The efficacy of perturbation training in Anterior Cruciate Ligament rehabilitation

10 years of researches

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PhD PT

DYNAMIC JOINT STABILITY

the ability of joint to remain stable when subjected to the rapidly changing loads during activity.(Williams et al 2001)

Dynamic stability is the result of the integration of

- articular geometry
- soft tissue restraint
- the load applied to the joint
  - weight bearing
  - muscle action

NEUROMUSCULAR CONTROL

the ability to produce controlled movement through coordinated muscle activity.

NEUROMUSCULAR CONTROL

results from

- Musculoskletal system
- Nervous system
  - Sensory organ
  - Neural pathways
  - Muscles

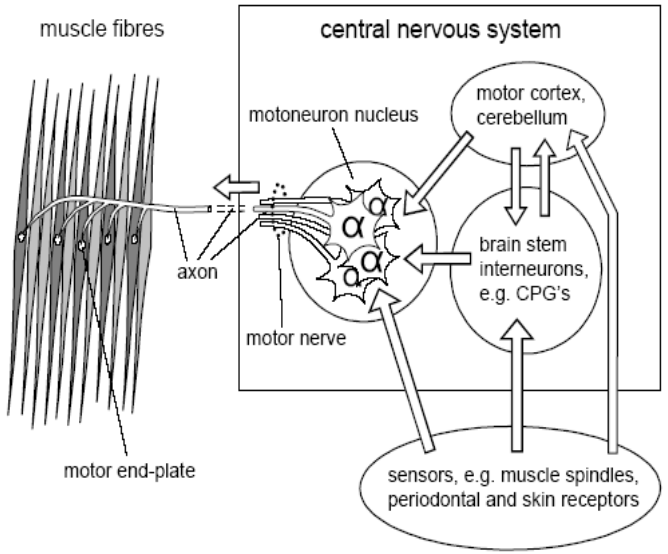


Figure 1. Convergence of neuronal signals, involved in the control of a muscle, on the alpha motor neurons of the muscle.

Consequences of ACL injury on Neuromuscular function

- weakness of knee extensors
- reduced proprioception
- altered central mechanisms of somstosensation
- altered movent & activation pattern
- reduced functional performance

Neuromuscular Training Programs

- Closed kinetic chain activity
- Eccentric loading
- Stretch shortening activity
- Biofeedback training
- Training on wobble board
- Stabilometery
- Functional training
- Agility training
- Perturbation training

Developing or reestabilishing the sensory charactristics and motor function will minimize reinjury and enhance function

Basic element to reestablishing neuromuscular control

- Proprioception & kinestetic sensation
- Dynamic joint stabilization
- Reactive neuromuscular control
- Functional motor pattern

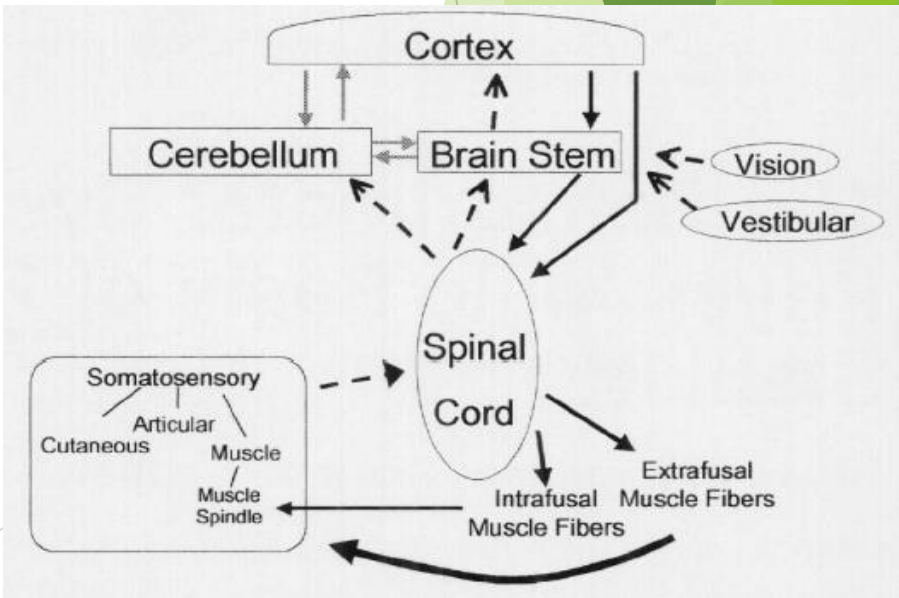
In the pathologic joint this element require compensatory adaptation

