International Journal of Research and Review
[Indexed, Peer-Reviewed Journal]
Volume 13; Issue: 6; June 2026
Website: www.ijrrjournal.com
Research Paper *E-ISSN: 2349-9788; P-ISSN: 2454-2237*

Effectiveness of Static Stretching Versus PNF Stretching (Contract Relax) in Increasing the Extensibility of Plantar Flexors in Young Athletes

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DOI: https://doi.org/10.52403/ijrr.20260632

ABSTRACT

Introduction: Many sports injuries are due to lack of flexibility. For example, an athlete with a tight muscle can easily injure it while sprinting. The aim of this study is to find out the effect of static versus PNF stretching in increasing the extensibility of plantar flexors in young athletes.

Methodology: A pre-test and post-test design with two comparison treatment – Quasi experimental study design. 20 athletes were taken and they were divided into two groups by using random methods. Static stretching (group A) and PNF stretching – contract relax technique (group B). Both groups underwent 6 weeks of intervention. Plantar flexor extensibility is assessed using Cole's standard goniometric technique of ankle dorsi flexion

Statistical analysis was done using paired and independent 't' tests with significance level set at $p<0.05$.

Results: Both groups showed significant pre-post improvements, Group B achieved higher scores compared to Group A in ankle plantar flexor extensibility ($t=3.92$).

Conclusion: PNF stretching is more effective than static stretching in improving the ankle plantar flexor extensibility in young athletes. Incorporating PNF stretching into athletic conditioning programs may optimize the kinetic chain, leading to improved functional performance on field.

Keywords: Ankle joint, Extensibility, Plantar flexors, PNF stretching, Static stretching.

INTRODUCTION

As the field of sport continues to evolve, the role of physiotherapy in athletic performance and injury prevention has become increasingly significant. Athletes frequently experience injuries during training or competition, prompting a growing body of research into the physiological effects and efficacy of emerging trends in sports medicine. Among the many performance-related factors, flexibility plays a critical role in both optimizing performance and preventing injuries. A lack of flexibility has been associated with conditions such as Achilles tendonitis, shin splints, plantar fasciitis, muscle strains, and joint injuries[1]. Adequate flexibility enables effective movement patterns and reduces the likelihood of muscle and tendon injuries, alongside strength, power, and endurance as essential components of athletic performance[2].

Flexibility is defined as the ability of a muscle to lengthen as a joint or body segment moves through its full range of motion (ROM). Flexibility exercises aim to increase the length of the musculotendinous unit, often interchangeably referred to as stretching exercises. Regular flexibility training enhances joint ROM and may reduce the incidence of exercise-induced muscle injuries[3]. Consequently, stretching is widely used as both a preventive and recovery strategy among athletes of all levels. The capacity of the musculotendinous unit to elongate relies on its ability to relax and yield to external stretch forces.

From a neurophysiological perspective, muscle elasticity and tone are regulated through the stretch reflex mechanism. This process involves two principal sensory receptors: muscle spindles and Golgi tendon organs (GTOs). Muscle spindles, located within muscle fibers, monitor changes in muscle length and help maintain tone during rest and movement. In contrast, GTOs, found at the musculotendinous junction, respond to tension. During a prolonged stretch, GTOs signal the spinal cord to inhibit muscle contraction, promoting relaxation[4]. The coordinated actions of these receptors provide a protective mechanism that maintains controlled extensibility of the muscle-tendon complex.

Stretching techniques can be categorized[5] as: Static stretching: The muscle or soft tissue is lengthened just beyond its resistance point and held for an extended period. Cyclic (intermittent) stretching: A shorter stretch force that is repeatedly applied, released, and reapplied gradually. Ballistic stretching: Rapid, forceful, and bouncing movements to push a muscle beyond its normal range; though once popular, it is now largely discouraged due to a higher risk of injury. PNF (Proprioceptive Neuromuscular Facilitation) stretching: Based on Sherrington's law of reciprocal inhibition, PNF employs neuromuscular inhibition to promote relaxation of shortened muscles. Common PNF methods include Contract-Relax and Hold-Relax techniques, which involve isotonic and isometric contractions, respectively. These methods enhance muscle length either by directly targeting hypertonic muscles or through reciprocal activation of their antagonists[6].

