A new etiological factor in ankle instability: understanding balance training

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Disclosure

- Speakers have no relevant financial relationship exists

Session Learning Objectives

- Part I: Introduction to a new etiological factor of functional ankle instability (FAI)
  - Demonstrate a new etiological factor of functional ankle instability
  - Examine the relationships with other factors
- Part II: Neurophysiological mechanisms of balance training on FAI symptoms
- Part III: Strategies of postural control during balance perturbation exercises: effects of a ball-kicking exercise

Part I
Introduction to a new etiological factor of functional ankle instability (FAI)

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- FAI and related factors
- Potential role of nervous system
- Study design and protocol
- Results and our interpretation

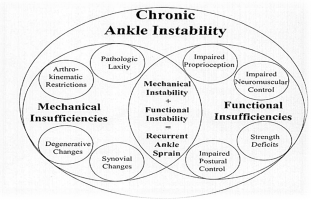
FAI and related factors

Ankle sprain injury

- Ankle sprains in US
  - Account for 40% of sports injuries
  - Approximately 30,000 cases each day
  - $4 billion per year in costs
- 85% of ankle sprains are lateral ligamentous injuries
- 15% -60% of patients develop Chronic Ankle Instability

FAI and related factors

Chronic ankle instability



FAI and related factors

Functional ankle instability and its factors

- FAI diagnosis: Recurrent ankle sprains / ankle "giving way"
- Important factors suggested in the literature
  - Ankle joint laxity (ankle mechanical instability)
  - Proprioceptive deficit
  - Peroneal muscle weakness
  - Impaired neuromuscular control
    - Impaired balance control
    - Perceived difficulties with ADL and sport-specific skills

FAI and related factors

Ankle joint laxity factor

- Ankle joint laxity presents in some but not all ankles with FAI，or vise versa
  - laxity not associated with proprioception or strength (Konradsen et al. 2002)
  - postural equilibrium not affected by ankle laxity (Tropp et al., 1984)

FAI and related factors

Proprioceptive deficit factor

- Ankle sprain may produce a proprioceptive deficit, however, conflicting results have been reported
  - Kinesthetic sense:
    - decreased (Lentell et al., 1995)
    - no difference (Hubbard et al., 2002)
  - Joint position sense:
    - decreased (Jerosch et al., 1995)
    - no difference (Gross, 1987)

FAI and related factors

Peroneal muscle weakness factor

- Conflicting results
  - Reported concentric and eccentric evertor muscle weakness in FAI patients
    - (Willems et al., 2002)
  - No eversion strength deficit in FAI patients
    - (Ryan et al. 1994)

FAI and related factors

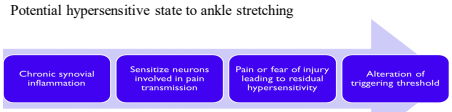
Impaired neuromuscular control factor

- Postural sway
  - Increased (Freeman et al., 1965; Rozzi et al. 1999)
  - No difference (Tropp et al., 1984)
- Reflexive activation of peroneal muscles
  - Muscular reaction may be too slow to protect the ankle during sudden ankle inversion (Konradsen et al., 2002)

Potential role of nervous system

Possible role of nervous system

- Unloading reaction under various stimulations
  - Shift the weight to the other foot
  - Flex the ankle, knee, and hip joints
- Potential hypersensitive state to ankle stretching



Potential role of nervous system

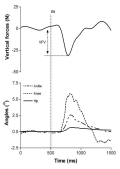
Hyper-reactivity to unloading reaction: Previous studies

- Du to a static ankle stretching
  - Healthy ankles
  - Electrical stimulation–1.2 x pain threshold
  - Supinated ankle position
- Du to FAI
  - Ankles with FAI vs. healthy ankles

Potential role of nervous system

Key variables

- Vertical force variation (VFV) - subtracting downward peak value of vertical forces after the stimulation from the mean of vertical forces before the electrical stimuli.
- Flexion angle variation (FAV) - subtracting the peak of 3 joint angles within 1second window after the stimulation by the mean of the corresponding angles before stimulation



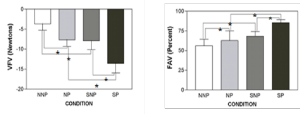
Potential role of nervous system

Previous results

Testing results on healthy ankles (Santos & Liu, 2008)

Painful stimulation increased the response

Supinated ankle position increased response



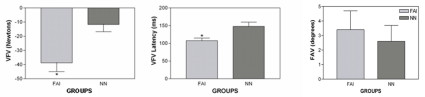
Potential role of nervous system

Previous results

Difference between FAI and healthy ankles (Santos et al. 2008)

Painful stimulation

Supinated ankle position



Potential role of nervous system

The next step?