Efferent and Afferent charactristic contribute to the maintenance of NM control

- Sesitivity of receptors
- Facilitation of afferent pathway
- Onset of the reflex muscle activation
- Magnitude of muscle activity
- Agonist_antagonist coactivation
- Muscle stiffness
- Discriminatory muscle activation

The signals from MECHANORECEPTORS are mediated in 3 levels

- **The segmental level in spinal cord**
  - *Quickest neuromuscular response (30-50 mSec)*
  - *Provide the framework for rapid postural response and regulation of limb mechanics during movement*
- **The brain stem and cerebellum**
  - *Long loop reflexes (50-80 mSec)*
  - *Can adapt when prior instructions are provided to system*
  - *To be important in the maintenance of dynamic stability*
- **The cerebral cortex**
  - *Voluntary reaction (>120 mSec)*
  - *Highly flexible*



Can joint injuries be prevented?

Pope et al(1979) simulate MCL injury

1. ligament loading at 39 mSec
2. first perceived pain 52 mSec
3. ligament rupture at 73 mSec
4. Reflex response > 128 mSec
5. Forceful contraction > 215 mSec

- It was suggested that muscular response is far too slow to prevent such an injury

Limitation(pope et al 1979) There was little to no muscle activity at time zero Motor response initiated in response to cutaneous feedback

REFLEX RESPONSE TO ENSEMBLE OF FEEDBACK OCCURE IN LESS THAN 128 mSec

Despite this, it is accepted that in most athletic injury scenarios, the rate of ligament loading and force involved are likely to be too great to allow prevention of injury via a feedback mechanism

Feedforward Mechanism

- By anticipation that an injury is about to ocure (conscious or subconscious), the coordinated muscular response could began prior to the onset of the injuries mechanism
- As the result , preparatory action could be taken to reduce the impact of the impeding injury mechanism

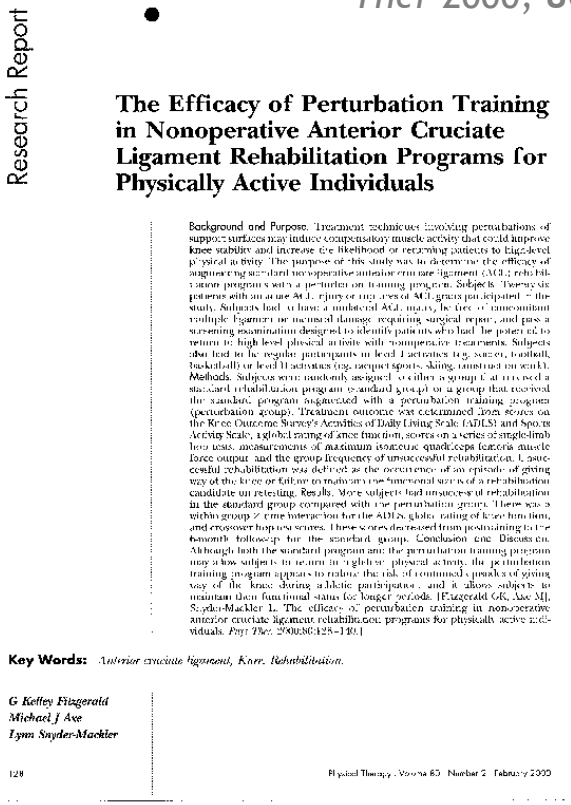
The feedforward mechanisms in the neuromuscular control system may enable such a prevention strategy to be employed

Perturbation Training

BASIC CONCEPT

repetitive challenging
to maintain static or
dynamic control of
joint results in
improved
neuromuscular control
and joint stability

Fitzgerald GK, Axe MJ, Snyder-Mackler L. The efficacy of perturbation training in non-operative anterior cruciate ligament rehabilitation programs for physically active individuals. *Phys Ther* 2000; **80**(2): 128-140.



