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Effects of immobilization and retraining on muscle function in young and older adults

Submission date
24/03/2025

Recruitment status
Recruiting

Registration date
25/03/2025

Overall study status
Ongoing

Last Edited
28/07/2026

Condition category
Musculoskeletal Diseases

[X] Prospectively registered
[_] Protocol
[_] Statistical analysis plan
[_] Results
[_] Individual participant data
[X] Record updated in last year

Plain English summary of protocol

Background and study aims
Aging and periods of immobilization due to injury or illness can lead to a decline in muscle strength, balance, and mobility, particularly in older adults. Women and older individuals may experience more severe declines and slower recovery after immobilization, but research on these effects is limited. This study aims to investigate how young and older men and women respond to a period of leg immobilization and subsequent retraining, helping to improve rehabilitation strategies for different age and sex groups.

Who can participate?
Healthy young adults (18-30 years) and older adults (60-70 years) who live independently and can attend training sessions.

What does the study involve?
Participants will undergo 10 days of unilateral lower limb suspension using a sling, followed by 3 weeks of supervised re-training (i.e. resistance training). The study will assess changes in muscular strength, balance, gait, and neuromuscular activation before and after immobilization and retraining. Testing will include strength measurements, gait and balance tests, MRI scans, ultrasound assessments, anthropometry, blood pressure and muscular activation.

What are the possible benefits and risks of participating?
Participants will gain insights into their physical performance and may improve their strength and motor functions through the retraining phase. Potential risks include muscle weakness and discomfort due to immobilization, which will be closely monitored. Preventative measures, such as an extensive medical check prior to the inclusion of volunteers, will be in place to minimize health risks.

Where is the study run from?
The training and testing will be conducted at the Department of Sport, Exercise and Health, University of Basel, Switzerland. MRI scans will take place at the research scanner of University Hospital Basel.

When is the study starting and how long is it expected to run?
The study is expected to begin in January 2026 and will run for approximately 3 years, including recruitment, intervention, and data analysis.

Who is funding the study?
The study is funded by the Swiss National Science Foundation.

Who is the main contact?
Martin Keller, martin.keller@unibas.ch

Contact information

Type(s)
Public, Scientific, Principal investigator

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Study information

Scientific Title
frAGILE: does function follow form in young and old adults in immobilization and retraining?

Acronym
frAGILE

Study objectives
Current Study objectives as of 05/11/2025:

The aim of the study is to investigate the effects of a period of immobilization followed by re-training on neuromuscular function, with a focus on sex- and age-specific effects.

Age-related effects: Older adults will experience greater declines in neuromuscular function after immobilization compared to young adults, with incomplete recovery after retraining.

Sex-related effects: Women will show more pronounced declines in neuromuscular function after immobilization period compared to men.

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Previous Study objectives:

Age-related effects: Older adults will experience greater declines in neuromuscular function after immobilization compared to young adults, with incomplete recovery after retraining.

Sex-related effects: Women will show more pronounced declines in neuromuscular function after immobilization period compared to men.

Ethics approval required
Ethics approval required

Ethics approval(s)
Approved 27/11/2025, Ethikkommission Nordwest- und Zentralschweiz (Tellplatz 11, Basel, 4053, Switzerland; +41 61 268 13 50; ehnz@bs.ch), ref: BASEC-Nr. 2025-02249

Primary study design
Interventional

Study design
Parallel group intervention study

Study type(s)
Treatment

Health condition(s) or problem(s) studied
Investigating the effects of unilateral lower limb immobilization and re-training in healthy young and older men and women.

Interventions
Current interventions as of 05/11/2025:

Participants will undergo 10 days of unilateral lower limb suspension using a sling to restrict movements and simulate muscle disuse. During this period, participants will be provided with crutches and instructed to avoid using the immobilized leg. Compliance will be monitored using accelerometers and activity logs.

Following immobilization, participants will complete 3 weeks of supervised retraining, consisting of resistance exercises targeting the immobilized leg. Training sessions will take place at the University of Basel and will focus on strength and neuromuscular activation. The training intensity will be progressively adapted based on individual performance assessments.

