Clinical Trial Protocol
Iranian Registry of Clinical Trials

22 Nov 2026

The Effect of PNF Stretching on Knee Extension Range of Motion and Bike-Fitting Kinematics in Adult Male Cross-Country Mountain Bikers with Hamstring Tightness: A Randomized Controlled Trial

Protocol summary

Study aim

To determine the effect of a six-week proprioceptive neuromuscular facilitation (PNF) stretching program on knee extension range of motion, posterior thigh pain, lower-limb and trunk pedaling kinematics assessed by bike fitting, and pedaling efficiency in adult male cross-country mountain bikers with hamstring tightness.

Design

Randomized, controlled, parallel-group clinical trial with outcome assessor and data analyst blinding, involving 40 cross-country mountain bikers (20 per group). Randomization was performed in blocks of four using a random sequence generated with Randomizer.org.

Settings and conduct

This study will be conducted in cycling clubs in Tabriz on 40 cross-country mountain bikers with hamstring tightness. Participants will be randomly allocated to an intervention group or a control group. Knee range of motion, posterior thigh pain, bike-fitting pedaling kinematics, pedaling efficiency and squat strength will be assessed after the intervention.

Participants/Inclusion and exclusion criteria

Inclusion criteria: Male cross-country mountain bikers aged 18–35 years at club level, with at least two years of regular training, hamstring tightness (inability to reach less than 15° of knee flexion in the Active Knee Extension test), and mild to moderate posterior thigh pain (VAS 3–7). Exclusion criteria: Hamstring strain within the past six months, lower-limb fracture or surgery within the past year, spinal disorders, posterior thigh pain of non-muscular or neural origin (positive Slump test), knee flexion contracture, and cardiovascular or metabolic disease contraindicating exercise.

Intervention groups

Intervention group: PNF stretching using the hold-relax technique for the hamstring muscles for six weeks. Control group: No intervention.

Main outcome variables

Active knee extension range of motion; posterior thigh pain intensity; maximum knee extension angle during pedaling

General information

Reason for update

Acronym

IRCT registration information

IRCT registration number: **IRCT20260627069971N2**
Registration date: **2026-11-04, 1405/08/13**
Registration timing: **prospective**

Last update: **2026-11-04, 1405/08/13**
Update count: **0**

Registration date

2026-11-04, 1405/08/13

Registrant information

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Name of organization / entity

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Recruitment status

recruiting

Funding source

Expected recruitment start date

2026-11-05, 1405/08/14

Expected recruitment end date

2026-12-26, 1405/10/05

Actual recruitment start date
empty
Actual recruitment end date
empty
Trial completion date
empty

Scientific title
The Effect of PNF Stretching on Knee Extension Range of Motion and Bike-Fitting Kinematics in Adult Male Cross-Country Mountain Bikers with Hamstring Tightness: A Randomized Controlled Trial

Public title
Effect of Hamstring Stretching on Knee Flexibility and Pedaling Pattern in Mountain Bikers
Purpose
Supportive
Inclusion/Exclusion criteria
Inclusion criteria:
Male, aged 18–35 years Cross-country mountain biker at trained/club level At least two years of regular training, with a minimum of three sessions per week Participation in at least one official provincial or club competition in the past 12 months Hamstring tightness, defined as inability to reach less than 15° of knee flexion in the Active Knee Extension (AKE) test Mild to moderate pain or discomfort (VAS 3–7/10) in the mid-posterior thigh at the end range of the AKE test Previous bike fitting and awareness of personal optimal bike settings No participation in a regular stretching program in the past three months Signed written informed consent
Exclusion criteria:
Hamstring strain within the past six months Lower-limb fracture or surgery within the past year History of serious lumbar spine injury Congenital spinal anomaly, disc herniation, or other diagnosed spinal pathology Posterior thigh pain of non-muscular origin, such as proximal hamstring tendinopathy or lumbar radiculopathy Symptoms predominantly located in the posterior knee or calf at the end range of the AKE test Positive Slump test, defined as reproduction of the same symptoms relieved by cervical extension Knee flexion contracture Leg length discrepancy, or spinal or foot deformity Limited ankle dorsiflexion in the Weight-Bearing Lunge Test Cardiovascular or metabolic disease contraindicating exercise Absence from more than two of the 18 training sessions Injury during the intervention period Change in bike settings during the study Use of any other therapeutic or stretching intervention for the hamstrings
Age
From **18 years** old to **35 years** old
Gender
Male