- Unloading reaction can be altered (hypersensitive)
  - Due to stretching of the ankle
  - Due to FAI
- However,
  - Only static stretching
  - No ankle giving way occurred
- We hypothesize two types of unloading reaction to a certain ankle stretching
  - Regular unloading reaction
  - Drastic unloading reaction

Potential role of nervous system

Objectives of the present study

- Objectives:
  - Examine unloading reaction under dynamic ankle stretching and nociceptive stimulation
  - Possible correlations with other measured variables
- To produce an episode of "ankle giving way" in a lab setting

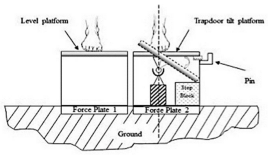
Study design and protocol

Subject information

- 24 subjects with unilateral FAI; 65% females; mean age: 34.2 ±7.7 years
- Inclusion Criteria
  - 18 to 45 years
  - at least 4 weeks after unilateral ankle sprain injury (grade II or III)
  - ongoing symptom of ankle "giving way" during functional activities
  - exercising at least 2 hours per week.
- Exclusion Criteria
  - Injury to other joints in the lower extremities
  - history of severe lateral ankle sprain, joint disease or fracture in the lower extremities,
  - vestibular deficits, insulin-dependent diabetes, or any systemic disease that interfere with function in the lower extremities

Study design and protocol

Equipment for unloading reaction test



Trapdoor with a tilt platform that allowed the platform to rotate 30°

Study design and protocol

Testing of unloading reaction

- Both ankles tested on two days separated by at least 3 days apart
- Maximal tolerable pain threshold was first determined
- The trapdoor was released without warning while the subject stands with equal weight on both feet
- First five trials without nociceptive stimulation ("no stim")
- Five trials of the combined foot drop and nociceptive stimulation ("with stim")
- Data from force plates and electrical stimuli generator were recorded

Study design and protocol

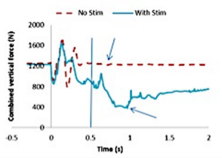
Other measurements

- Cumberland Ankle Instability Tool questionnaire (CAIT)
  - 9 items, 0 (severe instability) to 30 (no instability)
- Biodex Dynamometer
  - Ankle joint laxity
  - Ankle proprioception test: Position-reposition test at 15 and 30 degree of ankle inversion
  - Peroneal muscle strength
    - Isometric strength at 15 degree ankle inversion
    - Isokinetic strength at 1200/s

Results and our interpretation

Results

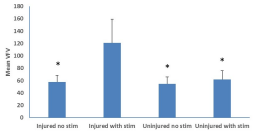
- VFV – peak value of the combined ground reaction force recorded within a 0.5-2 sec time window after trapdoor release



Results and our interpretation

Results

- Mean VFV in the injured ankles with painful stimulation was significantly greater than that in the injured ankles without painful stimulation, or in the uninjured ankles with or without painful stimulation



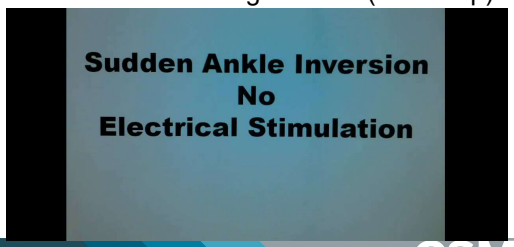
Study design and protocol

Correlation analyses

- No significant correlations between CAIT and VFV, or any one of the measured variables, excepte
  - A moderate significant correlation between CAIT and isokinetic strength of evertors (r = 0.66)
- No significant correlations between VFV and any one of the measured variables

Results and our interpretation

A drastic unloading reaction (video clip)



Results and our interpretation

Results

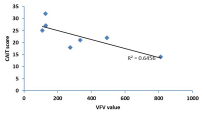
- 7 subjects showed drastic unloading reaction (VFV > 100 at the injured ankle with painful stimulation, when compared to non-drastic reaction

	Drastic reaction (n=7)	Non-drastic reaction (n=17)
Injured 'no stim'	111.5±67.5	33.4±20.8
Injured 'with stim'	325.1±255.3	36.5±23.2
Uninjured 'no stim'	94.6±82.3	38.0±28.5
Uninjured 'with stim'	117.2±105.6	39.2±29.8