Research Report

The Efficacy of Perturbation Training in Nonoperative Anterior Cruciate Ligament Rehabilitation Programs for Physically Active Individuals

Background and Purpose. Treatment techniques involving perturbations of support surfaces may induce compensatory muscle activity that could improve knee stability and increase the likelihood of returning patients to high-level physical activity. The purpose of this study was to determine the efficacy of augmenting standard nonoperative anterior cruciate ligament (ACL) rehabilitation programs with a perturbation training program. Subjects. Twenty-six patients with an acute ACL injury or high-grade ACL sprain participated in the study. Subjects had to have a unilateral ACL injury, be free of concomitant multiple ligament or meniscal damage requiring surgical repair, and pass a screening examination designed to identify patients who had the potential to return to high-level physical activity with nonoperative treatments. Subjects who had to be regular participants in level I activities (eg, soccer, football, basketball) or level II activities (eg, racquet sports, skiing, lacrosse) or both. Methods. Subjects were randomly assigned to either a group that received a standard rehabilitation program (standard group) or a group that received the standard program augmented with a perturbation training program (perturbation group). Treatment outcome was determined from scores on the Knee Outcome Survey's Activities of Daily Living Scale (ADLS) and Sports Activity Scale, a global rating of knee function, scores on a series of single-limb hop tests, measurements of maximum isometric quadriceps (extensor) muscle force output, and the group frequency of unsuccessful rehabilitation. Unsuccessful rehabilitation was defined as the occurrence of an episode of giving way of the knee or failure to maintain one functional unit of a rehabilitation candidate on retesting. Results. More subjects had unsuccessful rehabilitation in the standard group compared with the perturbation group. There was a within-groups 2-time interaction for the ADLS, global rating of knee function, and crossover hop test scores. These scores decreased from postraining to the 6-month follow-up for the standard group. Conclusion and Discussion. Although both the standard program and the perturbation training program may allow subjects to return to high-level physical activity, the perturbation training program appears to reduce the risk of continued episodes of giving way of the knee during athletic participation and it allows subjects to maintain their functional status for longer periods. [Fitzgerald GK, Axe MJ, Snyder-Mackler L. The efficacy of perturbation training in nonoperative anterior cruciate ligament rehabilitation programs for physically active individuals. *Phys Ther.* 2000;80:128–140.]

Key Words: *Anterior cruciate ligament, Knee, Rehabilitation.*

G Kelley Fitzgerald
Michael J Axe
Lynn Snyder-Mackler

First stage

- **First session:**
  - ✓ Double leg-5 min-rocker board
  - ✓ Single leg without perturbation
- **Second session:**
  - ✓ single leg with perturbation-rockerboard
  - ✓ Roller board
- **Third session:**
  - ✓ Same as second session (awareness of perturbation direction ,freq:30-35)
  - ✓ Verbal clues omission
  - ✓ Roller board (awareness of perturbation plane)
- **Forth session:**
  - ✓ Double leg-rockerboard-eye closed-5 min
  - ✓ Single leg-rockerboard-eye closed-perturbation
  - ✓ Roller board (same as last session)

Second stage

- **Fifth session:**
  - ✓ Physical activity added on rocker board-5 min
  - ✓ Roller board-eye closed (untill tenth sesssion)
- **Sixth session:**
  - ✓ Ball shooting with **hand**-different distance,direction height-5 min
- **Seventh session:**
  - ✓ Ball shooting with **foot** -different distance,direction height-5 min

Third stage

- **Eighth session:**
  - ✓ Foam on rockerboard-5 min (sagittal,frontal,diagonal)
  - ✓ Ball shooting same as 6th & 7th session
- **Ninth session:**
  - ✓ Physical activity on wobble board (same as 5th session)
  - ✓ Ball shooting same as 6th & 7th session
- **Tenth session:**
  - ✓ Foam on wobble board(ninth session exe.)
  - ✓ Different distance and freq.

Perturbation Training (stage1)

Perturbation Training (stages 2 & 3)






Research Tools

- Biodex Balance Test
- Isokinetic Dynamometry
- Motion Analysis sys
- Force plate
- Electromyography
- Questioner
  - IKDC-subjective
  - Lysholme
- Functional test
  - Cross Hop
  - Vertical Jump
  - Shuttle run

Cross Hop Test

IKDC subjective

Irrgang JJ, Anderson AF, Boland AL, Harner CD, Kurosaka M, Neyret P, etal. Development and validation of the international knee documentation committee subjective knee form. Ame J Sport Med 2001; 29(5): 600-613.