Phase
N/A
Groups that have been masked
No information
Sample size
Target sample size: **40**
Randomization (investigator's opinion)
Randomized
Randomization description
Participants will be allocated to the PNF stretching group or the control group using block randomization with a fixed block size of four and a 1:1 allocation ratio. Each block will assign two participants to the PNF group and two to the control group, keeping group sizes balanced throughout recruitment and reaching 20 participants per group. The unit of randomization is the individual, and no stratification will be used, as all participants are male cyclists of the same discipline and training level. Before recruitment begins, a person not involved in the study's assessments or intervention will generate a random sequence for 40 participants, comprising ten blocks of four, using an online program (Randomizer.org). The group assignment for each number will be written on a separate card and placed in an opaque, sealed envelope numbered sequentially from 1 to 40. To ensure allocation concealment, the envelopes will be kept by the same independent person. Once a participant has been confirmed as eligible, has signed the consent form and has completed the baseline assessment, the next envelope in sequence will be opened to reveal his group. Researchers who enroll participants and perform baseline testing will therefore remain unaware of group allocation until baseline assessment is complete.
Blinding (investigator's opinion)
Not blinded
Blinding description
Placebo
Not used
Assignment
Parallel
Other design features

Secondary Ids

empty

Ethics committees

1

Ethics committee
Name of ethics committee
Research Ethics Committee of Tabriz University of Medical Sciences
Street address
Tabriz / Azadi Street / Golgasht Street / Central Building of the University of Medical Sciences
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tabriz
Province
East Azarbaijan
Postal code
5166614766
Approval date
2026-07-27, 1405/05/05
Ethics committee reference number
IR.TBZMED.REC.1405.260

Health conditions studied

1

Description of health condition studied
English: Hamstring muscle tightness
ICD-10 code
M62.8
ICD-10 code description
Other specified disorders of muscle

Primary outcomes

1

Description
Active knee extension range of motion with the hip at 90 degrees of flexion
Timepoint
Before the intervention and 48 hours after the last training session (end of week six)
Method of measurement
Active knee extension test using a universal goniometer. The participant lies supine with the contralateral leg strapped to the table. The hip of the dominant leg is flexed to 90 degrees and maintained by contact of the anterior thigh with a horizontal bar. Keeping the lower back flat on the table and the ankle relaxed, the participant slowly and actively extends the knee as far as possible and holds the position for about 2 seconds. The goniometer axis is placed over the lateral femoral epicondyle, with the stationary arm aligned with the greater trochanter and the moving arm aligned with the lateral malleolus. The angle is recorded in degrees as the deficit from full knee extension, with 0 degrees representing full extension. The test is repeated three times with 30 seconds of rest, and the mean of the three trials is recorded.

Secondary outcomes

1

Description
Posterior thigh pain intensity at the end range of the active knee extension test
Timepoint
Before the intervention and 48 hours after the last training session (end of week six)
Method of measurement
Visual Analogue Scale; a 10-centimetre horizontal line anchored by “no pain” and “worst imaginable pain”, scored with a millimetre ruler

2

Description
Lower-limb and trunk pedaling kinematics
Timepoint
Before the intervention and 48 hours after the last training session (end of week six)
Method of measurement
After a 10-minute warm-up, the participant pedals for 4 minutes at a fixed cadence of 90 revolutions per minute and a fixed resistance level (approximately 3 watts per kilogram of body mass) on his own bicycle mounted on an electromagnetic trainer. Before recording, skin markers are placed on the acromion, greater trochanter, lateral femoral epicondyle, lateral malleolus, heel and fifth metatarsal head. During the last minute, sagittal and frontal video recordings are captured with a smartphone at 240 frames per second, mounted on a tripod at a fixed distance and height. Using Bike Fast Fit Elite motion analysis software, the maximum knee extension angle at the bottom of the pedal stroke, the maximum knee flexion angle at the top of the pedal stroke, the hip angle at the top and bottom of the pedal stroke, the torso angle relative to the horizontal, the foot angle relative to the horizontal and the ankle angle are calculated from the sagittal view, while knee tilt and the width and length of the knee path are calculated from the frontal view. For each angle, the mean of 10 consecutive pedal strokes of the dominant leg is recorded.

