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The impact of different recovery approaches on recovery and adaptation in physically trained and untrained individuals

Submission date 17/06/2025	**Recruitment status** No longer recruiting	[X] Prospectively registered [X] Protocol [_] Statistical analysis plan [X] Results [_] Individual participant data
Registration date 23/06/2025	**Overall study status** Completed	
Last Edited 02/11/2026	**Condition category** Other	

Plain English summary of protocol

Background and study aims
This study is looking at how different recovery methods affect the body after physical activity. Researchers want to understand how techniques such as cold compression, local cold application including ice massage, heat application, contrast therapy involving alternating cold and heat, ischemic preconditioning involving brief periods of restricted blood flow followed by restoration of blood flow, percussive massage, and combinations of these methods affect recovery. Combined methods include alternating ice massage and percussive massage. The goal is to compare their effects on muscle and tendon mechanical properties, physical performance, blood markers, soreness, fatigue and perceived recovery.

Who can participate?
Adults aged 18 to 45 who are physically active, either amateur or professional athletes, can take part. Participants must be in good health and have no medical issues that would prevent them from exercising. Specific age limits, training requirements and additional eligibility criteria vary between the individual study components.

What does the study involve?
Participants will be randomly placed into one of several groups, each using a different recovery method, or into a control group. Depending on the group, the recovery program will last either 72 h- 2 weeks, 8 weeks, or 6 months. The study will measure things like muscle strength, inflammation, and how participants feel during recovery. All procedures are safe and supervised.

What are the possible benefits and risks of participating?
Participants may benefit from improved recovery and reduced risk of injury. The risks are very low and may include mild, temporary discomfort from the recovery techniques used.

Where is the study run from?
The study is being carried out at CM Provita in Żory, Poland, with help from local sports clubs and training centers in southern Poland.

When is the study starting and how long is it expected to run for?
January 2025 to October 2026

Who is funding the study?
Investigator initiated and funded

Who is the main contact?
Dr Robert Trybulski, rtrybulski.provita@gmail.com

Contact information

Type(s)
Public, Scientific, Principal investigator

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Study information

Scientific Title

Assessment of adaptive effects of diversified recovery strategies among individuals with different levels of motor preparation

Acronym
ARM

Study objectives
Current study objectives as of 02/11/2026:

1. Participants undergoing recovery interventions (Game Ready, IPC, contrast therapy, ice massage, percussive massage, or combined this method) will show significantly greater improvements in biomechanical parameters compared to the control group
2. The effects of recovery strategies will differ depending on the participant's level of motor fitness, with professional athletes demonstrating more pronounced adaptations
3. Ischemic preconditioning (IPC) will result in higher perfusion and faster recovery than cold compression or contrast therapy
4. Participants receiving recovery interventions will report lower subjective fatigue and pain compared to the control group
5. There will be significant differences in the levels of inflammatory and muscle damage biomarkers (e.g., CK, IL-6, CRP) between intervention and control groups over time
6. Contrast therapy will be more effective in improving tissue elasticity and muscle stiffness compared to cold compression and ischemic preconditioning
7. Recovery interventions will reduce the risk of performance decline during the training cycle compared to no intervention

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6. Contrast therapy will be more effective in improving tissue elasticity and muscle stiffness compared to cold compression and ischemic preconditioning.
7. Recovery interventions will reduce the risk of performance decline during the training cycle compared to no intervention.

Ethics approval required
Ethics approval required

Ethics approval(s)

Approved 11/06/2025, Ethics Committee for Scientific Research of Physiotherapists at the Polish Physiotherapy Association (ul. Zygmunta Modzelewskiego 37/U8, Warszawa, 02-679, Poland; +48 22 840 18 73; biuro@fizjoterapeuci.org), ref: RESOLUTION No. 1/06/2025 of 11 June 2025

Primary study design
Interventional

Study design
Interventional randomized controlled trial

Study type(s)
Efficacy, Prevention, Treatment

Health condition(s) or problem(s) studied
Physical recovery

Interventions
Current interventions as of 02/11/2026:

Study Design Description (English Version)

Interventional, randomized controlled research programme designed to evaluate the adaptive effects of various recovery strategies in individuals with differing levels of motor fitness. The programme includes both parallel-group and crossover components, depending on the intervention duration and subgroup allocation. The interventions, number of groups, assessment methods and follow-up periods are specified for each experimental comparison.