Assessments of muscle strength, balance, gait, neuromuscular activation, and muscle structure will be conducted before and after immobilization, as well as throughout the retraining phase.

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Previous interventions:

Participants will undergo 10 days of unilateral lower limb immobilization using a cast to restrict movements and simulate muscle disuse. During this period, participants will be provided with crutches and instructed to avoid using the immobilized leg. Compliance will be monitored using accelerometers and activity logs.

Following immobilization, participants will complete 3 weeks of supervised retraining, consisting of resistance exercises targeting the immobilized leg. Training sessions will take place at the University of Basel and will focus on strength and neuromuscular activation. The training intensity will be progressively adapted based on individual performance assessments.

Assessments of muscle strength, balance, gait, neuromuscular activation, and muscle structure will be conducted before and after immobilization, as well as throughout the retraining phase.

Intervention Type
Other

Primary outcome(s)
Primary outcomes will be assessed before and after the disuse period as well as after the retraining period. Furthermore, the primary outcomes will be assessed in a mid-training test.
1. Knee extensor and flexor strength – Measured using isometric dynamometry to assess maximum voluntary contractions but also the rate of force development of knee extensors and knee flexors.
2. Balance performance – Evaluated using single-leg stance and tandem stance on a force platform.
3. Gait analysis– Gait analyses will be done using an optoelectric walkway to assess gait parameters such walking speed, stride length, or stride variability.

Key secondary outcome(s)
Secondary outcomes will be assessed before and after the disuse period as well as after the retraining period.
1. Voluntary Activation of knee extensors – The twitch-interpolation technique will be used to assess the level of voluntary activation of knee extensor muscles.
2. Muscle architecture and contractility – Muscle contractility during voluntary contractions will be assessed using dynamic ultrasound. Different parameters of muscle architecture and contractility such as fascicle length, pennation angle, fascicle shortening velocity, amount of shortening and changes in pennation angle will be assessed for the Vastus lateralis muscle during maximum voluntary contractions.
3. Muscular activation – High-density electromyography (HD-EMG) is a non-invasive technique to measure the electrical activity produced by skeletal muscles. HD-EMG signals will be recorded from the musculus vastus lateralis during contractions of different contraction intensities. A grid of electrodes will be used to assess central and peripheral properties of motor units.
4. Tendon stiffness – The stiffness of the patellar tendon will be assessed using dynamic ultrasonography. An ultrasound probe will therefore be fixated on the patellar tendon during a ramped isometric knee extension contraction.
5. Muscle and tendon volume and muscle strain – A magnetic resonance imaging (MRI) scanner will be used to assess muscle and tendon parameters such as muscle and tendon volume. Additionally, dynamic MRI to determine muscle deformation and strain will be performed in combination with neuromuscular electrical stimulation.
6. Anthropometry – Whole body as well as lower limb skeletal muscle mass, fat mass, lean mass, bone mineral density and bone mineral content will be obtained using dual-energy x-ray absorptiometry.

7. Blood pressure – Brachial blood pressure will be measured in a supine position after 10 min of rest using an automatic blood pressure monitor.
8. Accelerometry – Participants will be asked to wear accelerometers before, during and after the intervention period. Data from accelerometers will be used to monitor the total time spent passively and actively
9. Questionnaires and Diaries – Diaries and questionnaires will be used to record (inter alia) protein and caloric intake but also physical activity.

Completion date
31/12/2028

Eligibility

Key inclusion criteria
Current key inclusion criteria as of 28/07/2026:

1. Healthy men and women aged 18 to 30 years (young) as well as older adults (60-74 years) - active persons performing 1-3 active sessions per week
2. Willing and physically able to undergo the study demands (immobilization period and retraining exercises)
3. Daily tasks should not require them to be physically active during the immobilization period
4. Be able to travel to the facilities of the Department of Sports, Exercise and Health, University of Basel for the measurement sessions and three times per week to complete the retraining period
5. Be able to travel 5 times to the Department of Sports, Exercise and Health and to the University Hospital Basel for the measurement sessions
6. All participants will receive a medical examination and need medical clearance for participation
7. Signed informed consent

Previous key inclusion criteria as of 05/11/2025:

