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THE EFFECT OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION AND NERVE GLIDE INTERVENTIONS ON HAMSTRING FLEXIBILITY AND KNEE EXTENSION RANGE OF MOTION IN FEMALE RECREATIONAL RUNNERS IN THE SOLO RUNNERS COMMUNITY

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ABSTRACT

Limited hamstring flexibility and decreased knee extension range of motion (ROM) are risk factors for musculoskeletal injuries in recreational female runners. This study aimed to compare the effectiveness of proprioceptive neuromuscular facilitation (PNF) with nerve glide in improving hamstring flexibility and knee extension ROM. This quasi-experimental pre-test–post-test study involved 20 female runners from the Solo Runners community, who were randomly assigned to two groups (PNF and nerve glide, n=10 each). Both groups underwent 12 intervention sessions over 4 weeks (3 times/week). Flexibility was measured using the Sit and Reach Test (SRT), while knee extension ROM was measured using the Active Knee Extension (AKE) test. Data were analyzed using the Wilcoxon test, paired t-test, and Mann–Whitney U test. Both interventions significantly improved hamstring flexibility (PNF Δ=+7.1 cm, p=0.004; nerve glide Δ=+5.4 cm, p=0.004) and knee extension ROM (PNF Δ=−13.2°, p<0.001; nerve glide Δ=−10.1°, p=0.005). The improvement in flexibility was greater in the PNF group than in the nerve glide group (p=0.001), whereas the between-group difference in Δ ROM was not statistically significant (p=0.057). PNF is more effective than nerve glide in improving hamstring flexibility, whereas both techniques yield similar results in improving knee extension ROM. The selection of technique should be tailored to the primary source of movement limitation, whether muscle-dominant or nerve-related.

Keywords:

PNF, Nerve Glide, Hamstring Flexibility, Knee Extension ROM, Female Recreational Runner

1. INTRODUCTION

Hamstring muscle flexibility plays a crucial role in maintaining movement quality, optimizing performance, and preventing injury in runners. Hamstring tightness can limit stride length, increase tension on both passive and active tissues, and affect hip and knee joint kinematics. Furthermore, limitations in knee extension range of motion (ROM) can increase the mechanical load on joints and supporting muscles during running activities[1].

Reduced hamstring flexibility can lead to biomechanical changes such as increased posterior pelvic rotation, decreased hip extension, and compensatory knee movements, thereby elevating the risk of hamstring strain and other musculoskeletal injuries[3]. Epidemiological studies have reported that injury rates among recreational runners remain high, with an annual prevalence of up to 50%, and hamstring injuries account for approximately 29–30% of all lower limb injuries. [1], [2]

Proprioceptive Neuromuscular Facilitation (PNF) is a stretching technique that combines isometric contraction with passive stretching to lengthen muscles through the mechanism of autogenic inhibition, thereby increasing stretch tolerance and modifying the viscoelastic properties of muscle tissue[1], [3].This method has been proven effective in improving flexibility and ROM in both athletic and non-athletic populations[4].

Nerve glide or nerve mobilization is a technique aimed at enhancing the sliding of peripheral nerves, reducing intraneural tension, and improving neurodynamics, thereby potentially increasing ROM indirectly[5], [6].

Although both techniques are commonly used in sports physiotherapy, evidence comparing the effectiveness of PNF and nerve glide in recreational female runners remains limited. This study aimed to compare the effects of these two interventions on hamstring flexibility and knee extension ROM in recreational female runners.

2. METHODS

a. Methodology

Study design

This study employed a quasi-experimental design with two parallel intervention groups using a pre-test and post-test approach. The study was conducted over a four-week period. Ethical approval was granted by the Ethics Committee of the Faculty of Health, Universitas Muhammadiyah Surakarta (Approval No. 2000/UN14.2.2/KEP/2025). All participants were provided with a clear explanation of the study objectives, procedures, and potential risks and provided written informed consent prior to participation.

Subjects recruitment

Participants were recruited from the Solo Runners' community in Surakarta, Indonesia. Twenty female recreational runners aged 20–35 years were enrolled in this study. Inclusion criteria were: (1) being healthy, (2) actively participating in recreational running for at least 3 months, and (3) willingness to complete all 12 intervention sessions. Participants were excluded if they had (1) a history of lower-limb musculoskeletal injury within the past 6 months, (2) any diagnosed neurological disorders, or (3) had received physiotherapy treatment related to flexibility or ROM training within the previous 3 months.