Results and our interpretation

Results

- In those 7 subjects with drastic unloading reaction, VFV values were significantly correlated to CAIT scores (r = 0.8)



- No other significant correlations between any pair of measured variables in those 7 subjects or other subjects

Results and our interpretation

Hyper-reactivity to unloading reaction

- Ankle stretching + painful stimulation increased significantly the VFV in the injured ankles, but not in the uninjured ankles
- Ankle stretching (30 degree) along did not increase the VFV
- VFV depends on joint injury and stimulation
- VFV was not correlated to CAIT or other factors, supporting it an independent factor for FAI
- CAIT was only correlated with isokinetic strength of peroneal muscles.

Results and our interpretation

Two types of unloading reactions

- Two types of unloading reactions:
  - Drastic reaction
  - Non-drastic reaction
- The type of reaction may depend on
  - Individual nervous system
  - Intensity of ankle stretching and/or painful stimulation

Results and our interpretation

CAIT measure vs VFV

- No correlation in all subjects
- Highly significant correlation in subjects who showed drastic unloading reactions
- Subjective feeling of ankle instability may primarily reflect subject's experience of ankle "giving way"

Results and our interpretation

Summary and future research questions

- Duplicated the ankle 'giving way" in a lab setting
- Revealed a drastic unloading reaction
- Hyperreactivity to unloading reaction is proved an independent factor of ankle giving way

- Peripheral or central (spinal cord or brain) origin?
- Only in a portion of the ankles with FAI?
- Protective or sign of symptom pregression

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Part II
Objective Evaluation of Balance Exercise Treatment in subjects with FAI

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- Background
- Randomized control trial to investigate the effects of balance training in FAI

Treatment of FAI

- "Once a sprain, always a sprain" – O' Donoghue
- No relationship between the method of initial treatment and residual symptoms
- Conservative and surgical treatments for FAI have been inadequate
- Balance training is used widely in sports medicine clinics to treat FAI
- Conflicting results of balance training on various etiological factors
- Most of the previous studies focused on postural control deficits in FAI subjects

(Eils & Rosenbaum, 2001; Gauffin et al., 1988; Hale et al., 2014; Matsusaka et al., 2001)

Treatment of FAI

- Reduced ankle "giving way" episodes and reduced ankle injury after rolling board training
  - Varied length and duration: 3-7 days a week (4 – 12 weeks)
- Mechanism for reduced ankle "giving way" is unknown
- Balance training may help
  - retrain the nervous system,
  - desensitize fears and concerns,
  - alter pain attitudes and beliefs

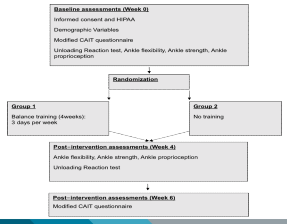
- Scientific exploration of effects on underlying mechanism in ankle functional stability is required

Research Goals

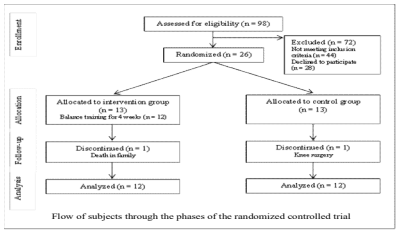
- Purpose of the study
  To determine the effect of balance training intervention in patients with unilateral Functional Ankle Instability (FAI)
  - Unloading reaction
  - Self assessment function scores (CAIT questionnaire)
  - Ankle joint laxity, peroneal muscle weakness, and ankle proprioception
- Clinical Significance
  - Develop an objective measure to determine the effectiveness of balance training
  - Design better rehabilitation programs for patients with FAI

Research Study Design

- Randomized, single blinded 4-week balance training trial



Subject Enrollment



Flow of subjects through the phases of the randomized controlled trial

Methods - Subjects

- Primary Inclusion Criteria
  - 18 to 45 years
  - unilateral functional ankle instability (FAI) (grade II or III)
  - at least 4 weeks after acute lateral ankle sprain
  - ongoing symptom of ankle "giving way" during functional activities
  - exercising at least 2 hours per week.

