjects are shown in **Table 1**. There were no significant differences among the three groups.

Table 2 showed the means and standard deviations of the sit-and-reach test for the BFRT, stretching, and combined (BFRT + stretching) groups in pre- and post-test conditions. An increase in the sit-and-reach test after the training exercise program was observed. The resultsindicated a significant increase in the sit-and-reach test in all intervention groups.

Table 3 showed the means and standard deviations of active knee extension (left) for the BFRT, stretching, and combined (BFRT + stretching) groups in pre- and post-test conditions. An increase in active knee extension (left) after the training exercise program was observed. The results indicated a significant increase in active knee extension (left) in all intervention groups.

Table 4 displayed the means and standard deviations of active knee extension (right) for the BFRT, stretching, and combined (BFRT + stretching) groups in pre- and post-test conditions. An increase in active knee extension (right) after the training exercise program was observed.The results indicated a significant increase in active knee extension (right) in all intervention groups.

Table 5 indicated that the combined group (BFRT + stretching) produced a significant increase in active knee extension (right) compared to the Stretching and BFRT groups.

However, there was no significant difference in the increase of the sit-and-reach test andactive knee extension (left) among all the groups.

Table 6 shows that in active knee extension (right) combined group shows significant improvement in compared to another intervention groups.

Table 1: Baseline data of subjects

NO.	Training group	Samplesize	Age	Gender
1	GROUP A	11	22.181818	(8 female , 3 male)
2	GROUP B	11	21.45	(6 female , 5 male)
3	GROUP C	11	22.36	(6 female , 5 male)

Table 2: Sit and reach test in within groups

Treatment	Pre	Post	Diff	P value
GROUP A	21±10.2	25.4±10.5	4.33±2.07	< 0.001
GROUP B	26.5±6.6	31±5.9	4.52±2.85	< 0.001
GROUP C	19.7±7	24.6±7.5	4.89±2.71	< 0.001

Table 3: Active knee extension (left) in within groups

Treatment	Before	After	Diff	P value
GROUP A	131.3±10.8	143.6±13.1	12.36±5.55	< 0.001
GROUP B	140.5±10.1	152.4±11.5	11.90±10.01	< 0.003
GROUP C	133±9.6	146.2±7.5	13.22±3.93	< 0.001

Table 4: Active knee extension (right) in within groups.

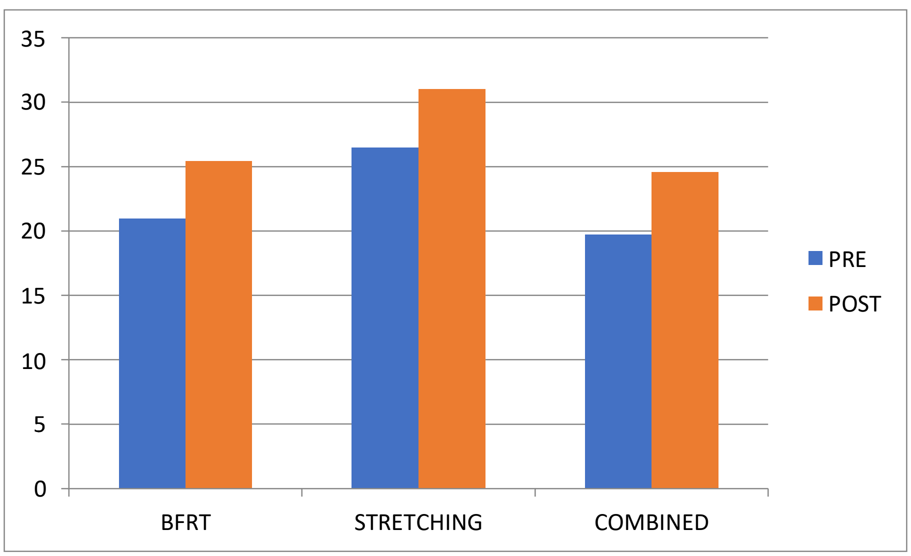
Treatment	Before	After	Diff	P value
GROUP A	133.5±12.2	145.2±11.1	11.63±3.10	< 0.001
GROUP B	135±11.2	145±8.6	10.045±6.45	< 0.001
GROUP C	131.6±10.4	149±8.9	17.36±4.15	< 0.001

Table 5: The difference of sit and reach test, AKE (L), AKE (R) after the trainingprogram among the groups

