The efficacy of perturbation training in Anterior Cruciate Ligament rehabilitation
10 years of researches

Ali ashraf Jamshidi
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

- Musculoskeletal 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
- Stabilometry
- Functional training
- Agility training
- Perturbation training
Developing or reestablishing the sensory characteristics and motor function will minimize reinjury and enhance function.

**Basic element to reestablishing neuromuscular control**

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

In the pathologic joint this element require compensatory adaptation

**Efferent and Afferent characteristic contribute to the maintenance of NM control**

- Sensitivity 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 OCCUR 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 occur (conscious or subconscious),
  the coordinated muscular response could have been initiated prior to the onset of the injuries mechanism.
- As a result, preparatory action could be taken to reduce the impact of the impending 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

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 session)

- **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 (stage 1)
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

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

M. Naserpour, MSc PT
AA. Jamshidi, Ph.D, PT
A. Amiri, Ph.D, PT
M. Kihany, MSc
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

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

N. Feizabadi, MSc, PT
AA. Jamshidi, Ph.D, PT
MA. Sanjari, MSc, Biomech
M. Jabal Ameli, MD
Ground Reaction Force (GRF) during Step down of an ACLD patient

N. Feizabadi Pt. Msc
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

N. Feizabadi Pt. Msc