Sports-related injuries remain prevalent, and stretching programs are widely implemented as preventative interventions. Multiple studies have demonstrated the benefits of static and PNF stretching in improving muscle extensibility and joint ROM[7, 8]. Conversely, ballistic stretching has been shown to increase injury risk if performed improperly. Currently, static stretching and PNF stretching are considered the two most effective and commonly used methods for improving flexibility among athletes[9]. Although comparative analyses between these techniques have been extensively conducted for hamstring flexibility, limited research exists regarding their effects on plantar flexors.

Many studies have been proven the effectiveness of the various techniques of stretching in improving the extensibility of muscle. Among them, techniques like ballistic stretching have been proven to cause injuries. At present the two most preferred techniques are static stretching and PNF stretching. Given the paucity of evidence comparing the effectiveness of static versus PNF (Contract-Relax) stretching on plantar flexor extensibility, the present study aims to address this gap. Specifically, the study seeks to evaluate improvements in plantar flexor flexibility among young athletes following a six-week intervention using Static Stretching and PNF Contract-Relax techniques.

The objectives of the study were to evaluate the improvement in the extensibility of plantar flexors in young athletes following a 6-week intervention of Static stretching versus PNF stretching exercises between the two groups.

MATERIALS & METHODS

Study design

The present study employed a pre & post-test comparative study design to find the effect of static versus PNF stretching in increasing the extensibility of plantar flexors in young athletes. Prior to administration, all participants were informed about the purpose of the study. Informed consent was obtained from the participant in compliance with ethical research guidelines.

Samples

20 young athletes were recruited from PSG College of Physiotherapy, Coimbatore, were allocated into two groups by random allocation method. The study was conducted in the college campus for duration of 6 months. The Participants' age was from 18 to 22 years, male with dominant leg as right, and physiological limitation to 20 of dorsiflexion in right ankle joint were included. Age less than 18 and more than 25 years, recent surgeries, recent injuries in both upper limb and lower limb, cardiac diseases, prior back or abdominal surgeries, pain or disability in upper or lower limb, neuromuscular disorders, scoliosis, limb length discrepancy and postural asymmetries were excluded.

Study tools

The full circle or universal goniometer was used throughout the study.

Cole's standard goniometric technique

1. Mark the fibular head, the lateral malleolus, the fifth metacarpal base and head with a marker.
2. The stationary arm of the goniometer was placed on the long axis of the fibula by using the marks on the fibular head and the lateral malleolus.
3. The moving arm of the Goniometer was placed to the lateral border of the foot by using the mark on the base and head of the fifth metacarpal.
4. The axis of the goniometer on the base and head of the fifth metatarsal. The zero position of dorsiflexion was defined as the 90 degree angle between the long axis of the fibula and the lateral border of the foot.

Interventions

The intervention was carried out over 6 weeks. Both groups received a warm up program consisting of warm up exercise consisted of active dorsiflexion and plantar flexion of the ankle joint with instruction to hold each movement for five seconds and to do 10 repetitions for 10 minutes. Followed by the Group A underwent Static stretching exercises and Group B underwent PNF stretching exercises.

Static stretching exercises

Static stretching is a method by which the muscle is slowly elongated to tolerance (a comfortable stretch, short of pain) and the position is held with the muscles in the greatest tolerated length. There are two types of static stretching: Active Static Stretch: The athlete sustains the stretch by himself. Passive Static Stretch: The athlete initiates the stretch and the therapist passively moves the joint towards the end range of motion. In this study Passive Static Stretch was applied by the therapist[10].

Athlete's position: Supine lying, hip and knee flexed Hand placement of therapist: one hand on the anterior surface of the tibia to stabilize. The other hand grasping the athlete's heel (Calcaneus). Maneuver: Calcaneus is pulled downward with the thumb and finger and a gentle upward push is applied on heads of the metatarsals, then the hip and knee are extended slowly. This position was held for 30 seconds. Five repetitions were done in a single session. This stretching program was continued for 4 times per week for 6 weeks period.

PNF (contract relax) stretching

Contract relax stretching is a method by which there is isotonic muscle contraction against resistance followed by passive stretch of the muscle[6].

Athlete's position: Supine lying on the treatment couch. Hand placement of the therapist: The ankle is dorsiflexed up to the

restricted range. He then grips the foot in such a way that gives cue to the patient to move the foot in the direction of plantar flexion. Thus the athlete is asked to perform isotonic contraction of the plantar flexors. The resistance offered by the therapist should gradually and smoothly build up to such an extent that the athlete is stimulated to contract the plantar flexors maximally. When the therapist feels that there is maximal recruit of the motor units in the plantar flexors, the patient is asked to relax. Immediately following maximal relaxation, the therapist applies a passive stretch to the new range of restriction. Then the entire procedure is repeated at this new range. Four repetitions were done in a single session. This stretching program was continued for 4 times per week for 6 weeks period.