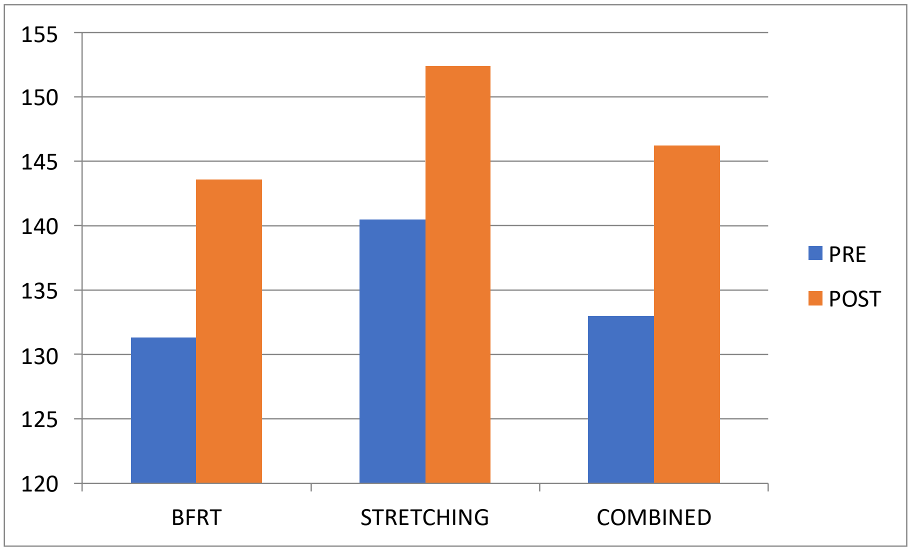
Outcomes	Treatment			F Value	P Value
	GROUP A	GROUP B	GROUP C		
SAR	4.33±2.07	4.51±2.85	4.89±2.71	0.133	0.876
AKE (L)	12.36±5.55	11.90±10.01	13.22±3.93	0.101	0.904
AKE (R)	11.36±3.10	10.04±6.45	17.36±4.15	7.134	0.003

Table 6: Active knee extension (right) between all the groups

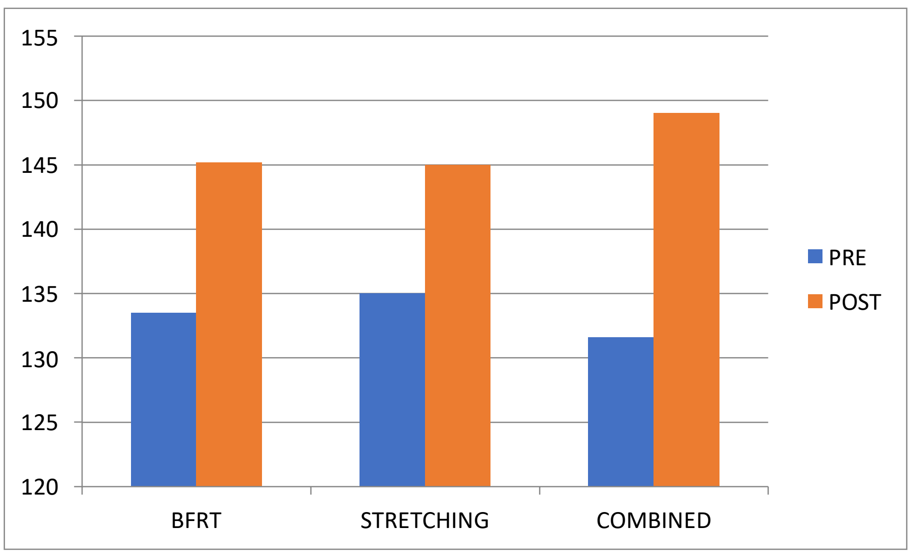
Intervention group (I)	Comparedgroup (J)	an diff(I-J)	Std error	P value	Interval	
					Upperbound	Lowerbound
GROUP A	GROUP B	1.591	2.038	0.718	-3.43	6.62
	GROUP C	-5.727	2.038	0.023	-10.75	-0.70
GROUP B	GROUP A	-1.591	2.038	0.718	-6.62	3.43
	GROUP C	-7.318	2.038	0.003	-12.34	-2.29
GROUP C	GROUP A	5.727	2.038	0.023	0.70	10.75
	GROUP B	7.318	2.038	0.003	2.29	12.34



Graph 1 (sit and reach test)



Graph 2 (active knee extension (left))



Graph 3 (active knee extension (right))

DISCUSSION

This was the first research to compare and examine the effects of increased muscular flexibility caused by agonist stretching, agonist strengthening by BFRT, and the combination of agonist stretching and BFRT. The active knee extension test and the sit-and-reach test wereused to determine the significant differences between the three groups in the outcomes of interest, such as hamstring flexibility. The first hypothesis—that is, that combining the two forms of BFRT would considerably enhance hamstring flexibility (AKE, S&RT) in comparison to the stretching group—was partially supported by these data. However, the Combined group's change in hamstring flexibility was noticeably better than that of the BFRT and stretching group. Furthermore, clinically, the combination of stretching and BFRT worked better than BFRT alone.