	No. of subjects	Age (yrs.)	Height (cm.)	Weight (kg.)
Control group	12 subjects (3 males, 9 females)	33.8±6.4	168.4±10.7	75.48±13.8
Intervention group	12 subjects (4 males, 8 females)	34.6±9.0	172.7±6.1	75.2±14.1

Methods – balance training

- Balance training program – 4 weeks (3 times per week)
- Single limb standing (affected limb), using both static and dynamic balance components [5]

Balancing Component	Activity	Stability level	Number of sets	Duration	Number of repetitions
Static	Single-leg stand	6	3	30	-
	Single-leg stand	2	3	30	-
Dynamic	A/P tilting	2	3	-	6
	M/L tilting	2	3	-	6
	CW circles	2	1	-	10
	CCW circles	2	1	-	10

Biodex Dynamic Stability System

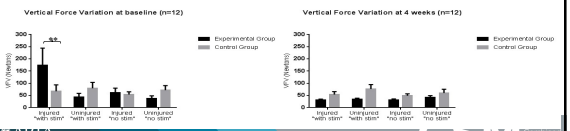
Methods - Instrumentation

- Unloading Reaction
  - Sudden ankle inversion using a 30° tilt platform
  - Vertical force variation (VFV) and Flexion angle variation (FAV)
- Biodex Dynamometer measurements
  - Ankle joint laxity
  - Peroneal muscle strength
    - Isometric strength at 150 ankle inversion
    - Isokinetic strength at 1200/s
  - Ankle proprioception
    - Position-reposition test at 15 & 30 degree of ankle inversion

Biodex Dynamometer

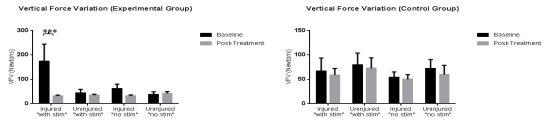
Results – Unloading Reaction

- Vertical Force Variation (VFV) processed using Matlab (Mathworks Inc.)
- VFV on the injured and uninjured leg were compared between and within the groups at the baseline and post-intervention.
- Baseline and post-intervention comparison



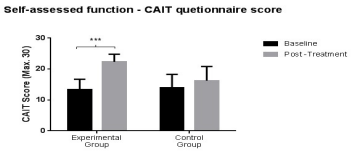
Results – Unloading Reaction

- Change in VFV at the end of 4-week balance training



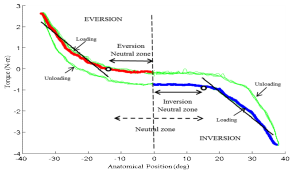
Results – CAIT questionnaire

- Cumberland Ankle Instability Tool questionnaire (CAIT)
  - discriminating and measuring the severity of FAI
  - 9 questions rating the functional status, severity and ability
  - scale of 0 (severe instability) to 30 (no instability)



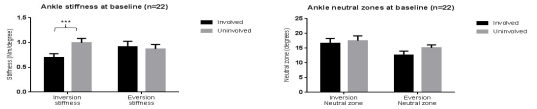
Results – Ankle joint laxity

- Inversion and Eversion stiffness - moment relative to angular displacement
- Inversion and Eversion neutral zone - area of the joint where accessory movement is available without ligamentous lengthening

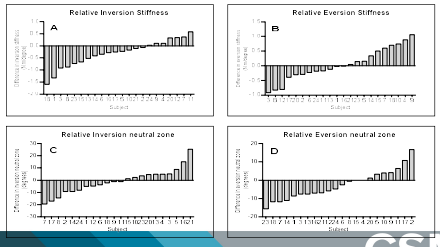


Results – Ankle joint laxity

- Baseline comparison between limbs

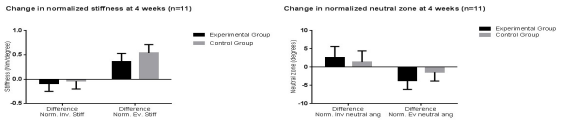


Results – Ankle joint laxity



Results – Ankle joint laxity

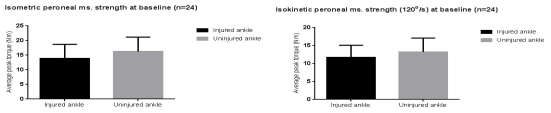
- Post-Intervention comparison between groups



Results – Peroneal muscle strength

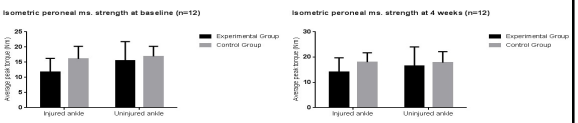
- Isometric peroneal muscle strength
- Isokinetic peroneal muscle strength at 120°/s