Statistical Methods

The pre and the post active ankle dorsiflexion range of motion values of all the two groups were obtained during the baseline and at the end of sixth week. The measurements were taken with the help of goniometer graded in degrees. Mean, standard deviation and between group differences in pre- to post intervention change scores were examined using independent-samples t-tests, whereas within-group differences from baseline to post intervention were assessed using paired samples t-tests. Statistical significance was set at $P < 0.05$ (two tailed) for all analyses.

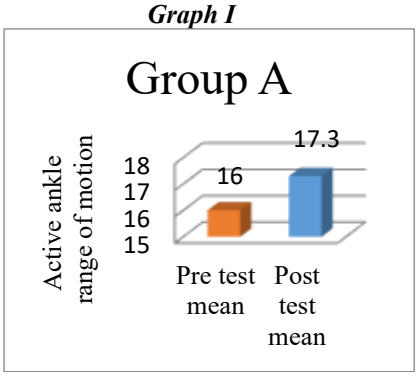
RESULTS

Within group analysis

Ankle plantar flexor extensibility of group A (Static stretching):

For 9 degrees of freedom and at 5% level of significance, the table "t" value is 4.78 and the calculated "t' value was 8.56. Hence there was significant effect of Static stretching on ankle plantar flexor extensibility in young athletes.

Graph I

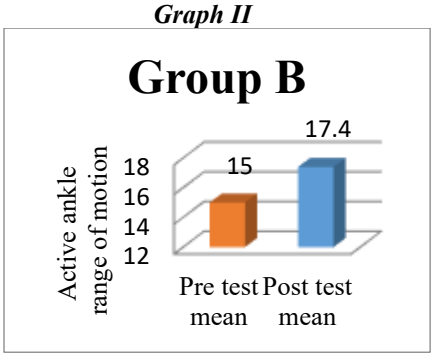


This graph shows paired 't' test mean values of active ankle dorsiflexion range of motion within Static stretching group (Group A)

Ankle plantar flexor extensibility of group B (PNF stretching):

For 9 degrees of freedom and at 5% level of significance, the table"t" value is 4.78 and the calculated "t' value was 14.68. Hence there was significant effect of PNF stretching on ankle plantar flexor extensibility in young athletes.

Graph II



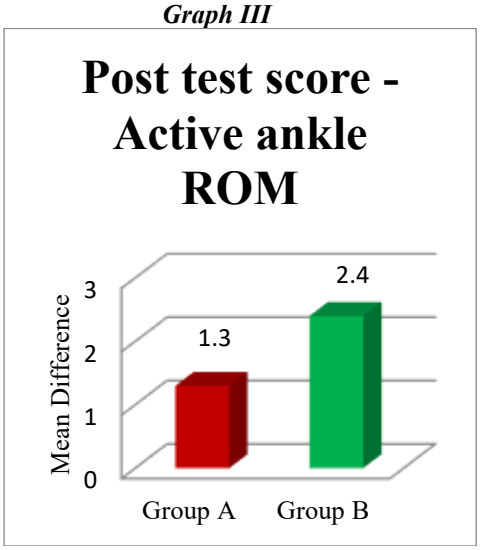
This graph shows paired 't' test mean values of active ankle dorsiflexion range of motion within PNF stretching (contract relax) group (Group B)

Between group analysis

Ankle plantar flexor extensibility of group A (Static stretching) and group B (PNF stretching):

For 38 degrees of freedom and 5% level of significance, the table"t" value 3.92 and the calculated "t" value is 4.928. The calculated "t" value was greater than the table "t" value, there was significant difference found between both the groups for ankle dorsiflexion range of motion as shown in graph III. The mean improvement in active ankle dorsiflexion range of motion in group B was 2.4 which was higher than the mean improvement in active ankle dorsiflexion range of motion in group A which was 1.3 (Graph 4). This indicates that there was a significant increase in active ankle dorsiflexion range of motion by applying PNF stretching (Contract relax) than Static stretching.

Graph III



Independent't' test mean values of ankle dorsiflexion range of motion between Static stretching (Group A) and PNF stretching (Group B).