Development and Validation of the International Knee Documentation Committee Subjective Knee Form*

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ABSTRACT

A committee of international knee experts created the International Knee Documentation Committee Subjective Knee Form, which is a knee-specific, rather than a disease-specific, measure of symptoms, function, and sports activity. The purpose of this study was to evaluate the reliability and validity of the new International Knee Documentation Committee Subjective Knee Form. To provide evidence for reliability and validity, we administered the final version of the form, along with the Short Form-36, to 532 patients with a variety of knee problems. Analyses were performed to determine reliability, validity, and different item function related to age, sex, and diagnosis. Factor analysis revealed a single dominant component, making it reasonable to combine all questions into a single score. Internal consistency and test-retest reliability were 0.92 and 0.95, respectively. Based on test-retest reliability, the value for a true change in the score was 9.0 points. The International Knee Documentation Committee Subjective Knee Form score was related to concurrent measures of physical function (r = 0.47 to 0.66) but not to cnt ral function (r = 0.16 to 0.28). Analysis of differential item function indicated that the questions functioned similarly for men versus women, young versus old, and for those with different diagnoses. In conclusion, the International Knee Documentation Committee Subjective Knee Form is a reliable and valid knee-specific measure of symptoms, function, and sports activity that is appropriate for patients with a wide variety of knee problems. Use of this instrument will permit comparisons of outcome across groups with different knee problems.

The Effect of a Modified Perturbation Training on Muscle Activation Pattern and Function in ACL Deficient Patients

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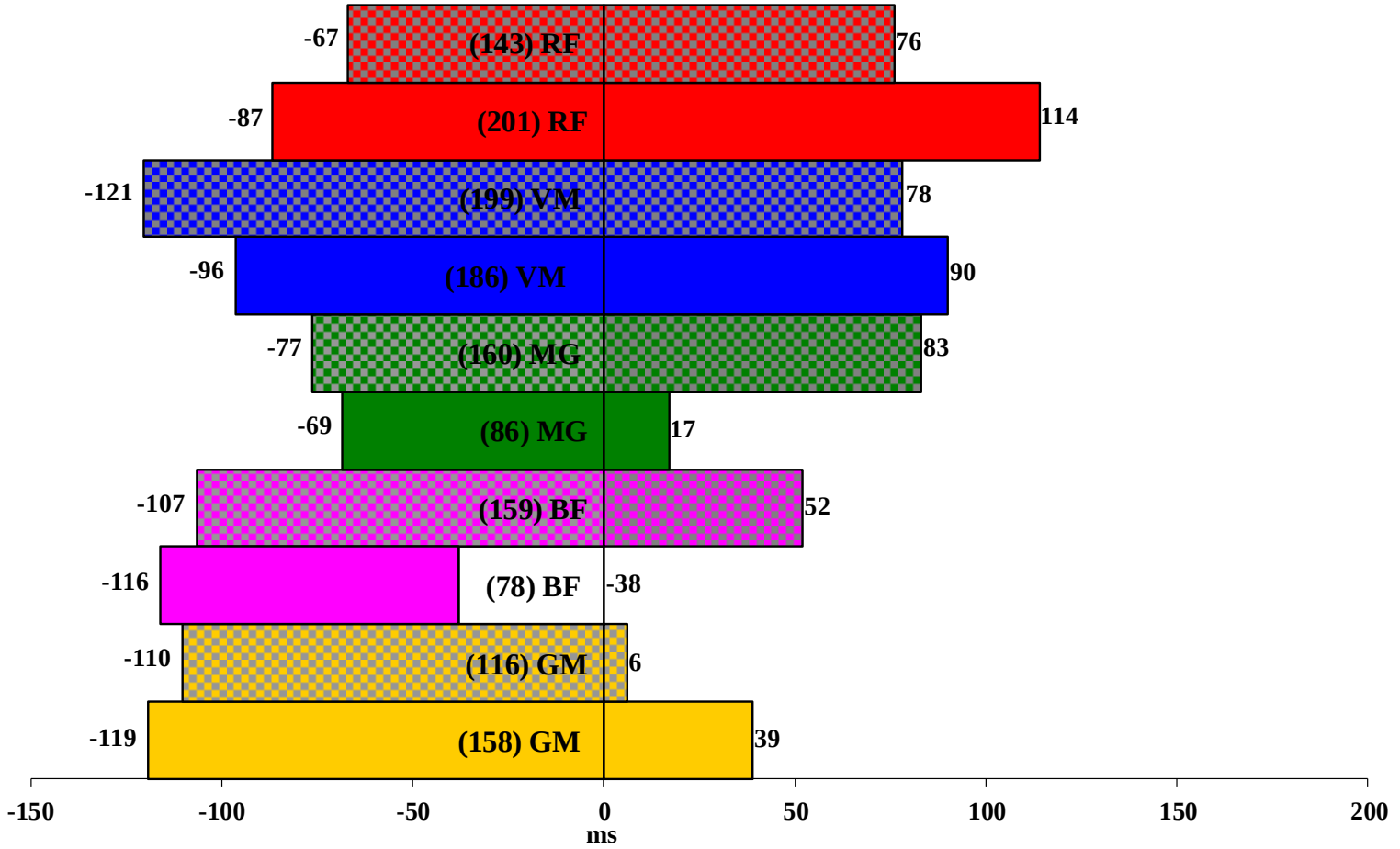
Muscle activation patterns