Baseline comparison between limbs



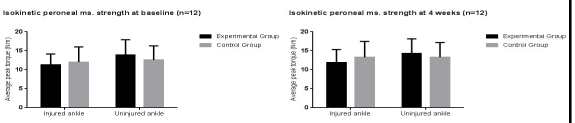
Results – Peroneal muscle strength

- Isometric peroneal muscle strength



Results – Peroneal muscle strength

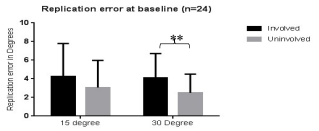
- Isokinetic peroneal muscle strength at 120°/s



Results – Joint position sense

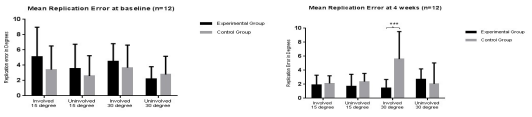
- Inversion joint position sense (passive)
  - Mean replication error at 15 degree
  - Mean replication error at 30 degree

Baseline comparison between limbs



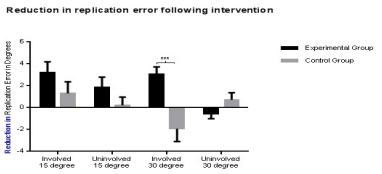
Results – Joint position sense

- Baseline and post-intervention comparison



Results – Joint position sense

- Reduction in replication error following balance training



Conclusions

- Greater unloading reaction was found in the FAI ankles with hyper-reactivity in some subjects
- Evidence of decreased ankle joint stiffness in FAI ankles
- Ankle proprioception: specifically, the perception of ankle inversion movement at 30 degree was found deficient in FAI ankles
- No difference was found in the peroneal muscle strength between the injured and uninjured ankles

Conclusions…

- Hyper-reactivity to unloading reaction decreased following balance training intervention
- Balance training may improve ankle proprioception in patients with CAI: specifically, the perception of ankle inversion movement
- Subjects reported significant improvement in self assessed function following balance training
- No difference was found in the ankle joint laxity and peroneal muscle strength between and within groups following balance training

Limitations

- Limited number of subjects in the study
- The accuracy of the test in simulating a real ankle giving way
  - Many episodes of ankle giving way occur during walking
  - bipodal vs. unipodal stance
- Measurements of FAI factors, rather than unloading reaction, were done in non-weight bearing seated position

Future directions

- Moving forward...
  - Discriminant function analysis
    - To investigate the contribution of multiple factors to FAI
    - To find predictors that can explain the effect of balance training
  - More varied and intense balance training program
  - Additional outcome measures to better assess the effectiveness of balance training

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Strategies of postural control during balance perturbation exercises: effects of a ball-kicking exercise

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Combined Sections Meeting 2017
San Antonio, Texas,
February 15 – 18, 2017

KU MEDICAL CENTER
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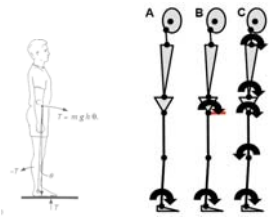
Objectives

- Describe compensatory postural control strategies in individuals with FAI during balance perturbation trainings
- Reveal the changes in postural control strategies as a result of balance perturbation trainings

Agenda

- Principles of postural control in quite stance
- Balance perturbation training for ankle instability
- Principles of anticipatory and compensatory adjustments
- Anticipatory and compensatory adjustments in functional ankle instability.

Postural Control in quiet double stance



- Inverted pendulum
- Double inverted pendulum
- Multij-oint coordination

Horak and Nashner, 1986, Creath et al., 2005, Hsu et al., 2007

Feedback systems

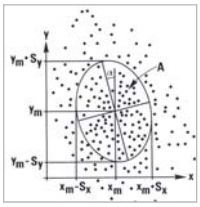
- Vestibular
- Somatosensory
- Visual

Biomechanical measurements in double –leg stance

- Participants: neurologic patients, older adults, patients with vestibular diseases and diabetes.
- Outcomes: center of pressure(COP) sway area, COP velocity and angular motion.
- Findings: COP sway and velocity is increased in these special populations and in older adults

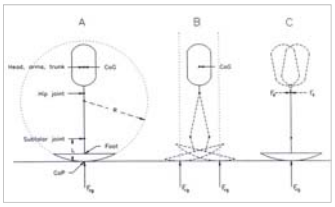
Horak et al., 2002 and 2002; Geurts et al. 2005; Prieto, 1996

