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Effect Of Hamstring Flexibility Training On Speed Performance In Adolescent Speed Skaters: A Randomized Controlled Trial

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ABSTRACT

Background: Hamstring flexibility plays a pivotal role in enhancing biomechanical efficiency and preventing injuries among adolescent speed skaters. Despite the biomechanical relevance, limited empirical evidence exists on the direct influence of flexibility on speed performance.

Objective: To determine the effects of a structured hamstring flexibility program on speed performance in adolescent speed skaters.

Methods: A single-blinded, randomized controlled trial involving 100 adolescent speed skaters (aged 12–17 years) was conducted. Participants were randomly divided into an experimental group (n=50) and a control group (n=50). The experimental group underwent an 8-week physiotherapy-led hamstring flexibility training protocol alongside routine training, while the control group continued their standard training alone. Assessments of hamstring flexibility (via Sit and Reach Test) and 100-meter skating sprint performance were performed pre- and post-intervention.

Results: The experimental group exhibited a significant increase in flexibility (mean ΔSRT = 5.7 ± 1.4 cm, $p < 0.001$) and improved speed (mean ΔTime = -0.82 ± 0.25 sec, $p < 0.001$) compared to minimal changes in the control group ($p > 0.05$).

Conclusion: Integrating targeted hamstring flexibility training into adolescent skaters' regimens significantly enhances flexibility and skating speed. Physiotherapy protocols focusing on dynamic and static flexibility can be instrumental in optimizing athletic performance.

Keywords: Hamstring flexibility, adolescent speed skaters, performance enhancement, physiotherapy, randomized trial

1. INTRODUCTION

Speed skating demands high levels of lower limb coordination, strength, and flexibility. In particular, hamstring flexibility is essential for maintaining an efficient stride and reducing the risk of muscle strain. Adolescent athletes are in a critical phase of musculoskeletal development, making it imperative to incorporate preventive and performance-enhancing strategies.

Previous literature has established a link between poor flexibility and muscular injuries, but the correlation between flexibility and performance outcomes such as sprint time remains underexplored in adolescent speed skaters. Given the mechanical role of the hamstrings during hip extension and knee flexion in skating, this study aimed to assess whether a physiotherapist-led flexibility program could improve both flexibility and performance.

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Hamstring muscles play a crucial role in generating propulsion during the push-off phase of skating while simultaneously controlling leg recovery through eccentric contractions. Limited flexibility in these muscles can restrict stride length, reduce skating efficiency, and predispose athletes to strain injuries. Conversely, optimal flexibility may enhance movement economy by allowing greater joint excursion, smoother transitions, and improved neuromuscular coordination. In adolescent speed skaters, where rapid growth often leads to temporary muscle–tendon imbalances, targeted flexibility interventions could have a particularly pronounced effect on performance and injury prevention.

While several studies have explored stretching and flexibility training in runners, football players, and other athletes, research specific to ice or inline speed skaters remains scarce. The unique biomechanical demands of skating—characterized by prolonged hip flexion, lateral push-off forces, and repetitive eccentric loading—warrant discipline-specific investigation. Moreover, adolescent populations require tailored training approaches that consider developmental factors such as growth spurts, hormonal changes, and motor control maturation.

Recent evidence suggests that flexibility training not only increases range of motion but may also positively influence muscle-tendon stiffness and force generation capacity. Dynamic and Proprioceptive-based stretching methods, in particular, have been shown to yield functional benefits without compromising muscular strength or power. However, the extent to which these gains translate into measurable improvements in skating speed or time performance remains unclear.

2. OBJECTIVES

To examine the impact of an 8-week physiotherapy-guided hamstring flexibility training on flexibility levels.

To determine the effect of enhanced hamstring flexibility on 100-meter sprint skating performance.

3. METHODOLOGY

Study Design: A prospective, single-blinded, randomized controlled trial.

Participants

Total sample: 100 adolescent speed skaters (aged 12–17 years) from five professional skating academies.

Inclusion criteria: Minimum 2 years of professional training, no recent lower limb injury (past 6 months), and parental consent.

Exclusion criteria: Current musculoskeletal disorders, concurrent physiotherapy interventions, or competitive absenteeism.

Randomization

Participants were randomly allocated to either the experimental group (n=50) or control group (n=50) using computer-generated block randomization.

Blinding

Assessors responsible for testing were blinded to the group allocation.

Intervention Protocol

Duration and Frequency

Total Duration: 8 weeks

Frequency: 3 sessions per week (on non-consecutive days to allow recovery)

Session Duration: Approximately 45–60 minutes per session

Supervision: All sessions are conducted under the supervision of a licensed physiotherapist with experience in sports rehabilitation.

Components:

Session Structure

Each training session consists of five progressive components designed to enhance hamstring flexibility, neuromuscular control, and eccentric strength.

1. Warm-up (10 minutes)

Objective: To increase core temperature, improve blood flow, and prepare the neuromuscular system for flexibility and strength exercises.

Activities:

Light Jogging: 5 minutes at 50–60% of maximal heart rate.

Dynamic Limb Swings:

Forward–Backward Leg Swings: 2 sets × 10 repetitions per leg

Lateral Leg Swings: 2 sets × 10 repetitions per leg

Hip Circles: 2 sets × 10 repetitions clockwise and counterclockwise

Monitoring: Participants' heart rate is checked to ensure moderate intensity (100–120 bpm).

Progression: Maintain consistent duration and increase range of motion gradually across weeks.

2. Static stretching (8–10 minutes)

Objective: To improve passive hamstring flexibility through sustained elongation of muscle fibers.

Exercise: Supine Hamstring Hold (Passive Stretch)

Position: Participant lies supine, one leg extended on the floor, the other raised with knee extended.