Study Type:
Interventional study (clinical trial).
Randomized controlled designs, including parallel-group trials and crossover trials in selected components.
Crossover procedures are used only in the components for which they are specified, to minimize inter-subject variability and increase statistical power.
The programme involves different sports clubs and rehabilitation centers, with standardized protocols for each component. Individual trials may be conducted at a single center.

Randomization:
Participants are randomly assigned to the intervention or control conditions included in each experimental comparison using a computer-generated sequence with block randomization. Four-arm comparisons use a 1:1:1:1 allocation ratio. The number of groups and allocation procedures are specified for each comparison; not all methods listed below are included in every trial.

Stratification based on age, sex and motor preparation level (amateur vs. professional) is applied where specified in the relevant protocol and is not assumed to apply to every component.

For the four-arm comparison of ice massage, percussive massage, combined recovery and passive recovery, an independent researcher prepared the allocation sequence. Allocation was concealed using sealed opaque envelopes opened after exercise and the immediate post-exercise assessment.

Recovery Interventions and Control Conditions:
Cold compression therapy: Local cooling combined with compression, including application using the Game Ready system.
Ischemic preconditioning (IPC): Interventions involving alternating periods of vascular occlusion and reperfusion.
Thermal recovery interventions: Local cold application, including ice massage; local heat application; and contrast therapy involving alternating cold and heat stimuli. These interventions are not restricted to the Game Ready system. The application method, duration and sequence of stimuli are specified for each experimental comparison.
Percussive massage: Mechanical stimulation of the target muscles using a percussive massage device, with frequency, amplitude and treatment duration specified for each experimental comparison.
Combined recovery interventions: Combined application of recovery methods, including alternating ice massage and percussive massage within the same treatment session. The constituent methods, sequence and duration are specified for each experimental comparison.
Control conditions: Passive recovery without a recovery intervention, or sham/placebo procedures where applicable.

Assessment Schedule and Measurements:
Assessment schedules depend on the experimental component. In addition to the previously described longer follow-up periods, the programme includes a 72-hour recovery assessment following eccentric exercise, with measurements before exercise, immediately after exercise before treatment, and at 24, 48 and 72 hours.

This short-term comparison includes seven recovery sessions in the active groups: one immediately after exercise and two daily sessions over the following three days.

Measurements in this comparison include muscle and Achilles tendon stiffness assessed using SonoScape shear-wave elastography, Reactive Strength Index assessed using ForceDecks, serum lactate dehydrogenase activity, Numerical Rating Scale soreness, perceived recovery and perceived exertion.

Blinding (Masking):
Masking procedures depend on the interventions and control conditions used in each experimental comparison. Participant blinding is used where feasible with sham procedures.

Participants and treating physiotherapists are not blinded in comparisons involving readily distinguishable ice massage, percussive massage, combined treatment and passive recovery.

In that comparison, follow-up outcome assessors are not informed of group allocation, laboratory samples are coded without treatment-group identifiers, and the primary statistical analysis uses masked group codes. Participants are instructed not to disclose their allocation to assessors. The success of assessor blinding is not formally evaluated.

Due to the nature of physical interventions, full double-blinding is not feasible across all components. Standardized procedures are used to reduce assessment bias and minimize expectancy effects.

Crossover Design:
For selected subgroups and where ethically and logistically feasible, a crossover approach is used. After a washout period, participants may receive a second type of intervention, allowing within-subject comparison and better evaluation of intervention-specific effects.

Summary:
This RCT investigates short-term (72 h - 2-week), medium-term (8-32 week), and long-term (6-month) outcomes related to recovery strategies. The study incorporates objective physiological, biomechanical, and biochemical measures, as well as subjective recovery and fatigue scales. The design supports high internal validity while reflecting practical implementation in sports and physiotherapy settings

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Previous interventions:

Study Design Description (English Version)
Interventional, randomized controlled trial (RCT) designed to evaluate the adaptive effects of various recovery strategies in individuals with differing levels of motor fitness. The study is prospective and includes both parallel-group and crossover components depending on the intervention duration and subgroup allocation.

Study Type:
Interventional study (clinical trial)

Randomized Controlled Trial (RCT)

Partially crossover in selected phases to minimize inter-subject variability and increase statistical power.

Multicenter setting with standardized protocols implemented across different sports clubs and rehabilitation centers.

Randomization:
Participants are randomly assigned to one of four groups using a computer-generated sequence with block randomization (1:1:1:1). Stratification is applied based on age, gender, and motor preparation level (amateur vs. professional), ensuring balanced distribution across groups.