The flexibility gains from static stretching in this study are generally consistent with those reported by Sullivan *et al*. **[8, 9]**, who found that after 10 stretching sessions, there was a 9 increase for static stretching, which was statistically significant (P <.05). We disagree with some and concur with Sullivan *et al*. and Winegardner, J. that there is no discernible difference between static and PNF stretching **[10, 11]**. We think that a confounding factor in hamstring stretching[8] is pelvic position, which has not been accounted for in other investigations[10, 11]. Consequently, the goal of using either of these stretching methods will be to increase flexibility. Acute muscular stretching has been shown to decrease H-reflex amplitudes, which may suggest an increase in inhibitory feedback onto the agonist motoneurone pool. However, to our knowledge, this impact has not been studied in relation tomuscle length **[12]**. Therefore, further testing has to be done on this. Static stretching is, in our experience, far simpler to execute and teach than other types of stretching. For this reason, static stretching is advised to improve hamstring flexibility.

Co-contraction and reciprocal inhibition enhance antagonist strengthening by reducing agonist muscle activity during resistance training. This dynamic interaction, fostering neuromuscular coordination, results in balanced force distribution around joints, creating a safer base for agonist-focused activities. The equilibrium formed minimizes muscle imbalances and joint instability, promoting a balanced and effective strength profile. Prolonged antagonist strengthening induces neurological changes, leading to enhanced force generation in subsequent agonist-focused workouts through increased motor unit synchronization and recruitment. These adaptations lay the foundation for optimal strength growth in targeted agonist muscles **[13, 14]**.

Blood Flow Restriction therapy (BFRT) induces metabolic stress and localized hypoxia by restricting blood flow to exercising muscles through tourniquets or pressure cuffs. This prompts physiological responses like growth factor release and cellular swelling, amplifying the cellular response to resistance training. The hypoxic conditions lead to increased metabolic stress, activating satellite cells for cellular repair and regeneration. BFRT enhances muscle cell adaptation, potentially accelerating strength gains. Additionally, BFRT stimulates anabolic signaling pathways, including mTOR (mammalian target of rapamycin) activation, crucial for muscle protein synthesis and hypertrophy. The combined effects of BFRT and resistance training may synergistically amplify anabolic signals, fostering a conducive environment for greater muscle adaptation. Integrating antagonist strengthening with BFRT enhances neuromuscular synergy, combining neurological adaptations from antagonist training with heightened cellular responses induced by BFRT for optimal strength gains. Reciprocal inhibition from antagonist strengthening aligns with BFRT's localized hypoxia, potentially improving targeted agonist muscle activation in subsequent resistance exercises. This synergy may lead to more efficient and robust strength gains, presenting a potential avenue for time-efficient training. Leveraging reciprocal inhibition and localized hypoxia could allow practitioners to achieve significant strength gains with optimized protocols, potentially reducing overall training volume and duration **[15]**.

This study founds active knee extension (right) was having significant result in combined group and sit and reach test, active knee extension (left) was not significant in all the intervention group. The active knee extension test was found to be more sensitive to hamstring length changes, and should be used in the assessment of flexibility **[16]**.

LIMITATION

The study had some possible limitations, including those related to participant characteristics and the sample size on the findings. Because of the study's brief duration, it was difficult to understand long-term impacts, which called for more research on long-term adaptations

CONCLUSION

In conclusion, the immediate effects of combined group (BFRT + Stretching), BFRT on hamstring flexibility reflect a confluence of traditional wisdom and contemporary innovations. While stretching stands as a time-tested method, BFRT emerges as a dynamic and efficient strategy. The synthesis of these approaches offers a diversified toolkit for practitioners and individuals seeking to optimize hamstring flexibility. As we concluded fromthe study that passive stretching and BFRT are effective to release hamstring tightness. Combination therapy of stretching and BFRT is comparatively more effective than BFRT andstretching.

CLINICAL IMPLICATION:

To release the tightness of muscle, agonist should be relax and antagonist muscle should be strengthened. This study focuses on the immediate effect of combination of passive stretchingand BFRT on hamstring tightness.

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