during Hop test before and after 10 sessions of perturbation training



Perturbation training has a central effect that modifies neuromuscular control system through the change in feed-forward control for ACL deficient patients.

M. Naserpour et al

Gait kinematics of ACL deficient patients can be modified following 10 sessions of perturbation training

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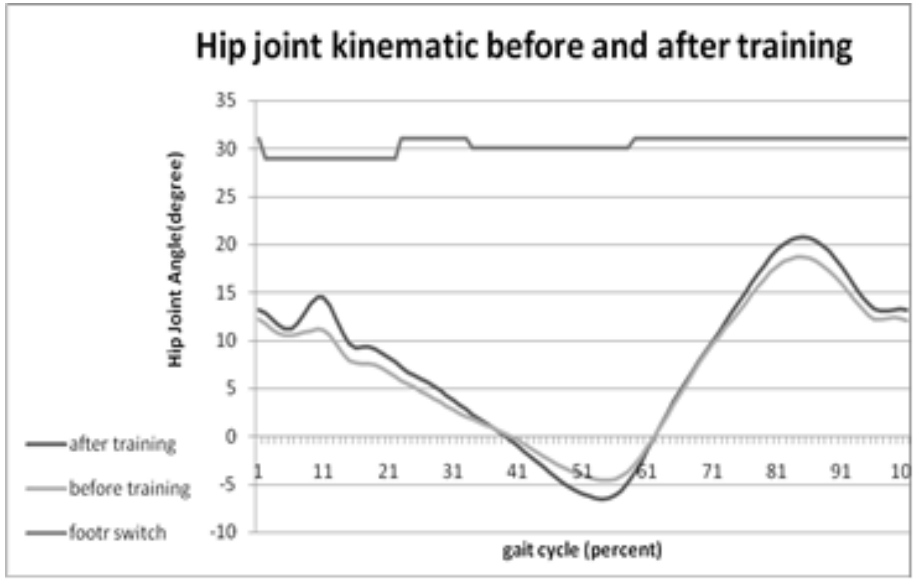
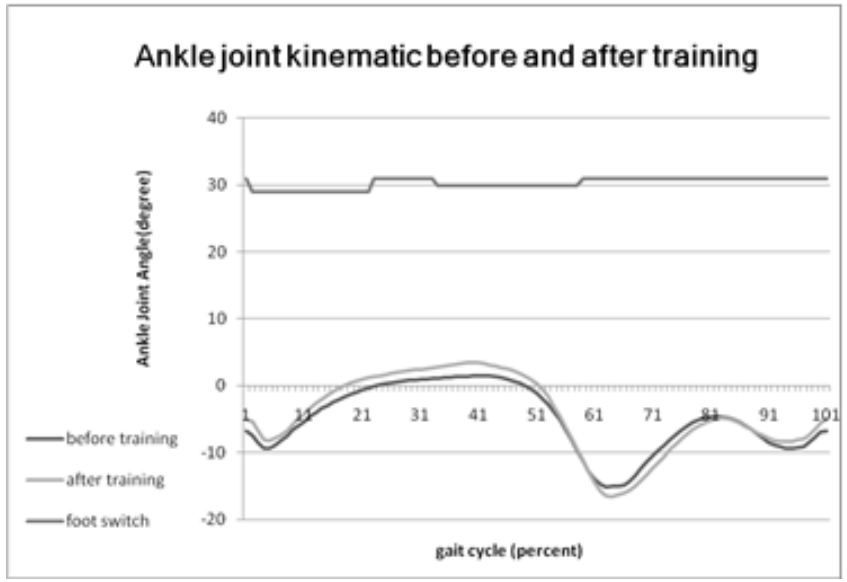
Saeedeh Seyed Mohseni, Saeed Sayadi, Hassan Jafari,
Armaghan Mahmoudian

Hip excursion (*P*=0.02)
Peak flexion of hip (*P*=0.02)
Hip angle at stance phase (*P*=0.02)
Peak dorsiflexion of ankle (*P*=0.03)
were significantly increased after 10 session of perturbation training





Probably, perturbation training with neuromuscular effects and feed forward control improvement modifies compensatory patterns of ACL deficient patients during gait.

