

Protocols for Clinical Work Package of the European Project RISE

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Abstract

The persons involved in the EU RISE project at the Department of Physical Medicine and Rehabilitation, Wilhelminenspital Wien, at the Ludwig Boltzmann Institute of Electrical Stimulation and Physical Rehabilitation, Vienna and at the Center for Biomedical Engineering and Physics, Medical University Vienna, Austria were H Kern, C Hofer, S Löffler S, M Vogelauer, M Mödlin, and W Mayr. Following the pioneering work of Helmut Kern, the FES Vienna Group developed the project, and made before and during the two years of the study evaluation and follow-up of all the SCI persons enrolled in the EU Project RISE.

Key Words: RISE, FES, Denervate Muscle, Ethical Committee Approval, Austria

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RISE Protocols for Clinical Work Package Rise protocols 39/21 02.03.2006

Part 1. Pre-selection:

Protocol for patient pre-selection

performed in rehabilitation centres: about 100 patients

Part 2. Rehabilitation centre:

Protocol for clinical evaluation and patient selection

performed in the rehabilitation centre with support from Vienna (about 60 patients)

A. Short overview

B. Advanced examination

Part 3. Begin of the study

Protocols for the begin of the study

performed in Vienna: about 40 patients

Part 4. A. During muscle training

protocols performed in the rehabilitation centre

Part 4. B. During muscle training

protocols performed in Vienna

Part 5. End of the study

Protocols performed in Vienna (about 20 patients)

Part 1. Protocol for patient pre-selection performed in rehabilitation centres

Evaluation based on: patient records only

Inclusion criteria:

- epiconus, cauda, conus paraplegia and lesion of pelvis plexus with denervation of the m. quadriceps
- dervation between 6-12 months and 9 years
- absence of sensation in the thigh (stimulation site)
- neurologically demonstrated flaccid paralysis with no spasticity, absence of segmental reflex activity
- intact skin (no decubital ulcers)

Exclusion criteria:

- implants
 - passive implants in hip and knee, thigh
 - pacemaker, no ICD (implantable cardioverter defibrillator)
 - active implants such as Brindley stimulator, pumps, pain stimulator
- in case of implants special considerations can be made
 - no hazardous infections or diseases (bodyable subjects)
 - HIV
 - hepatitis B, C
 - pregnancy
 - genesis?

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Part 2.

Protocol for clinical evaluation and patient selection at the rehabilitation centre with support from Vienna

Informed consent on RISE

A. Short overview

- I. Brief medical history
- II. Brief physical examination: sensory and motor function, p ROM
- III. Laboratory assessment of the denervation:

Test stimulation with 5ms impulse, 40Hz and an amplitude of 100mA → contraction of thigh muscle?

yes: → exclusion from the study

no: → further tests, see **Part 2. B**

B. Advanced medical examination

I. Medical history

Clinical report related to the injury: (see sheet of medical history page 1-4)

- date of injury
 - what happened (e.g. car accident, etc.)
important additional information which allows to estimate forces and acceleration that occurred during the event of injury
 - single or multiple trauma
 - status at the onset
 - status now
 - changes in the period between the onset of the injury and the present
 - What can patient tell us – before, after
 - patients feeling, quality of life
- List of supportive examinations already done before: X-ray, MRI, EMG, SSR, MEP

II. Physical examination

Probably video for demonstration of technique.

The clinical evaluation will be performed at the rehabilitation centre by specially instructed, trained personnel.

Tests on the sensory function will be worked out first because this tests are more demanding regarding the concentration of the patient than tests on motor function.

1. Sensory function

The equipment has to be standardised for all participating centres where this tests will be performed.
Testing conditions: comfortable bed, light, curtain

The sensation is categorised in 3 qualities:

2: normal, 1: altered, 0: absent

Altered sensation will be further divided in:

1a less, 1b more, 1c different sensation

*The **stimulus will be applied once**, no stimuli repetition
In case of **absent sensation** the test will be performed
with **repetitive stimulation***

(approx. 1Hz) to check for summation.

Repetition 3 to 5 times.

Touch: 1st level of normal sensation, first abnormal level (rough overview)

for testing a cotton swab is used: yes → 1a, 1b, 1c;
2 no → 0 if 0 → Summation: repeat (3 to 5 times) - fatigue?

The results are documented in a dermatome picture (in front, behind, beside)

Pinprick: test instrument is a small monofilament rod

same procedure as Point A

Cold/ Warm : only sternum, crista illiaca ant. sup., patella and malleolus med.