Study Groups:
GR-C: Cold compression therapy (Game Ready system)

GR-IPC: Ischemic preconditioning (IPC)

GR-KT: Contrast therapy (alternating cold and heat)

GR-K: Control group (no intervention or sham/placebo)

Blinding (Masking):
The study applies single-blind masking, where participants are blinded to the specific nature of the intervention, especially in the case of sham procedures.

Assessors and data analysts are also blinded to group assignments to reduce assessment bias (i.e., assessor-blinded).

Due to the nature of physical interventions, full double-blinding is not feasible, but steps are taken to ensure procedural uniformity and minimize expectancy effects.

Crossover Design:
For selected subgroups and where ethically and logistically feasible, a crossover approach is used. After a washout period, participants may receive a second type of intervention, allowing within-subject comparison and better evaluation of intervention-specific effects.

Summary:
This RCT investigates short-term (2-week), medium-term (8-32 week), and long-term (6-month) outcomes related to recovery strategies. The study incorporates objective physiological, biomechanical, and biochemical measures, as well as subjective recovery and fatigue scales. The design supports high internal validity while reflecting practical implementation in sports and physiotherapy settings

Intervention Type
Mixed

Primary outcome(s)
Current primary outcome(s) as of 02/11/2026:

At baseline, after 72 h - 2 weeks of intervention, and after 8 weeks. For long-term follow-up groups, we will also conduct measurements at 6 months. For the 72-hour recovery component, serum LDH activity, Reactive Strength Index and SWE-derived muscle and tendon stiffness are assessed before exercise, immediately after exercise before the first recovery intervention, and at 24, 48 and 72 hours after exercise.

1. Biochemical markers (measured in blood serum):
1.1. Creatine kinase (CK) – measured in U/L; spectrophotometric ELISA; standard laboratory method; Poland, 2023
1.2. C-reactive protein (CRP) – measured in mg/L; immunoturbidimetric assay; Poland, 2023
1.3. Lactate dehydrogenase (LDH) – measured in U/L; spectrophotometric assay; Poland, 2023
1.4. Interleukin-6 (IL-6) – measured in pg/mL; ELISA; Poland, 2023
1.5. Tumor necrosis factor alpha (TNF-α) – measured in pg/mL; ELISA; Poland, 2023
1.6. Cortisol – measured in μg/dL; immunoassay; Poland, 2023
1.7. Testosterone – measured in ng/dL; immunoassay; Poland, 2023
2. Mechanical and biomechanical measures:
2.1. Muscle tension, stiffness, and elasticity – measured in N/m and milliseconds; assessed using MyotonPRO (Myoton AS), Estonia, 2021
2.2. Reactive Strength Index (RSI) – measured in m/s; assessed with ForceDecks (Vald Performance), Germany, 2020
2.3. Maximal voluntary contraction (MVC) – measured in Newtons (N); assessed using K-Force (Kinvent), Italy, 2023
2.4. Tissue perfusion – measured in Perfusion Units (PU); evaluated using Laser Doppler Flowmeter (Perimed), Sweden, 2004
2.5. Pressure pain threshold (PPT) – measured in kg/cm²; assessed with Algometer FPIX 25 (Medoc), USA, 2021
2.6. Electromyographic activity (EMG) – measured in μV; recorded using TruScan EMG (Deymed), Germany, 2022
2.7. Range of motion (ROM) – measured in degrees (°); assessed using Baseline Inclinometer, Italy, 2020
2.8. Body composition (fat percentage, muscle mass) – measured in %; evaluated using Accuniq BC720, South Korea, 2021
2.9. Muscle and tendon stiffness – measured in kPa using shear-wave elastography (SWE);

assessed with a SonoScape Elite S80 ultrasound system (SonoScape Medical Corp., China) equipped with a 3–20 MHz linear-array transducer. Measurements include the medial and lateral gastrocnemius muscle bellies and the Achilles tendon approximately 4 cm proximal to the calcaneal insertion on the dominant lower limb

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Previous primary outcome(s):

At baseline, after 2 weeks of intervention, and after 8 weeks. For long-term follow-up groups, we will also conduct measurements at 6 months:
1. Biochemical markers (measured in blood serum):
1.1. Creatine kinase (CK) – measured in U/L; spectrophotometric ELISA; standard laboratory method; Poland, 2023.
1.2. C-reactive protein (CRP) – measured in mg/L; immunoturbidimetric assay; Poland, 2023.
1.3. Lactate dehydrogenase (LDH) – measured in U/L; spectrophotometric assay; Poland, 2023.
1.4. Interleukin-6 (IL-6) – measured in pg/mL; ELISA; Poland, 2023.
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2.1. Muscle tension, stiffness, and elasticity – measured in N/m and milliseconds; assessed using MyotonPRO (Myoton AS), Estonia, 2021.
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2.8. Body composition (fat percentage, muscle mass) – measured in %; evaluated using Accuniq BC720, South Korea, 2021.