Sampling technique

Participants were randomly allocated into two groups, the PNF and nerve glide groups, using simple randomization. To minimize bias, allocation was conducted by an independent researcher who was not involved in data collection.

b. Material and procedure

Material

Flexibility was assessed using the Sit and Reach Test (SRT), which was performed with a standardized sit-and-reach box calibrated in centimeters. Knee extension ROM was measured using a universal plastic goniometer (Baseline®, USA) following the Active Knee Extension (AKE) method and recorded in degrees.

Procedures PNF protocol

Participants in the PNF group underwent the hold-relaxation technique. Each subject was positioned supine, with the hip flexed at 90°. The hamstring muscle was stretched passively to the point of resistance, followed by isometric contraction of the hamstring for 5–6 s. After contraction, a further passive stretch was applied for 10 seconds[7]. This sequence was repeated three times per session, with a frequency of three sessions per week over four consecutive weeks (total of 12 sessions).

Nerve glide protocol

Sciatic nerve mobilization exercises were performed in the nerve-glide group. These consisted of dynamic movements involving sequential knee extension and ankle dorsiflexion while seated and supine, designed to mobilize the sciatic nerve along its path. Each exercise cycle was performed for 10 repetitions per session, with the same frequency and duration as in the PNF group (3 sessions per week for 4 weeks).

c. Assessment

The baseline and post-intervention measurements were performed by blinded examiners. Flexibility (cm) and ROM (degrees) were measured using SRT and AKE, respectively. To ensure accuracy, each test was repeated thrice, and the best score was recorded.

d. Data analysis

Statistical analyses were performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Normality of data distribution was assessed using the Shapiro-Wilk test. Paired t-tests or Wilcoxon signed-rank tests were used for within-group comparisons depending on the data distribution. Between-group differences were evaluated using independent t-tests or Mann–Whitney U tests. Statistical significance was set at $P<0.05$.

3. RESULTS

This study involved 20 participants divided into two intervention groups, the PNF group and the nerve glide group, with 10 participants in each group. Data analysis was conducted to assess changes in hamstring muscle flexibility and knee extension ROM before and after the intervention within each group (within-group analysis) and to compare changes between the two groups (between-group analysis). The results are presented in Tables 1, 2, and 3.

Table 1. Within-Group Comparison of Hamstring Flexibility (Wilcoxon Test)

Group	Pre-test (Median ± IQR)	Post-test (Median ± IQR)	Difference (Median ± IQR)	*p*-value
PNF	26.5 ± 12.5 cm	33.5 ± 10.5 cm	7.5 ± 2.0 cm	0.004*
Nerve glide	24.5 ± 9.5 cm	29.5 ± 8.75 cm	5.5 ± 1.0 cm	0.004*

In both the PNF and nerve glide groups, there was a significant improvement in hamstring flexibility after 4 weeks of intervention ($p < 0.05$). The PNF group showed an increase in median flexibility from 26.5 ± 12.5 cm to 33.5 ± 10.5 cm, with a mean change of 7.5 ± 2.0 cm ($p = 0.004$, Wilcoxon test). The nerve glide group also demonstrated an improvement from 24.5 ± 9.5 cm to 29.5 ± 8.75 cm, with a mean change of 5.5 ± 1.0 cm ($p = 0.004$, Wilcoxon test).

Tabel 2. Within-Group Comparison of Knee Extension ROM

Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Difference (Mean ± SD)	*p*-value
PNF	21.0 ± 9.5°	7.8 ± 6.6°	13.2 ± 3.29°	0.000†
Nerve glide	23.5 ± 17.5°	14.5 ± 11.5°	9.0 ± 6.3°	0.005*

The knee extension ROM deficit was significantly reduced in both groups ($p < 0.05$). In the PNF group, the mean ROM deficit decreased from 21.0 ± 9.5° to 7.8 ± 6.6°, with a mean change of 13.2 ± 3.3° ($p = 0.000$, paired t-test). In the nerve glide group, the ROM deficit decreased from 23.5 ± 17.5° to 14.5 ± 11.5°, with a mean change of 9.0 ± 6.3° ($p = 0.005$, Wilcoxon test).