1. Healthy men and women aged 18 to 30 years (young) as well as older adults (60-70 years) - active persons performing 1-3 active sessions per week
2. Willing and physically able to undergo the study demands (immobilization period and retraining exercises)
3. Daily tasks should not require them to be physically active during the immobilization period
4. Be able to travel to the facilities of the Department of Sports, Exercise and Health, University of Basel for the measurement sessions and three times per week to complete the retraining period
5. Be able to travel 5 times to the Department of Sports, Exercise and Health and to the University Hospital Basel for the measurement sessions
6. All participants will receive a medical examination and need medical clearance for participation
7. Signed informed consent

Previous key inclusion criteria:

1. Age Groups: Young adults (18-35 years) and older adults (>65 years).
2. Health Status: Primarily healthy individuals living independently in the community.
3. Physical Ability: Participants must be physically capable of undergoing the study demands, including immobilization and retraining.
4. Daily Activity Requirements: Daily tasks should not require participants to be physically active during the immobilization period.
5. Travel Availability: Participants must be able to travel to the Department of Sports, Exercise, and Health at the University of Basel for the retraining phase.
6. Medical Clearance: All participants must undergo a medical examination and receive medical clearance to participate.

Participant type(s)
Healthy volunteer

Healthy volunteers allowed
No

Age group
Mixed

Lower age limit
18 Years

Upper age limit
74 Years

Sex
All

Total final enrolment
0

Key exclusion criteria
Current key exclusion criteria as of 05/11/2025:

1. History of cardiovascular, pulmonary or chronic inflammatory disease
2. Personal or family history of blood clots
3. Orthopaedic problems or surgery (within the last 6 months)
4. Body mass index >35 kg/m2
5. Pregnancy
6. History of osteoporosis or a recent (past 6 months) lowtrauma fracture
7. Use of assistive walking device within the previous year
8. Expecting to travel abroad throughout the intervention
9. Participants who do not agree to the collected data being made available in coded form (open science)
10. History of cancer within the past 5 years
11. Current use of oral contraceptives with esrtogen or oestrogenic hormone therapy
12. Usual contraindications to MRI as defined in the clinical practice

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Previous key exclusion criteria:

1. Medical Conditions:
1.1. History of cardiovascular, pulmonary, or chronic inflammatory diseases.
1.2. Personal or family history of blood clots.
1.3. Allergy to heparin (used for anticoagulation during immobilization).
2. Orthopedic Issues:
2.1. Recent orthopedic surgery (within the last six months).
2.2. Existing orthopedic problems that could interfere with participation.
3. Body Composition:
3.1. Body mass index (BMI) > 30 kg/m².
4. Bone Health:
4.1. History of osteoporosis.
4.2. Recent (past six months) low-trauma fracture.
5. Mobility and Functional Restrictions:
5.1. Use of assistive walking devices within the previous year.
5.2. Expectation of travel during the intervention period.
6. Pregnancy:
6.1. Pregnant individuals will be excluded.

Date of first enrolment
01/01/2026

Date of final enrolment
31/12/2027

Locations

Countries of recruitment
Switzerland

Study participating centre
University of Basel; Department of Sport, Exercise and Health
Grosse Allee 6
Basel
Switzerland
4052

Sponsor information

Organisation
University of Basel

ROR
https://ror.org/02s6k3f65

Funder(s)

Funder type
Government

Funder Name
Schweizerischer Nationalfonds zur Förderung der Wissenschaftlichen Forschung

Alternative Name(s)
Schweizerischer Nationalfonds, Swiss National Science Foundation, Fonds National Suisse de la Recherche Scientifique, Fondo Nazionale Svizzero per la Ricerca Scientifica, Fonds National Suisse, Fondo Nazionale Svizzero, Schweizerische Nationalfonds, The Swiss National Science Foundation (SNSF), SNF, SNSF, FNS

Funding Body Type
Private sector organisation

Funding Body Subtype
Trusts, charities, foundations (both public and private)

Location
Switzerland

Results and Publications

Individual participant data (IPD) sharing plan

IPD sharing plan summary
Data sharing statement to be made available at a later date