3

Description
Mean heart rate during submaximal pedaling at a constant intensity and cadence
Timepoint
Before the intervention and 48 hours after the last training session (end of week six)
Method of measurement
English: Heart rate is measured simultaneously with the kinematic assessment. The participant pedals for 4 minutes at a fixed cadence of 90 revolutions per minute and a fixed resistance level equivalent to approximately 3 watts per kilogram of body mass on an electromagnetic trainer. Heart rate is recorded with a chest-strap heart rate monitor connected to an iGPSPORT BSC100S bike computer, and the mean heart rate during the last minute is reported. Power output and cadence are also monitored with the same device to confirm identical test intensity at baseline and follow-up.

Intervention groups

1

Description
Intervention group: Participants will receive proprioceptive neuromuscular facilitation stretching using the hold-relax technique for the hamstrings of both legs, three sessions per week on non-consecutive days for six weeks (18 sessions in total). Each session will begin with a 10-minute low-intensity cycling warm-up. The participant will lie supine with the contralateral leg strapped to the table, and the therapist will raise the target leg with the knee extended. Each stretching cycle will consist of a 15-second passive stretch to an intensity of about 7/10 on the numerical pain rating scale (strong but not painful), a 6-second maximal voluntary isometric hamstring contraction against the therapist’s resistance,

a 3-second relaxation, and a 15-second deeper stretch. The cycle will be repeated four times per leg with 20-second rest intervals, starting with the dominant leg. Each session will last about 15 minutes. All sessions will be delivered by the same trained therapist using standardized instructions. Participants will continue their usual cycling training.

Category

Rehabilitation

2

Description

Control group: Participants will receive no stretching program during the six weeks and will continue only their usual cycling training. They will be asked to avoid any other stretching program or therapeutic intervention for the hamstring muscles during this period. Baseline and follow-up assessments for this group will be performed at the same time interval and under the same conditions as the intervention group.

Category

N/A

Recruitment centers

1

Recruitment center

Name of recruitment center

East Azerbaijan Province Cycling Board

Full name of responsible person

Omid Soleimani

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Sponsors / Funding sources

1

Sponsor

Name of organization / entity

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Full name of responsible person

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Grant name

Grant code / Reference number

Is the source of funding the same sponsor organization/entity?

No

Title of funding source

Department of Biomechanics and Motor Control, University of Tabriz

Proportion provided by this source

100

Public or private sector

Private

Domestic or foreign origin

Domestic

Category of foreign source of funding

empty

Country of origin

Type of organization providing the funding

Persons

Person responsible for general inquiries

Contact

Name of organization / entity

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Full name of responsible person

