“Chronic Ankle Instability – Two Steps Forward and One Step Back”

University of Arizona
College of Medicine
Department of Orthopaedic Surgery
Grand Rounds Lecture Series
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Co-Founder International Ankle Consortium
University of Delaware

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• No financial conflicts of interest.
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  – NCAA/DOD Grand Alliance Care Consortium
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  – Tekscan, Inc.
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• Isokinetic International website support.

International Ankle Consortium
• International Ankle Consortium is a non-profit organization which provides forums for the exchange of new scientific and clinical insights into prevention, assessment, and treatment of ankle pathologies from a multidisciplinary perspective.
• We aim to build an organization to support:
  a. Student scholarships
  b. Conference awards
  c. Speaker travel expenses

http://sites.udel.edu/chs-atep/ian/

Ankle Sprain Epidemiology
• Ankle sprains are extremely common in:
  – Sport and exercise
  – Military training
  – Occupational injuries
  – General population
• 1.6 million physician visits annually for ankle sprains in the US
• Annual aggregate medical costs of 2 billion dollars in US

Ankle Sprain Epidemiology
• Recurrence rates >70% in basketball
• 55-78% report residual symptoms 6 months post-injury
• 74% reported at least one residual symptom at 2 years post-injury
  – 47% reported perceived instability and more than one symptom
  – Also rated lower general health quality of life (SF-36) compared to those with upper extremity injuries
Ankle Sprain Epidemiology

- Most common predisposition to an ankle sprain is the history of a previous sprain
- 55% of ankle sprains are not treated by a health care professional
- Relationship between ankle sprain history and development of osteoarthritis

Traditional Mechanism of an Acute Ankle Sprain

- Supination of the rearfoot coupled with external rotation of the lower leg
  - Plantar flexion
  - Inversion
  - Internal Rotation
- More plantar flexion and inversion at initial contact increases likelihood of a sprain (Wright et al, J Biomech, 2000)

Video Analysis of Ankle Sprain: Fong et al, AJSM, 2009

- 23 year old male incurred a Grade I ATFL sprain while performing a cutting task during a laboratory study
- Comparison of "sprain trial" kinematics to 3 previously completed trials
- Comparison of "sprain trial" center of pressure path to 3 previously completed trials
Video Analysis of Ankle Sprain: Fong et al, AJSM, 2012

- 5 ankle sprains recorded from television footage of professional tennis from 1995-2010
  - Utilized MBIM analysis

**Bottom Line:**
Not all ankle sprains happen in a consistent manner!

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Summary of 10 Reported Cases

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<tr>
<th>Peak INV (°)</th>
<th>Peak INV Vel (°/s)</th>
<th>Time to Peak INV (s)</th>
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<th>Peak FF (°)</th>
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<th>Time to Peak FF (s)</th>
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Consequences of an Acute Ankle Sprain

- Most commonly ligament structures injury patients with only minor change in body position to an acute inversion
  - Present to emergency room or occupational medicine
- Injury based on pain at site of PTT
  - Anterior Talofibular Lig. (75%)
  - Calcaneofibular Lig. (54%)
  - Posterior Talofibular Lig. (54%)
  - Deltoid Lig. (37%)
  - Ankle joint capsule (55%)
  - Inferior extensor (55%)
  - Peronei (33%)
  - Lisfranc (8%)
  - Syndesmotic (5%)

*Fallet et al, J Foot Ankle Surg, 1998*

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A Public Health Issue?

- Cost of initial treatment and follow-up rehabilitation
- Strong link with an increased risk for osteoarthritis and articular degeneration

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**CLINICAL ORTHOPAEDICS AND RELATED RESEARCH**

The Impact of Osteoarthritic Implications for Research.