Cold: small container filled with ice and water

Hot: small container filled with water heated to an exact temperature (e.g. 40°C)

Vibration: only sternum, crista illiaca ant. sup., patella and malleolus med.

tuning fork 1/8

Image of feet preserved, when the eyes are closed?

2. Motor function

*The **motor function** of the key muscles, **muscle tone** and **volitional activity** have to be tested in the lying and in the sitting position (legs just touching floor).*

reflexes: patella tendon, achilles tendon, adductors, hamstrings,
abdominal (touch from lateral to medial, tap upper, middle, lower area)
plantar reflex (touch of the lateral foot sole towards the great toe; touching the lower part of the sole a flexion of the toes is normal)

volitional activity: **volitional movement of the joints of the lower extremities**

both legs, right leg, left leg, single joint movement ankle, knee, hip

description of ROM, sequence, velocity (e.g. full hip flex left faster than right)

reinforcement procedures (performed in Vienna)

3. Joints: passive ROM of the lower extremities

4. Skin: trophism of the skin

5. Bladder:

sensory: feel if full?

micturition: suprapubic catheter

intermittent catheterism

bladder dysfunction

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6. Bowel movement

7. Sexual function

erection: yes, no

8. Internal examination:

including ECG (not older than one year), blood pressure

Part 3. Protocols at the beginning of the study performed in Vienna (about 38 patients)

A. Check of medical history

Verify the medical history

- date of injury
- what happened (e.g. car accident, etc.)
important additional information which allows to estimate forces and acceleration that occurred during the

Event of injury

- single or multiple trauma
- status at the onset
- status now
- changes in the period between the onset of the injury and the present
- *What can patient tell us – before, after*
- patients feeling, quality of life

B. Physical examination

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Testing conditions: comfortable bed, light, curtain

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Altered sensation will be further divided in: 1a less, 1b more, 1c different sensation.

The stimulus will be applied once, no repetition of stimuli!

In case of absent sensation the test will be performed with repetitive stimulation (approx. 1Hz) to check for summation. Repetition 3 to 5 times.

Touch: last level of normal sensation, first abnormal level (rough overview) for testing a cotton swab is used
yes → 1a, 1b, 1c, 2 no → 0 if 0 →
Summation: repeat (3 to 5 times) - fatigue?

the results are documented in a dermatom picture (in front, behind, beside)

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both legs, right leg, left leg,

single joint movement ankle, knee, hip

description of ROM, sequence, velocity (e.g. full hip flex left faster than right)

Reinforcement procedures (only performed in Vienna)

Joints: passive ROM of the lower extremities

Skin: trophic of the skin

3. Internal Medicine examination:

including ECG (not older than one year), blood pressure

III. Laboratory methods:

III A. Assessment of neurological status

1. Test stimulation

With 5ms impulse, 40 Hz and an amplitude of 100mA - contraction of thigh muscle?

yes: → **exclusion from study**

no: → further tests

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a) BMCA

Surface electrodes will be used to record the polyelectromyogram during maximal volitional contraction. Sixteen-channel parallel recording will be performed from muscle groups of lower limbs and lower trunk including segments D-10 to S-4 (pelvic floor).

b) Lumbosacral and Transcranial magnetic stimulation

m- wave, afterwards

c) **Sympathetic Skin Response, SSR:** stimulation of n. femoralis

d) **NCV:** if m-wave available in BMCA of n. fem. → exclusion

LSEP

n. tibialis bilateral stimulation

n. femoralis optional

Needle EMG m. quadriceps

m. rectus femoris: in the middle between crista and patella, (vastus lat.?)

spontaneous activity: - fibrillation potentials → amplitude, frequency

sharp waves

volitional activity

Don't repeat within 10 days!

Surface EMG

for evaluation of balance and trunk coordination in Isola, performed by Bajd

III B. Assessment of morphology

1. CT Scan:

Muscle cross-sectional area, muscle density and diameter of the cortical bone are documented by means of CT scans at certain levels of the thigh, the top of the trochanter major as individual reference point. Additional cross-sectional areas are made distally at equal distances. This method produces comparative data from a patient's thigh during the study.

2. **MRT of the spine** not older than one year

3. **X-ray of the spine** not older than two years

4. Muscle biopsies

Muscle structure and function are further assessed by analysis of biopsies. Histological, histochemical, immunohistochemical, and morphometric techniques are used to determine fibre type composition, fibre number, fibre diameter, proportions of muscle and non-muscle tissue (collagen and non-collagen), and capillary density. Biochemical techniques are used for electrophoretic analysis of myosin isoforms and for

assay of enzymes of metabolic significance. Biopsies are analysed in Vienna and Padua.