DISCUSSION

Stretching is a widely practiced technique in sports medicine and rehabilitation, primarily aimed at increasing the tensile strength of tendons to prevent injury and improve athletic performance[11]. Various stretching techniques have been developed including static stretching, cyclic stretching, ballistic stretching, and proprioceptive neuromuscular facilitation (PNF) stretching, all of which have been shown to increase the extensibility of muscles and their associated tissues[12].

The primary objective of this study was to compare the improvement in the extensibility of plantar flexors in young athletes following a 6-week intervention of static stretching versus PNF stretching exercises between two groups. The results demonstrated that while both interventions were effective, the PNF stretching group achieved a statistically significant superior improvement for the outcome measures, suggesting that the method of muscle activation prior to stretching may influence the magnitude of extensibility gains achieved.

The calculated 't' value for Group I 18.50 was greater than the table 't' value of 4.78, indicating a significant increase in the extensibility of plantar flexors following static stretching application. Static stretching when applied for 5 repetitions with a 30-second hold produced plastic changes in the musculotendinous unit, thereby increasing the extensibility of muscle, which is consistent with the statements of Toft et. al., (1989)[13]. The mechanism underlying these improvements can be attributed to viscoelastic creep, where prolonged stretching causes plastic deformation of the muscle-tendon unit, and decreased muscle spindle sensitivity leading to reduced stretch reflex activity Bandy &

Irion (1994)[14]. Additionally, repeated sessions of static stretching result in cumulative changes in the series elastic component and collagen fiber orientation, allowing for greater lengthening of the musculotendinous structure over time Gajdosik (1991)[15]. The 30-second hold duration selected in this protocol is supported by previous research indicating that this duration produces optimal changes without causing excessive fatigue or diminished returns Feland & Marin (2004)[16].

The calculated 't' value is 14.68 for Group B was greater than the table 't' value 4.78, indicating a significant increase in the extensibility of plantar flexors by applying PNF stretching (contract-relax technique). The PNF stretch (contract-relax) when applied for 4 repetitions produces relaxation of tightened muscles prior to stretch, allowing the muscle to yield more during the stretch, thereby increasing the extensibility of the muscle, which is consistent with the statements of Sharman et. al., (2006)[6]. The neurophysiological basis for PNF's effectiveness lies in its utilization of autogenic inhibition and reciprocal inhibition mechanisms as described by Sherrington[11]. When the athlete performs maximal isotonic contraction against resistance, golgi tendon organs are activated, which temporarily reduces neural excitability and allows greater elongation during the subsequent passive stretch phase. This active contraction phase maximally recruits motor units, leading to greater subsequent relaxation through autogenic inhibition, which explains why Group B (PNF) showed superior extensibility gains compared to static stretching.

The superior results observed with PNF in this study may be attributed to the combination of both neural and mechanical adaptations, suggesting that PNF stretching may be more effective for athletes requiring rapid improvements in muscle extensibility[12]. While static stretching primarily produces mechanical changes through viscoelastic creep and plastic deformation of the musculotendinous unit[13]. PNF incorporates an active component that engages neural pathways, resulting in deeper relaxation and greater subsequent range of motion gains[6]. These findings have significant clinical implications for athletic training programs, as improved plantar flexor extensibility reduces the risk of Achilles tendinopathy, gastrocnemius strains, and ankle sprains while also enhancing performance through improved dorsiflexion range that positively affects squat depth, jumping mechanics, and running efficiency. The time efficiency of PNF, requiring fewer repetitions (4 reps) compared to static stretching (5 reps × 30 seconds), further supports its utility in busy training schedules. However, future research should consider long-term follow-up to assess retention of gains, comparison of combined static plus PNF protocols, and biomechanical analysis of tendon behavior using ultrasound elastography to provide deeper insight into the structural changes occurring within the muscle-tendon unit following these interventions.

CONCLUSION

This study concludes that while both Static stretching and PNF stretching – contract relax significantly improve extensibility of ankle plantar flexors in young athletes, the PNF stretching – contract relax method is a superior intervention allows for a more efficient in increasing the extensibility of ankle plantar flexors in young athletes.

Declaration by Authors

Ethical Approval: Approved
Acknowledgement: None
Source of Funding: None
Conflict of Interest: No conflicts of interest declared.

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How to cite this article: Ragunath Balu, V. Ramamoorthy, Syed Ibrahim Syed Kadar Oli. Effectiveness of static stretching versus PNF stretching (contract relax) in increasing the extensibility of plantar flexors in young athletes. *International Journal of Research and Review*. 2026; 13(6): 315-321. DOI: *https://doi.org/10.52403/ijrr.20260632*

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