Buckwalter, Joseph A MD; Saltzman, Charles MD; Brown, Thomas PHD

October 2014
Chronic Ankle Instability (CAI)

- The encompassing term used to describe the chronic symptoms that may develop following an acute ankle sprain, with injury recurrence at the epicenter of the chronic paradigm
  - Episodes of ankle joint “giving way”
  - Pain
  - Swelling
  - Decreased function

(Chronic ankle pain, including swelling and weakness)

A Look at CAI Paradigms

- Mechanical Ankle Instability (MAI)
  - Pathological laxity
  - Arthrokinematic restrictions
  - Degenerative changes
  - Synovial changes

- Functional Ankle Instability (FAI)
  - Impaired postural control
  - Impaired proprioception
  - Impaired neuromuscular control
  - Strength deficits

(Chronic ankle pain, including swelling and weakness)

International Ankle Consortium Recommendations

Selection Criteria for Patients With Chronic Ankle Instability in Controlled Research: A Position Statement of the International Ankle Consortium

IAC CAI Inclusion Criteria

IAC CAI Exclusion Criteria

University of Delaware
Ankle Injury Assessment and Tracking in an Athletic Population Prospective Study
Testing Protocol

• Baseline testing student-athletes from 9 high risk sports (MSOC, WSOC, FH, VB, FB, WBB, MBB, WLAX, and MLAX)
  – Protocol entails 1.5 hr.
  – Since 2009 we’ve tested 619 S’A’s
  – Also include FMS-7 protocol testing data from UD S&C staff
• Post-Acute Ankle Sprain Follow-Up
  Testing:
  – 24 hr., 2-4 weeks, 3 mos., 6 mos., 1 yr., and 2 yr. (if feasible)

Kin Com Isokinetic Dynamometer

• Peak Torque (PT)
  – Eversion (EV)
  – Plantar flexion (PF)
  – Dorsiflexion (DF)
  – Inversion (INV)
• Type of Contraction
  – Concentric (CON)
  – Eccentric (ECC)
• Velocity
  – 30˚/sec
  – 120˚/sec

Ankle Arthrometer

• LabVIEW software (National Instruments, Austin, TX)
  • Anterior displacement (millimeters)
  • Inversion/eversion rotation (degrees)
  • Average of three trials

Methods: Dynamic Stability

• Four Directional Jump (Liu & Heise, 2010)
  – Forward (From 100% of leg length, over a 15 cm hurdle)
  – Backward (Over a 5 cm hurdle)
  – Medial (Over a 5 cm hurdle)
  – Lateral (Over a 5 cm hurdle)
• AMTI Force Plate
  – GRF collecting at a sampling rate of 100 Hz for 5 sec
  – 60 Hz and 3 sec have been found to be sensitive (Wikstrom et al., 2005; Ross & Guskiewicz, 2003)

Y-Balance Testing Assessment

• Average across 3 trials
• Reach distance is normalized to limb length
  – Reach Distance
  – Limb Length x 100
• A composite reach distance = sum of the 3 reach directions (normalized)
Balance Error Scoring System (BESS)

MobileMat BESS (Tekscan, Inc., Boston, MA)

ANKLE LAXITY ULTRASOUND

What makes a stable joint?

Ligamentous Restraints

ARTHROKINEMATIC IMPAIRMENTS

- Hypomobility – “Subluxation”
- Inferior Tibiofibular Joint Positional Fault
- Limited Posterior Talar Glide
**POSITIONAL FAULT OF INFERIOR TIB-FIB JOINT**

- Brian Mulligan has proposed that the distal fibula gets “stuck” anteriorly and inferiorly after sprain.
- Evidence supports this phenomenon in patients with:
  - Acute ankle sprains
  - Chronic ankle instability
  (Hubbard et al., JOSPT, 2006, Manual Therapy, 2008)

**RESTRICTED POSTERIOR TALAR GLIDE**

- Posterior talar glide restricted 12 weeks after ankle sprain
  (Denegar et al., JOSPT, 2002)
- Patients treated with posterior talar mobilization regained dorsiflexion ROM quicker after acute sprain
  (Green et al., Phys Ther., 2001)
- Patients with CAI treated with posterior talar mobilization had immediate increases in dorsiflexion ROM and posterior talar glide
  (Vicenzino et al., JOSPT, 2006)

**PROPRIOCEPTION & NEUROMUSCULAR CONTROL MODEL**

- Cutaneous Receptors
- Articular Receptors
- Tendon & Muscle Receptors
- Alpha motor neurons
- Extrafusal Muscle Fibers
- Intrafusal Muscle Fibers
- Gamma motor neurons

**A BETWEEN GROUPS ANALYSIS OF INVERSION AND EVERSION STRENGTH DOES NOT DISTINGUISH THOSE WITH AND WITHOUT ANKLE INSTABILITY**