Postural Control in quiet single-leg stance



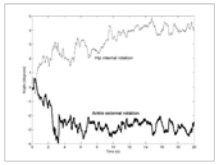
Tropp et al., 1984

Ankle and hip strategy in singe stance

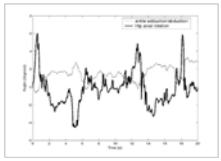


Hoogvliet et al., 1997

Ankle and hip strategy in single stance



Ankle and Hip ER/IR



Ankle inversion/eversion and Hip ER/IR

Liu et al. Gait and Posture 2012

Biomechanical measurements in single-leg stance

Participants: patients with athletic injuries: ankle and knee injuries. Effects of brace/orthoses use and balance training.

Outcomes: COP sway area, COP velocity and angular motion.

Findings: COP sway, velocity and angular motion is increased in patients with instable ankle or knee. These variables decrease when using braces and orthoses and by performing balance trainings.

Santos and Liu, 2008; Tropp et al., 1984; Bennel and Goldie, 1994; Liu et al., 2012; Loudon et al., 2008

Active exercises for Functional ankle instability

Systematic Review of literature:

1. Loudon JK, **Santos MJ**, Franks L, Liu W. The effectiveness of active exercise as an intervention for functional ankle instability: a systematic review. Sports Med, 2008.
2. McKeon PO, Hertel J. Systematic review of postural control and lateral ankle instability, part II: is balance training clinically effective? J Athl Train. 2008.
3. Webster KA, Gribble PA. Functional rehabilitation interventions for chronic ankle instability: a systematic review. J Sport Rehabil. 2010.

Most of them involved balance exercises

(wobble board/ankle disks)

Mattacola et al Journal of Athletic Training 2002

Conclusions

1. "Conservative treatment interventions including balance, proprioceptive and muscle strengthening exercises are effective for patients with FAI… Both a lack of level I evidence(large randomized controlled trial, low error risk) and a lack of follow-up data limits the ability to generalize these findings to the clinic in order to prevent recurrent ankle instability." Loudon et al. 2008

2. "Studies showed improvements in both dynamic postural control and self-reported function in those with CAI. However, it is clear that more high-quality research is needed in this area to ensure the efficacy of functional dynamic rehabilitation for those with CAI." Webster and Gribble, 2010

*Bottom line: Improve, but high quality research is lacking

Conclusions

3. "Evidence is lacking to assess the reduction in the risk of recurrent sprains, inconclusive to demonstrate improved instrumented postural control measures, and limited, albeit promising, to show improvements in self-reported function in those with CAI who complete balance and coordination training." McKeon and Hertel, 2008

*Bottom line: inconclusive and limited

Balance exercises usually

involve postural perturbations

Postural Perturbations

- **INTERNAL**

Self generated: head, arm and leg movements

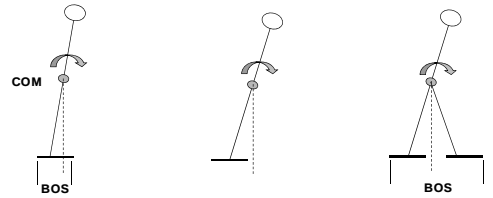
PREDICTABLE

- **EXTERNAL**

Moving bus, pulls, push, catching, kicking and other forms of perturbations

PREDICTABLE AND UMPREDICTABLE

Postural Perturbations



Feet-in place reaction

Limit of stability

Compensatory stepping reaction

Postural adjustments strategies

- ***Anticipatory postural adjustments (APA)**
  Feed-forward mechanisms
- ***Compensatory postural adjustments (CPA) or Simultaneous postural adjustments (SPA)**
  Feedback mechanisms
- **Stepping reactions**
  Feedback mechanisms

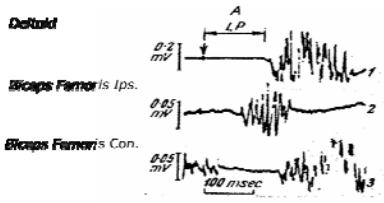
* Featured topics in the current lecture.