Key secondary outcome(s)
Current key secondary outcome(s) as of 02/11/2026:

At baseline, after 72 h - 2 weeks of intervention, and after 8 weeks. For long-term follow-up groups, we will also conduct measurements at 6 months:
1. Psychometric scales and questionnaires:
1.1. TQR (Total Quality Recovery 0–20 scale)
1.2. Subjective fatigue – assessed using the Borg Rating of Perceived Exertion Scale (6–10 points); international tool
1.3. Perceived recovery – assessed using the TQR (Total Quality Recovery) Scale (6–20 points); international tool
1.4. Pain intensity – assessed using the RNS Pain Scale (0–10 points); validated version used in Poland

2. Maximal voluntary contraction (MVC) – measured in Newtons (N); evaluated using Kinvent K-Force (Kinvent), Italy, 2023

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Previous key secondary outcome(s):

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1.4. Pain intensity – assessed using the RNS Pain Scale (0–10 points); validated version used in Poland.
2. Maximal voluntary contraction (MVC) – measured in Newtons (N); evaluated using Kinvent K-Force (Kinvent), Italy, 2023.

Completion date
10/10/2026

Eligibility

Key inclusion criteria
1. Age between 18 and 45 years.
2. No contraindications to physical activity – confirmed by a physician.
3. Valid medical clearance for participation in physical training, issued within the past 6 months.
4. Regular physical training history, defined as:
4.1. At least 2 training sessions per week for a minimum of 1 year for amateur participants.
4.2. At least 6 training sessions per week for a minimum of 5 years for professional athletes, as classified according to the McKay et al. (2022) system.
5. Completed health screening questionnaire with no exclusionary findings.
6. Written informed consent to participate, signed voluntarily after being informed of the study protocol, risks, and benefits.

Participant type(s)
Healthy volunteer, Learner/student, Patient

Healthy volunteers allowed
Yes

Age group
Adult

Lower age limit
18 Years

Upper age limit
45 Years

Sex
All

Total final enrolment
160

Key exclusion criteria
1. Cardiovascular diseases or any medical contraindications to physical exertion.
2. Recent musculoskeletal injuries that limit activity and occurred within 3 months prior to study initiation.
3. History of orthopedic surgery involving the musculoskeletal system within the past 9 months.
4. Active skin diseases or unidentified skin lesions at the intended site of intervention (e.g., for compression devices).
5. Poor general health, excessive fatigue, or symptoms of sports-related depression.
6. Use of substances or medications affecting hemodynamics or masking physiological recovery markers, including:
6.1. Beta-blockers (e.g., metoprolol, bisoprolol)
6.2. Vasodilators (e.g., nitrates, calcium channel blockers)
6.3. Diuretics (e.g., furosemide, hydrochlorothiazide)
6.4. ACE inhibitors and sartans (e.g., enalapril, losartan)
6.5. Anticoagulants (e.g., heparins, NOACs such as apixaban, rivaroxaban)
7. Use of performance-enhancing drugs (doping substances).
8. Refusal to provide informed consent or voluntary withdrawal at any stage of the study.

Date of first enrolment
10/07/2025

Date of final enrolment
20/10/2025

Locations

Countries of recruitment
Poland

Study participating centre
Provita Medical Centre
al.Zjednoczonej Europy, 37
Żory
Poland
44-240

Sponsor information

Organisation

Provita Medical centre

Funder(s)

Funder type
Research council

Funder Name
Investigator initiated and funded

Results and Publications

Individual participant data (IPD) sharing plan
The anonymized datasets will be available upon request from Dr hab. Robert Trybulski (rtrybulski@rehabilitacja-provita.pl), after study completion in October 2026, for 5 years. Access will be granted following formal request and ethical approval. Participant consent for data reuse in anonymized scientific analyses has been obtained.

IPD sharing plan summary
Available on request

Study outputs

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
Results article	Impact of cold compression across all groups	01/06/2026	19/06/2026	Yes	No
Results article	Untrained amateur climbers	25/06/2026	15/07/2026	Yes	No
Results article	Recovery in recreational crossfit athletes	15/07/2026	17/07/2026	Yes	No
Protocol file			23/06/2025	No	No