Kaminski TW, Liu K, Gustavsen G.
Athletic Training Research Laboratory
University of Delaware (USA)

- Freeman in this seminal paper stated:
  - “… no patient was found at the time of discharge to display any mechanical instabilities and/or calf muscle weakness. Therefore, in no case could late functional instability be attributed to these pathological processes.”
- 45+ years later is this still the pervasive viewpoint?
Data Analysis

• A between groups ANOVA was conducted using normalized (lean body mass) PT to determine if differences in isokinetic strength existed between the 3 groups (AI, COPER, HEALTHY)

Results

– Inversion Strength Analysis

Results Eversion Strength Analysis

• It is clearly evident that in this cohort of intercollegiate athletes there are no differences in strength in either the ankle invertors or evertors, despite the presence of AI or previous ankle injury.

• We are confident that post-injury rehabilitation efforts to restore ankle INV and EV strength are effective, and that factors other than deficits in INV and EV isokinetic strength are involved in AI.

Discussion

• It is clearly evident that in this cohort of intercollegiate athletes there are no differences in strength in either the ankle invertors or evertors, despite the presence of AI or previous ankle injury.

• We are confident that post-injury rehabilitation efforts to restore ankle INV and EV strength are effective, and that factors other than deficits in INV and EV isokinetic strength are involved in AI.

Summary of Studies Examining Isokinetic Strength

• Isolated eversion strength deficits do not appear to be evident in those with AI
• EV_{CON}:INV_{CON} ratios higher in the AI group, however not statistically different
• Conclusions:
  – Adaptive mechanism
  – Articulate activity during gait cycle
  – Deficits at other points in the kinetic chain?
  – Weakness not a factor in AI?
  – Is the “synergy” between PL and TP disrupted?

Holmes & Delahunt, Sports Med, 2009

• Consensus in the literature is that evetor strength deficits are not a common finding in subjects with AI
• Despite this consensus – peroneal strengthening continues to form a central component of ankle injury rehab!
• Some have suggested it might be lack of peroneal muscle endurance or ineffective timing
• Invertor weakness – selective inhibition (arthrogenic muscle inhibition)?
Holmes & Delahunt, Sports Med, 2009

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Definition of IT and Intervention (qual)</th>
<th>Outcome measure</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davis et al. (2009)</td>
<td>Controlled group pre-post-intervention n = 20 (exercise: n = 10, control: n = 10)</td>
<td>F/I = 1 second to the bukle, Glen epoch of 1000 trials, 200 ms, 50 Hz, 100 trials</td>
<td>Strength testing</td>
<td>T = in endurance and strength training</td>
</tr>
<tr>
<td>Keravel et al. (2010)</td>
<td>Controlled group pre-post-intervention n = 20</td>
<td>F/I = defined according to F/I 1 group: progression 1 session strengthening programs of 6 weeks, 1 group: progression of strength training using 3-day/week interval Group 3: combination of both programs in 6 weeks</td>
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Discussion

- Inclusion of Coper Group
- Evidence that the large scale strength assessment study does not appear to offer any evidence that differentiates COPERs from either the AI or HEALTHY groups of athletes.
- Willems et al. (JAT, 2002)
- Measured CON/ECC INV and EV strength in CAI group and COPER groups
- Differences in EVECC120 and EVECC30 at 2 and 5 years between CAI and COPER groups
- No differences in COPER vs HEALTHY controls

Best Practice Question

Which therapeutic interventions will improve self-reported function in patients with Chronic Ankle Instability?
Systematic Review of Interest

- Articles appraised using Downs and Black Checklist and PRISMA guidelines
- Each article was given level of evidence according to CEBM guidelines
- Data Sources: PubMed, CINAHL, MEDLINE, SPORTDiscus
- Inclusion criteria:
  - Written in English
  - Identify patients with CAI
  - Use a form of therapeutic intervention
  - Use a self-reported questionnaire as a main outcome measure
  - Articles with level 4 evidence or higher