ANTICIPATORY POSTURAL ADJUSTMENTS

Feed-forward mechanism (pre-programmed)

- Changes in the activity of the muscles prior to the disturbance(-100ms to -250ms)
- Small changes in kinetics and Kinematics
- ***Depend on body configuration, stability, magnitude of perturbation, prior experience and learning**

Anticipatory postural adjustments (APAs)

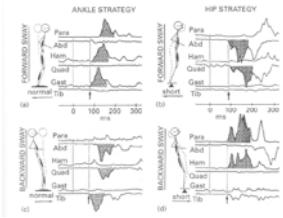


Belenkii et al., Biophysics, 1967

COMPENSATORY POSTURAL ADJUSTMENTS

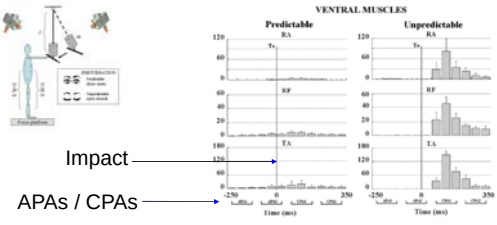
- Earliest effective responses to maintain postural stability after the balance is perturbed (reflex responses, postural reaction, reactive corrections)
- Changes in EMG activity, kinetics and Kinematics after the perturbation.
- ***Depend on body configuration, stability, magnitude of perturbation: prior experience and learning**

COMPENSATORY POSTURAL ADJUSTMENTS



Horak and Nashner, 1986

Inter-relationship between APA and CPA

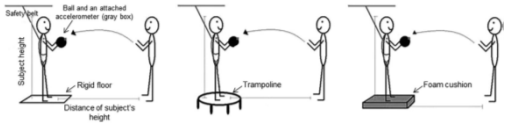


Santos et al, JEK 2010a: EMG analysis

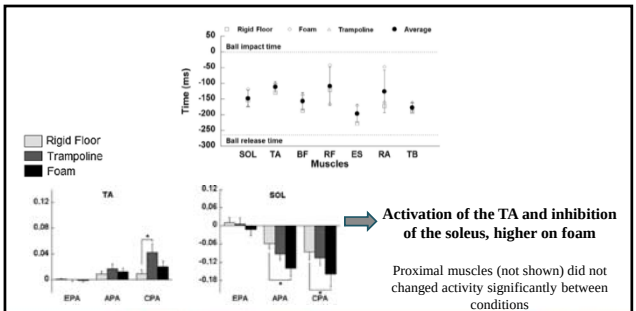
Perturbation balance exercises in people with Functional ankle instability

***Poor knowledge of Postural adjustments strategies**

For instance…



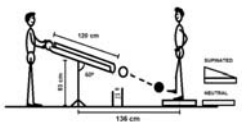
Scariot et al., Journal of Bodywork and Movement Therapies 2016



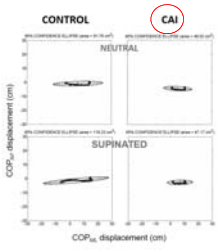
Activation of the TA and inhibition of the soleus, higher on foam

Proximal muscles (not shown) did not changed activity significantly between conditions

Ball- Kicking perturbation and ankle instability(FAI)



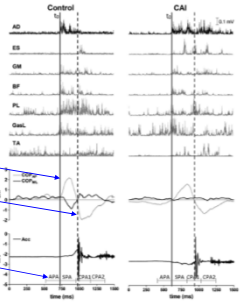
FAI	Control
21	21



Less COP excursion

Santos et al., Gait and Posture, 2014

DATA PROCESSING



Leg movement

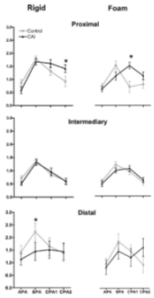
Ball impact

APA / CPA1 / CPA2 / CPA3

Rios et al., Human Movement Science, 2014

Muscle activity

*Increased muscle activity at the proximal muscles and decreased at the distal ones (around ankle)



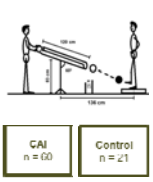
Rios et al., Human Movement Science, 2014

Compensatory mechanism in individuals with Functional ankle instability

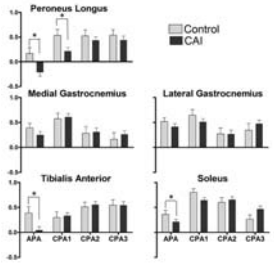
Table 2 - Results of PCA for all muscles of both groups during the kicking task; loadings over 0.5 are shown in bold. Note the differences in significant loadings (>0.5) between groups across the four principal components (PC).