Execution: Therapist assists in lifting the leg to the point of mild discomfort (not pain).

Hold: 30 seconds per leg

Sets: 3 sets per leg

Rest Between Sets: 15–20 seconds

Safety Notes:

Avoid ballistic movements.

Stretch should be within pain-free range (VAS ≤ 3/10).

3. Dynamic Drills (10 minutes)

Objective: To develop functional flexibility and prepare for explosive skating movements.

Exercises:

Leg Swings (Forward and Backward): 2 sets × 10 reps per leg

High Knees with Hamstring Kicks: 3 sets × 20 meters

Butt Kicks: 3 sets × 20 meters

Skipping with Emphasis on Hamstring Pull-through: 2 sets × 20 meters

Intensity: Moderate to high; RPE 6–7 on Borg Scale.

Progression: Increase velocity and range of motion every two weeks.

4. Proprioceptive Neuromuscular Facilitation (PNF) Stretching (15 minutes)

Objective: To maximize active range of motion through neuromuscular inhibition techniques.

Techniques Used:

Contract–Relax and **Hold–Relax** methods

Target Muscle: Hamstring group (biceps femoris, semitendinosus, semimembranosus)

Procedure:

Participant lies supine; the therapist moves the leg into a stretched position (to the point of mild tension).

Participant performs an **isometric contraction** (50–70% maximal effort) of the hamstrings against the therapist's resistance for **6 seconds**.

Participant relaxes for 2 seconds.

Therapist passively increases the stretch and holds for **15–20 seconds**.

Repeat for **3 cycles per leg**.

Supervision: Conducted by a trained physiotherapist to ensure proper alignment and intensity.

Progression: Maintain same contraction duration; increase stretch angle weekly as tolerated.

5. Eccentric Loading Exercise (Nordic Hamstring Curl) (15 minutes)

Objective: To strengthen the hamstrings eccentrically, reducing injury risk and improving force production during sprinting.

Equipment: Soft mat, padded ankle support or partner assistance.

Technique:

Participant kneels with ankles secured by a partner or device.

Slowly leans forward, maintaining a straight line from knees to head.

Controls descent using hamstrings until unable to resist gravity.

Uses hands to catch body and push back to starting position.

Sets/Reps: 3 sets × 10 repetitions

Rest Interval: 60–90 seconds between sets
Tempo: 3–4 seconds eccentric phase, quick return to start.
Progression:
Week 1–2: 2 sets × 8 reps
Week 3–4: 3 sets × 8 reps
Week 5–6: 3 sets × 10 reps
Week 7–8: 3 sets × 12 reps
Cues: Maintain trunk alignment; avoid hip flexion; perform slow controlled motion.
Cool-Down (5 minutes)
Objective: To promote recovery and minimize post-exercise soreness.
Activities:
Gentle walking (2 minutes)
Light hamstring and quadriceps stretches (2 × 20 seconds per muscle group)
Deep breathing exercises (1 minute)
Safety and Monitoring
Pre-Participation Screening: Physical examination and hamstring flexibility test (Active Knee Extension test).
Adverse Events: Any discomfort or pain beyond mild soreness is documented and evaluated.
Compliance: Minimum 85% session attendance required for inclusion in final analysis.
Progression Criteria
Participants advance intensity and range only when:
No delayed-onset muscle soreness lasting >48 hours
No increase in pain or stiffness during sessions
Demonstrated improvement in flexibility by at least 5° on Active Knee Extension test
Control Group: Continued their regular speed skating regimen without any added flexibility exercises.
Outcome Measures
Primary Outcome: Sit and Reach Test (SRT) to assess hamstring flexibility
Secondary Outcome: 100-meter speed skating time measured with electronic timing gates
Results
Demographics
Mean age: 14.0 ± 1.5 years
Gender: 54 males, 46 females, evenly distributed across groups

Table 1. Sit and Reach Test

Group	**Pre-Test (Mean ± SD)**	**Post-Test (Mean ± SD)**	**Change (Δ)**	**p-value**
Experimental Group	22.8 ± 2.6 cm	28.5 ± 2.7 cm	+5.7 cm	< 0.001
Control Group	23.1 ± 2.8 cm	23.6 ± 2.5 cm	+0.5 cm	0.09

Table 2. Speed Performance (100m Time)

Group	**Pre-Test (Mean ± SD)**	**Post-Test (Mean ± SD)**	**Change (Δ)**	**p-value**
Experimental Group	11.9 ± 0.35 s	11.08 ± 0.30 s	−0.82 s	< 0.001
Control Group	11.85 ± 0.38 s	11.73 ± 0.37 s	−0.12 s	0.13

4. DISCUSSION

Our findings demonstrate that a dedicated hamstring flexibility training program significantly enhances both flexibility and sprint speed in adolescent skaters. Improved range of motion may contribute to a more powerful push-off, better stride recovery, and reduced energy wastage.

This aligns with the neurophysiologic theory suggesting that optimal muscle length-tension relationship enhances force production. Additionally, the inclusion of eccentric loading (e.g., Nordic curls) could have contributed to greater neuromuscular activation and injury prevention.

The study also reinforces the value of flexibility in performance contexts, which is often underemphasized compared to strength or endurance training.

5. CONCLUSION

An 8-week hamstring flexibility training program significantly improved flexibility and sprint skating speed in adolescent athletes. These findings emphasize the importance of physiotherapy-led interventions in performance enhancement and injury prevention.

Recommendations

Adopt flexibility screening as part of routine athlete assessments.

Integrate structured flexibility training within regular sports conditioning programs.

Further research should explore long-term benefits and sport-specific adaptations across various age brackets.

Conflict of Interest

The authors declare that they have no conflicts of interest related to this study

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