Evidence Categories Made Simple

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>SORT Grade</th>
<th>Clinical Practice Recommendation</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>Based on consistent and good evidence</td>
<td>No brainer! You should be doing this in clinical practice</td>
</tr>
<tr>
<td>B</td>
<td>Based on inconsistent or limited-quality evidence</td>
<td>Should probably include in our clinical practice!</td>
</tr>
<tr>
<td>C</td>
<td>Based on consensus or usual practice</td>
<td>Flip a coin — it is up to you to decide!</td>
</tr>
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Hedges’ g

- Effect Size (g)
  - Weak (<0.4)
  - Moderate (0.4 – 0.8)
  - Strong (>0.8)
- Negative effect size—improved self-reported function

Therapeutic Interventions

- Balance training
- Joint mobilisation
- Multimodal
- Resistive training
- Soft-tissue mobilisation
- Orthotics
- Static stretching

Evidence Categories Taxonomy

<table>
<thead>
<tr>
<th>Strength of Recommendation Taxonomy (SORT)</th>
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<tbody>
<tr>
<td>A Recommendation based on consistent and good-quality patient-oriented evidence.</td>
</tr>
<tr>
<td>B Recommendation based on inconsistent or limited-quality patient-oriented evidence.</td>
</tr>
<tr>
<td>C Recommendation based on consensus, usual practice, opinion, disease-oriented evidence, or case series for studies of diagnosis, treatment, prevention, or screening.</td>
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Balance Training

- Four RCTs and two case-control studies
- Average risk of bias was 19 (range 16–22) on Downs and Black
- Balance training is beneficial for improving self-reported measurements related to activities of daily living and physical activity
- SORT = A (consistent & good-quality)
Joint Mobilisation
- Three RCTs and two case series
- Average risk of bias score of 21 (range 18-24)
- It cannot be determined if a beneficial or harmful treatment effect exists
- SORT = C (lower quality of evidence and inconsistent findings)

Multimodal
- Five RCTs and one case-control study
- Average risk of bias score of 18.3 (range 15-23)
- A truly beneficial treatment effect cannot be concluded, however, supervised rehabilitation programs are effective at improving self-reported function
- SORT = B (inconsistent evidence)

Resistive Training
- Three RCTs
- Average risk of bias score of 21.5 (range 21-22)
- Few high quality of evidence and consistent results, however, the results show that resistive training does not provide clinically meaningful improvements in self-reported function
- SORT = B (limited-quality)

Soft-Tissue Mobilisation
- One RCT (plantar massage)
- Moderate effect size
- Six sessions of plantar massage does not provide clinically meaningful improvements in self-reported function
- SORT = B (limited-quality)

Orthotics
- One case-series
- Moderate treatment effect (~0.46) on CAIT
- Orthotics do not provide a clinically meaningful improvement on self-reported function
- SORT = C (evidence based on case-series)

Static Stretching
- One study included
- Strong to moderate effect sizes on two different questionnaires
- Static stretching of the triceps surae can improve self-reported function during activities of daily living but not physical activity
- SORT = B (limited-quality)
Conclusions

• Balance training and multimodal rehabilitation programs are beneficial treatment interventions to those with CAI.

• Balance has the greatest impact on self-reported function:
  - Increase demands on sensorimotor system
  - Change the tasks and/or environment (closing eyes, introduce unanticipated movements, unstable surfaces)
  - Patients will develop new movement patterns to overcome the functional limitation
  - Effective in reducing subsequent injuries

• Supervised high-intensity multimodal rehabilitation programs could provide a positive treatment effect when employed at the proper time in the healing process.

Take Home Message

• Incorporate balance training that will challenge the sensorimotor system and increase difficulty gradually including unanticipated events

• Treat each case separately by following these steps:
  1. Identify the areas of diminished function
  2. Treat that specific area with the appropriate treatment intervention or a combination of interventions/multimodal (ex. balance, agility, ROM, strength, flexibility)
  3. Re-evaluate the patient following the intervention to determine if it has given a positive treatment effect

Helpful Resources

• Section I Risk and Risk Reduction of Ankle Sprains
• Section II Diagnosis
• Section III Treatment and Rehabilitation
• Section IV Surgical Considerations

The Future of Acute Ankle Sprain Treatment Intervention?

https://www.youTube.com/watch?v=vADfbmsBsTU
Thank You!

Athletic Training Research Laboratory