	Controls				CAI			
Muscles	**PC1**	**PC2**	**PC3**	**PC4**	**PC1**	**PC2**	**PC3**	**PC4**
RA	-0.03	0.01	**0.77**	-0.13	-0.04	0.05	-0.02	**0.89**
ES	-0.02	0.02	**0.74**	0.09	**0.70**	-0.19	0.03	0.12
GM	0.04	**0.87**	-0.06	-0.20	**0.80**	0.16	-0.05	-0.21
RF	-0.13	**0.76**	0.14	0.22	**0.52**	0.11	-0.07	0.38
BF	**0.62**	0.00	0.42	-0.06	0.08	**-0.56**	0.01	0.30
PL	-0.02	-0.22	0.06	**0.80**	0.39	**-0.52**	-0.15	0.00
TA	0.04	0.23	-0.17	0.74	-0.01	0.08	**-0.93**	-0.15
GAsL	**0.91**	-0.03	-0.13	0.02	0.01	**-0.86**	0.02	-0.18
GAsM	**0.95**	-0.08	-0.10	-0.05	-0.22	**-0.86**	-0.04	-0.04
SOL	**0.50**	0.19	0.20	0.35	-0.02	-0.11	**-0.83**	0.19

Soleus (SOL), medial head of the gastrocnemius (GasM), lateral head of the gastrocnemius (GasL), tibialis anterior (TA), peroneus longus (PL), biceps femoris (BF), rectus femoris (RF), gluteus medius (GM), and erector spinae (ES), rectus abdominis (RA).



DISTAL muscles
Decreased activity in PL, TA, SOL



Rios et al.. 25th Congress of the International Society of Biomechanics, Glasgow, UK, 2015.

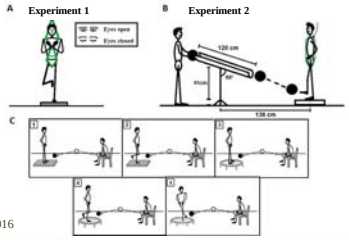
Principal component analysis

	CAI			Control		
Muscles	PC1	PC2	PC3	PC1	PC2	PC3
SOL	.076	-.041	**.953**	.421	.322	.637
TA	**.836**	.119	.116	-.117	**.977**	-.024
GasL	.141	**-.881**	-.136	**.910**	.059	-.047
GasM	-.117	**-.850**	.199	**.986**	-.163	.000
PL	**.827**	-.147	-.050	.354	.286	**-.710**

Ball-kicking BALANCE training

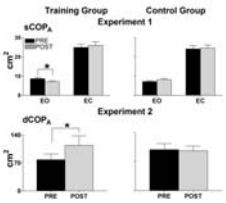
immediate effect

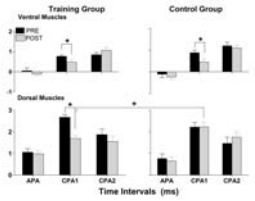
22	22
FAI exercises	FAI No exercises



Conceição et al., Journal Athletic Training 2016

Increased balance sway/ Decreased muscle activity





Balance exercises promoted decreased postural sway during static tasks but increased postural sway during dynamic tasks (decreased muscle activity).

Conceição et al., J Athletic Training 2016

Summary

- People with FAI/CAI reduced postural sway dynamic tasks and increased postural sway during static tasks
  - Increased anxiety levels, **avoiding** "giving way" or hyper-responses.
- Individuals with FAI/CAI increase the proximal muscular activity (hip and spine) to compensate for their ankle deficits and maintain reduced balance sway during the task performance (kicking a ball).
- The results of our PCA analysis show that individuals with FAI/CAI also alter the way they combine and coordinate their muscular activation patterns to control balance sway during postural disturbances.
  - balance perturbations exercises using kicking a ball tasks may effectively target the proximal instead of the distal (ankle) muscles in individuals with CAI. Thus, associating balance control/ sway improvements with ankle neuromuscular enhancement after these specific trainings might be taken with caution.

Summary

- Balance training promoted decreased postural sway during static tasks but increased postural sway during dynamic tasks. The later is combined with decrease muscular activity.
  - They acquired enhanced ability to address body disturbances and increased postural stability relative to task requirements.
  - Decreased levels of anxiety and better cope with hypersensitivity (**desensitization?)**

Take home message

- There is a need to better understand the postural control strategies throughout the varied/available balance exercises techniques in healthy individuals and in those with FAI.
- Then, specific balance exercise treatments would be better addressed to people with FAI.

THANK YOU !

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