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Latest degree

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Sharing plan

Deidentified Individual Participant Data Set (IPD)
Yes - There is a plan to make this available
Study Protocol
Yes - There is a plan to make this available
Statistical Analysis Plan
Yes - There is a plan to make this available
Informed Consent Form
Yes - There is a plan to make this available
Clinical Study Report
Yes - There is a plan to make this available
Analytic Code
Yes - There is a plan to make this available
Data Dictionary
Yes - There is a plan to make this available
Title and more details about the data/document
The de-identified individual participant dataset of the PNF stretching and pedaling kinematics trial will include all primary and secondary outcome variables recorded at the individual level at baseline and follow-up. These variables comprise active knee extension range of motion, posterior thigh pain intensity, pedaling kinematic angles (maximum knee extension and maximum knee flexion angles, hip angle at the top and bottom of the pedal stroke, torso angle, foot and ankle angles, knee tilt, and the width and length of the knee path), mean heart rate during constant-intensity pedaling, and the estimated one-repetition maximum in the single-leg squat. The dataset will also include baseline demographic variables, namely age, height, weight, body mass index, leg length and training experience, as well as test-condition control variables, namely mean power output and cadence. The correlation analysis between changes in knee angle and changes in heart rate will also be included as an exploratory analysis, but will be explicitly labelled “exploratory”. All direct and indirect participant identifiers, including video files, will be removed before release. In addition to the dataset, the full study protocol will be shared. It includes the inclusion and exclusion criteria, a detailed description of the intervention and stretching protocol, the randomization and allocation concealment procedures, the assessor blinding method and the pre-specified outcome measurement schedule. The statistical analysis plan will also be shared, providing full specifications of the pre-specified statistical models: analysis of covariance with the baseline score as a covariate, Quade’s non-parametric analysis of covariance if residuals are not normally distributed, the Wilcoxon test for within-group changes, and Pearson or Spearman correlation coefficients. The plan also specifies the assessment of assumptions using the Shapiro-Wilk and Levene tests and homogeneity of regression slopes, the reporting of effect sizes as partial eta squared, the per-protocol analysis approach, and the method for assessing attrition bias. The complete SPSS syntax file to reproduce all primary, secondary and exploratory analyses reported in the article, and a blank, de-identified copy of the informed consent form used in this study (the form template only, not participants’ completed forms), will also be made available.
When the data will become available and for how long
The access period for de-identified data, analysis scripts, and supplementary materials will begin immediately upon final acceptance of the manuscript for publication. These materials will be accessible via a Digital Object Identifier (DOI), included in the published article, hosted in the public Zenodo repository, and this access will continue for a minimum of 10 years from the date of publication. During the peer review process (prior to final acceptance), materials will be made available through the corresponding author upon reasonable request.
To whom data/document is available

Because the data and documents from this study will be deposited publicly and without access restrictions in the Zenodo repository, they will be available to any researcher — whether affiliated with academic institutions, research centres, or industry — whose intended use is legitimate scientific research, replication of findings, or meta-analysis, without requiring specific permission from the authors. The only requirement will be appropriate citation of the original data source (the published article and repository DOI).

Under which criteria data/document could be used

In addition to the criteria described above regarding who is eligible to request access, the following conditions will govern the use of data and documents from this study: 1. Purpose of use: Data may be used solely for non-commercial research purposes; any commercial use will require separate written permission from the corresponding author. 2. Permitted types of analysis: No restrictions will be placed on the type of statistical analysis or research methodology applied to the delivered data; researchers may use any analytical approach appropriate to their research objectives. 3. Request process: Applicants must submit a written request to the corresponding author, including the project title, research objectives, proposed methodology, and a written commitment to adhere to research ethics principles. 4. Data delivery mechanism: Upon approval of the request, data will be provided to the applicant either through the public Zenodo repository (using the dedicated DOI) or via direct file transfer. 5. Citation requirement: Researchers will be required to properly cite the data source, including the DOI and reference to the original article, in any publication resulting from secondary use of the data. 6. Participant privacy protection: Applicants will be required to commit to using the data solely for the purposes stated in their request and to refrain from any attempt at re-identification of participants.

From where data/document is obtainable

First priority (direct public access): All de-identified data, analysis scripts and supplementary materials will be uploaded to the Zenodo public repository and made available through a digital object identifier (DOI) included in the published article. Interested users can download the data free of charge, without direct contact, by following the DOI link provided in the article. Second priority (request to the corresponding author): If additional information or documents not uploaded to the public repository are required (such as the informed consent form), applicants may send a written request to the corresponding author, including the project title, research objectives, proposed methodology and a written commitment to adhere to research ethics principles. Corresponding author contact details: Name: Sina Najafpour Affiliation: Department of Sports Injuries and Biomechanics, Faculty of Sport Sciences, Bu-Ali Sina University, Hamedan, Iran Postal code: 65178-38695 Email: sina.student15@gmail.com Phone: +98 914 630 1771

What processes are involved for a request to access data/document

Applicants should first access the public Zenodo repository via the Digital Object Identifier (DOI) provided in the article and download the data directly and free of charge, a process expected to take less than 5 minutes. If access to the repository is not possible, the applicant must submit a written request — including the project title, research objectives, proposed methodology, and a commitment to adhere to research ethics principles — by email to the corresponding author. The request will be reviewed within 3 to 7 business days, and if approved, the data will be provided to the applicant within 1 to 3 business days via an access link, email, or secure file-sharing platforms. The total time required, in cases where the public repository is not accessible, will be approximately 1 to 2 weeks.

Comments