Leila Abbasi

Effect of perturbation training
on function & GRF of ACLDs during stair ascending and descending

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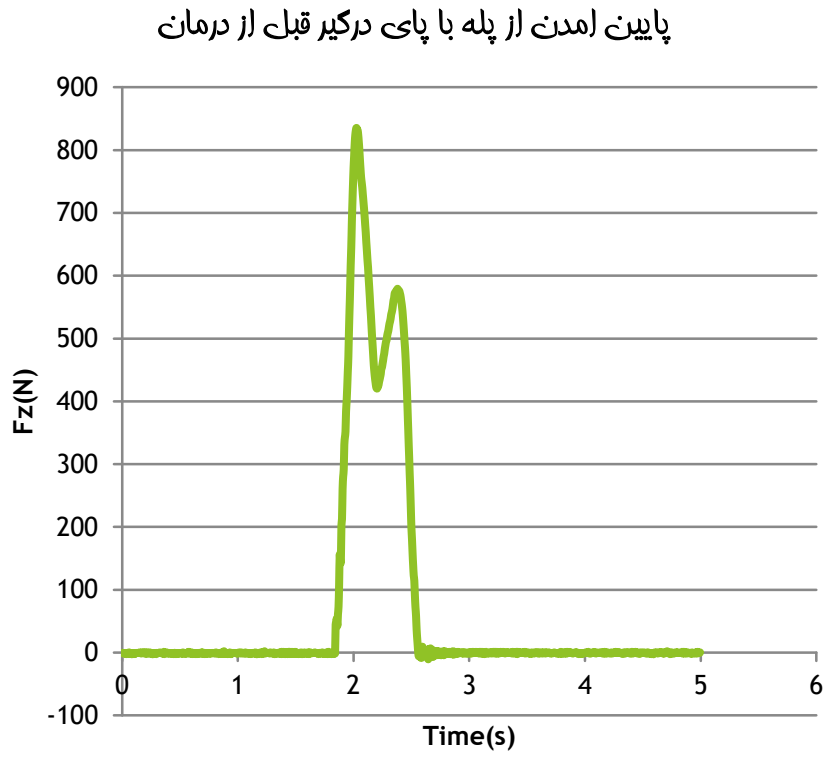
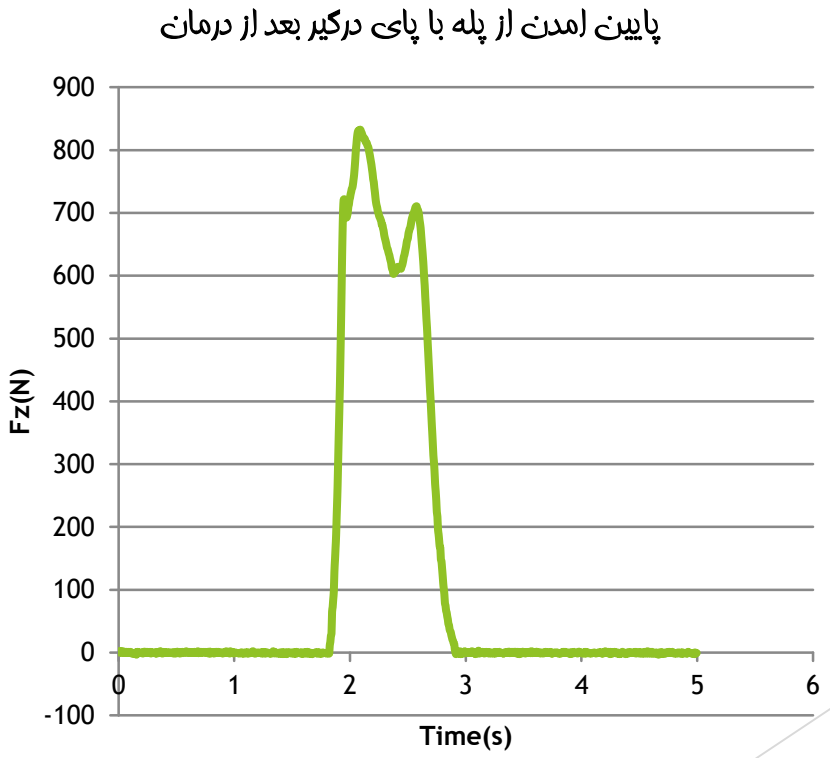
M.Jabal Ameli, MD