Biopsies are harvested at the beginning and at the end of the study.

5. Evaluation of secondary effects

(partly to be worked out by clinic of dermatology)

While the main emphasis is on achieving the functional muscle goals, secondary effects on thickness and perfusion of muscles, skin and other denervated tissues including the trophic condition of the skin will be documented.

6. Dual-X-Ray-Absorptiometry

III C. Mechanical and functional measurements

1. Mechanical evaluation:

a) Contractile speed and latency, tested by patella accelerometer measured as time to peak of 3 single muscle twitches elicited by a standardised stimulation pulse to describe muscle twitch characteristics

b) Force developed by m. quadriceps in a single twitch, or where appropriate a single tetanus, elicited by the standardised stimulation pattern and measured by knee-dynamometer

c) Fatigue resistance: force and time-to-peak twitch contraction measured before and after 50 repetitions

d. M-wave measured during stimulation

2. Functional improvements:

- a) knee extension torque up to 20-30Nm developed in response to appropriate stimulation protocols
- b) the endurance required to support short periods of standing
- c) standing up and sitting down
- d) maintenance of muscle performance.
- e) functional outcome: measurement or assessment of locomotor performance, including ground reaction forces and video analysis. Assessment will include postural stability, standing time and the force on handle bars (with eyes open and closed).

Part 4. A. Protocols during muscle training performed in rehabilitation centre

Examination of biological effects of stimulation on denervated muscle during the course of the study (see particular sheets)

1. **Neurological examination** each 6 months

2. Blood parameters:

CPK, myoglobin and lactate profilesampling intervals best suited to human clinical application will be determined

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3. CT Scan:

It is proposed to make a CT Scan at regular interval of 6 months

4. Mechanical evaluation:

- a. Contractile speed and latency, tested by patella accelerometer measured as time to peak of 3 single muscle twitches elicited by a standardised stimulation pulse to describe muscle twitch characteristics
- b. Force developed by m. quadriceps in a single twitch, or where appropriate a single tetanus, elicited by the standardised stimulation pattern and measured by knee-dynamometer
- c. Fatigue resistance: force and time-to-peak twitch contraction measured before and after 50 repetitions
- d. (M-wave measured during stimulation (validation of data?))

5. Functional improvements:

- a) knee extension torque up to 20-30Nm developed in response to appropriate stimulation protocols
- b) the endurance required to support short periods of standing
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6. Check of stimulation, adaptation of parameters

within the first year assessment each 4-6 weeks, afterwards four times per year

7. Evaluation of secondary effects

(partly to be worked out by clinic of dermatology)

While the main emphasis will be on achieving the functional muscle goals, we will also document secondary effects of this new rehabilitation procedure on thickness and perfusion of mus

8. Dual-X-Ray-Absorptiometry

Part 4. B. Protocols during muscle training performed in Vienna

Eventually, more than one time.

1. CT Scan

at the beginning of the study, after one year and at the end of the study.

2. Check of stimulation, adaptation of parameters

Within the first year assessment each 4-6 weeks, afterwards, four times per year

3. Mechanical evaluation

- a. Contractile speed and latency, tested by patella accelerometer measured as time to peak of 3 single muscle twitches elicited by a standardised stimulation pulse to describe muscle twitch characteristics
- a. Force developed by m. quadriceps in a single twitch, or where appropriate a single tetanus, elicited by the standardised stimulation pattern and measured by knee-dynamometer

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6. MRS (MR-Spectroscopy)

during the last phase of FES-training.

High-field MRI and especially T2-mapping can provide local information about actually activated regions shortly after FES, thus supplying both localised information of the immediate training-effects of FES and for validation and adaption of computer models. A validated computer model could predict training effects of different FES-parameters and thus help further optimise efficiency and increase safety of FES training.

Part 5. Protocols at the end of the study performed in Vienna

A. Medical history

during the last 3 years

B. Physical examination

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1. Sensory function

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Touch

last level of normal sensation, first abnormal level (rough overview) for testing a cotton swab is used

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4. Needle EMG m. quadriceps

m. rectus femoris: in the middle between crista and patella, (vastus lat.?)

a) spontaneous activity: - fibrillation potentials → amplitude, frequency

- sharp waves

b) volitional activity

Do not repeat within 10 days!

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