Tabel 3. Between-Group Comparison (Mann–Whitney U Test)

Variable	PNF (Mean ± SD / Median ± IQR)	Nerve Glide (Mean ± SD / Median ± IQR)	*p*-value
Flexibility Δ	7.5 ± 2.0 cm	5.5 ± 1.0 cm	0.001*
ROM Δ	13.0 ± 4.5°	9,0 ± 6.3°	0.057

Analysis of between-group changes (delta) showed that hamstring flexibility was significantly greater in the PNF group than in the nerve glide group ($p = 0.001$, Mann–Whitney test). In contrast, the difference in knee extension ROM changes between the groups was not statistically significant ($p = 0.057$, Mann–Whitney test).

4. DISCUSSION

This study demonstrated that both PNF and nerve glide techniques are effective in improving hamstring flexibility and knee extension ROM in female recreational runners. These findings hold important relevance in the context of injury prevention and performance optimization in running-based sports, as limited flexibility and ROM have been shown to be risk factors for injuries, such as hamstring strains, alterations in gait patterns, and decreased movement efficiency[1], [8]

Consistent with previous research, the PNF group showed a significantly greater improvement in flexibility than the nerve glide group. The mean increase of 7.5 cm in the SRT suggests a stronger effect of PNF on the lengthening of the musculotendinous unit. This mechanism can be explained by the principle of autogenic inhibition mediated by the Golgi Tendon Organ (GTO). In the hold-relax technique, a brief isometric contraction followed by passive stretching reduces muscle spindle excitability and increases stretch tolerance, resulting in a temporary increase in muscle length[1], [3]

In contrast, the nerve glide technique yielded significant flexibility gains, albeit to a lesser extent. This intervention targets peripheral nerve structures, particularly the sciatic nerve, to enhance nerve sliding and reduce intraneural tension. Although it does not directly lengthen the muscle tissue, this technique is beneficial for individuals with neurodynamic restrictions, such as subclinical sciatic nerve tension[5], [6]. This mechanism supports the finding that the SRT changes in the nerve glide group were smaller than those in the PNF group, as the primary target is the nervous system rather than the muscle tissue.

For ROM, both groups demonstrated significant within-group improvements. The PNF group experienced a mean reduction in the knee extension deficit of 13.2°, whereas the nerve glide group showed a reduction of 9.0°. Although the difference in ROM changes (delta) between the groups was not statistically significant ($p = 0.057$), the data trend indicated better absolute results in the PNF group. This suggests that PNF can address movement limitations originating from a combination of muscular and neuromuscular factors, whereas nerve glide is more optimal when restrictions are predominantly neural in origin[5], [9].

These findings highlight that the choice of the flexibility training method should consider the underlying source of movement limitation. For individuals with muscle-dominant stiffness, PNF may provide faster and more significant improvements. Conversely, individuals showing signs of neural tension, such as positive slump test or straight leg raise test results, may benefit more from nerve-glide techniques[6].

An important contribution of this study is its focus on female recreational runners, a relatively underrepresented population in flexibility and rehabilitation research. Differences in neuromuscular patterns, hormonal influences on connective tissue, and injury profiles between men and women may influence responses to stretching interventions[1].Moreover, recruiting participants from a real-world running community (Solo Runners) enhances the external validity and practical relevance of the results for community-based fitness programs.

However, this study had several limitations. The small sample size ($n = 20$) may limit the statistical power, especially for variables with high inter-individual variability, such as ROM. The absence of a control group also limits the ability to isolate intervention effects from external factors such as activity awareness or placebo effects. The four-week intervention period was sufficient to detect short-term improvements, but the long-term retention of these effects remains uncertain.

Future research should explore the effectiveness of combined protocols, such as integrating PNF with nerve glide, which may offer synergistic benefits. Including male participants, athletes from other sports, and longer follow-up periods would improve the generalizability and clinical relevance of our findings. The use of objective neurophysiological assessments, such as electromyography (EMG) or ultrasonography, may also provide deeper insights into the mechanisms of change and support more individualized intervention planning.

5. CONCLUSION

This study showed that PNF and nerve glide are equally effective in improving hamstring flexibility and knee extension ROM in female recreational runners. PNF resulted in significantly greater flexibility gains than nerve glide, whereas the difference in ROM gains between the two groups was not statistically significant.

These findings indicate that PNF is more appropriate for cases of limited mobility, primarily due to muscle stiffness, while nerve glide may be an appropriate option for individuals with limitations due to peripheral nerve tension.

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