

## Study Protocol

### Title:

Acute effects of tissue flossing on the viscoelastic properties of the muscles and jump performance in handball players: a crossover design

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### Protocol Version/Date:

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### Ethics Approval:

Approved by the Ethics Committee of the Faculty of Physical Education and Sport at Charles University (protocol no. 177/2020).

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## 1. Background and Rationale

Warm-up routines are essential in optimizing performance in competitive handball. Self-myofascial release (SMR) techniques such as foam rolling (FR) and the emerging method of tissue flossing (TF) have been shown to improve range of motion (ROM), reduce muscle stiffness, and potentially influence neuromuscular performance.

While FR is well documented, TF remains underexplored, particularly regarding its acute effects on explosive performance. Preliminary findings suggest TF may improve neuromuscular excitability through ischemic preconditioning and metabolic stress mechanisms. However, direct comparisons of TF and FR in major lower limb muscle groups relevant to explosive actions (e.g., countermovement jump [CMJ]) are lacking.

This study addresses this gap by comparing TF, FR, and control (CON) interventions on active range of motion (AROM), viscoelastic muscle properties, and jump performance in adolescent handball athletes.

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## 2. Objectives

### Primary Objective:

- To determine the acute effects of tissue flossing versus foam rolling on AROM, viscoelastic muscle properties, and jump performance.

### Secondary Objectives:

- To compare the magnitude and time course of TF- and FR-induced changes at 1 and 15 minutes post-intervention.
- To explore whether TF provides superior improvements in force development compared with FR and CON.

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### 3. Study Design

- **Design:** Randomized, controlled, crossover study.
- **Conditions:**
  1. Tissue Flossing (TF)
  2. Foam Rolling (FR)
  3. Control (CON)
- **Population:** 30 male adolescent handball players.
- **Randomization:** Intervention order randomized using [www.randomizer.org](http://www.randomizer.org).
- **Washout:** Minimum 24 h, maximum 5 days between sessions.
- **Blinding:** Due to the nature of interventions, blinding participants was not feasible; however, outcome assessors were blinded to condition.

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### 4. Participants

#### Inclusion Criteria:

- Male handball players aged 16–18 years.
- $\geq 5$  years of playing experience.
- Injury-free in the last 3 months.

#### Exclusion Criteria:

- Prior experience with TF.
- Regular use of FR.
- Contraindications to compression therapy or vigorous exercise.

**Recruitment:** Participants recruited from handball training centers in Prague.

#### Sample Size Justification:

Power analysis (G\*Power 3.1.9.4) indicated  $n = 21$  required (effect size = 0.398,  $\alpha = 0.05$ , power = 0.8). To account for dropout, 30 participants enrolled.

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### 5. Study Procedures

#### Warm-up (standardized for all sessions):

- 5 min cycling (100 W, 80 rpm)
- 10 squats, dynamic stretches (quadriceps, hamstrings, lunges, leg swings)
- 5 squats, 5 jumps @ 75% max

### Interventions:

- **TF:** Both thighs wrapped with elastic bands at 150% tension, followed by squats and lunges, then removal.
- **FR:** Quadriceps and hamstrings rolled for 30 sec per muscle per side.
- **CON:** Same exercises as TF, but without bands.

### Outcome Measures:

1. **Active Range of Motion (AROM):** Active Knee Extension (AKE) test.
2. **Viscoelastic Muscle Properties:** Stiffness and tone measured with MyotonPRO in VL, RF, and BF.
3. **Jump Performance:** CMJ height and braking rate of force development via force plate.

**Timing of Assessments:** Baseline, 1 min post, 15 min post intervention.

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## 6. Statistical Considerations

- **Software:** SPSS v25.0; MATLAB for data organization/graphs.
  - **Normality:** Shapiro-Wilk test.
  - **Reliability:** Intraclass correlation coefficient (ICC) and coefficient of variability (CV).
  - **Primary Analysis:** Two-way repeated measures ANOVA (Condition × Time).
  - **Post Hoc:** Bonferroni correction.
  - **Effect Sizes:** Cohen's d and partial eta squared ( $\eta^2$ ).
  - **Significance Threshold:**  $p < 0.05$ .
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## 7. Ethics and Safety

- Conducted in line with Declaration of Helsinki.
  - Written informed consent obtained from all participants (and guardians, if <18).
  - Right to withdraw at any time without consequence.
  - Minimal risk: interventions are widely used in sports training.
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## 8. Data Management and Availability

- Data coded for confidentiality.
  - Stored securely on institutional servers.
  - Available upon reasonable request to the corresponding author.
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## **9. Amendments**

All protocol amendments must be approved by the Ethics Committee and communicated to all participating locations before implementation.

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## **10. Dissemination Plan**

- Results will be published in peer-reviewed sport science journals.
- Findings shared with coaching and physiotherapy staff for practical implementation.