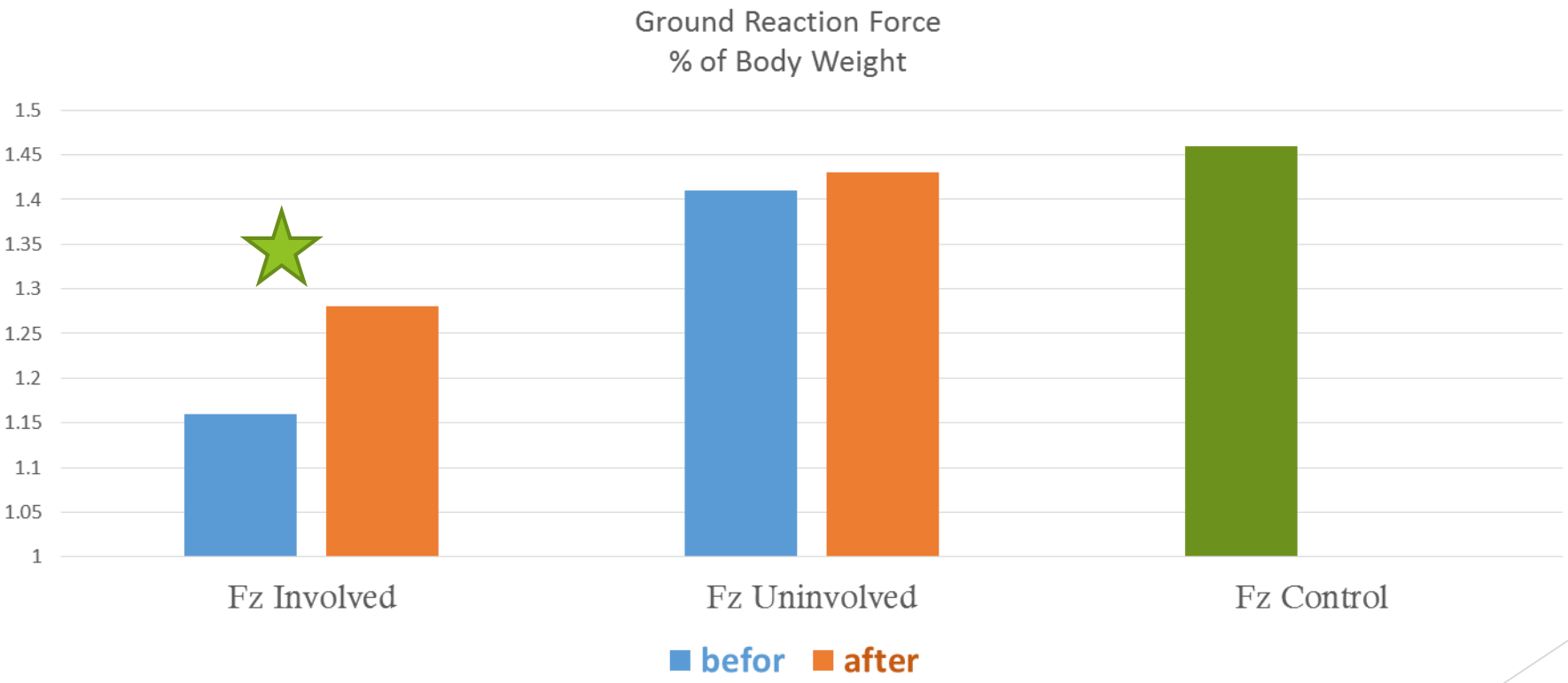
Ground Reaction Force (GRF) during Step down of an ACLD patient





Ground Reaction Force during Step down

Involved and Uninvolved limb of ACLD patients before & after 10 session of perturbation training compare to control healthy group



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