# Beyond the Bar Graph: Visual Presentation of Results

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*Journal of Athletic Training* Reviewers' Workshop
Baltimore, MD
June 22, 2016

# OUTLINE

- Is your graph worth 1,000 words?
- Graphing Options
  - So, no bar graphs ever?
  - Illustrating individual differences
  - Visualizing magnitudes of difference
  - Motion analysis options
  - Other Considerations
- Reviewer recommendations

# Is your graph worth 1,000 words?

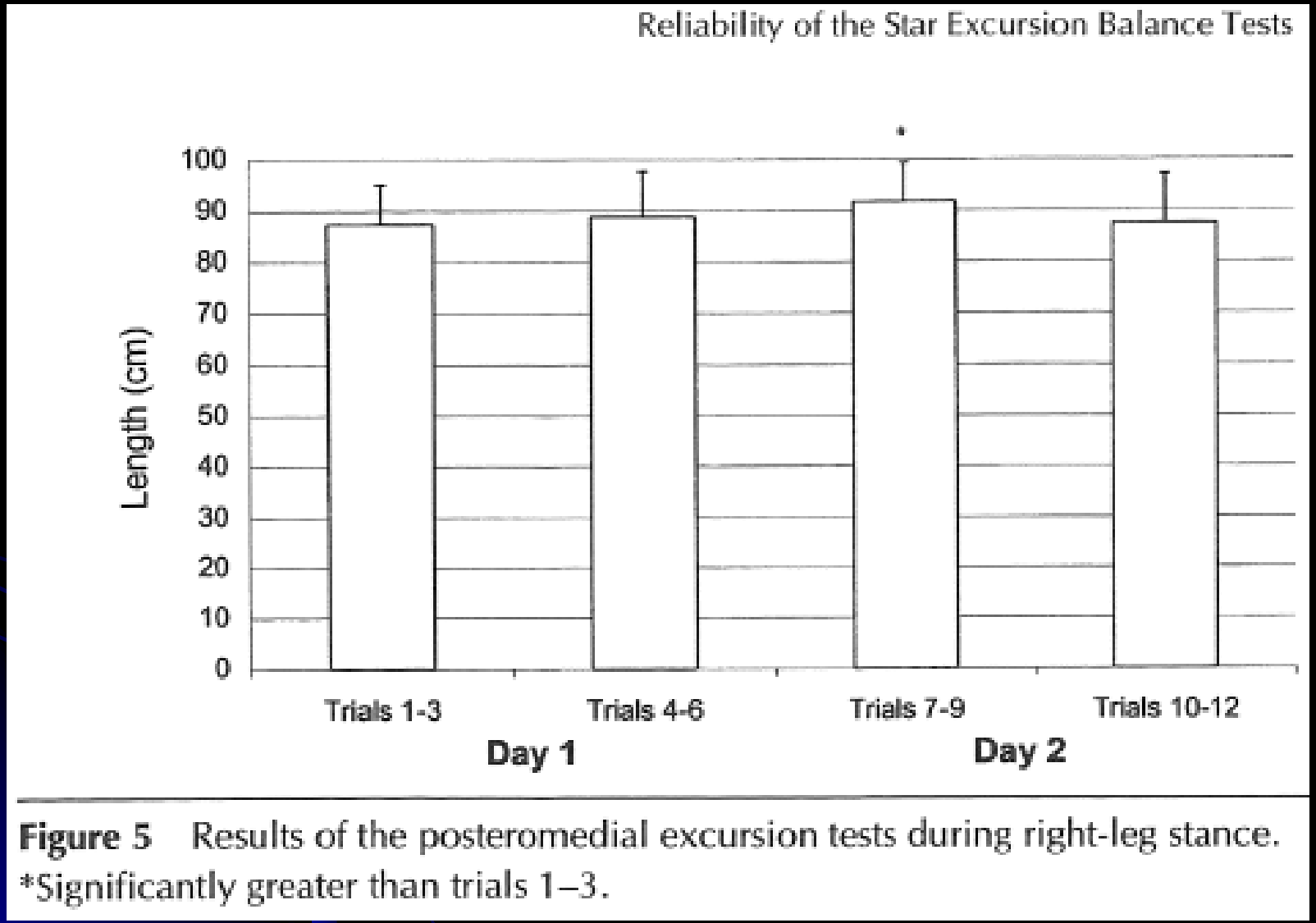


**Figure 5** Results of the posteromedial excursion tests during right-leg stance. *Significantly greater than trials 1–3.

Hertel et al., *J Sport Rehabil*. 2000

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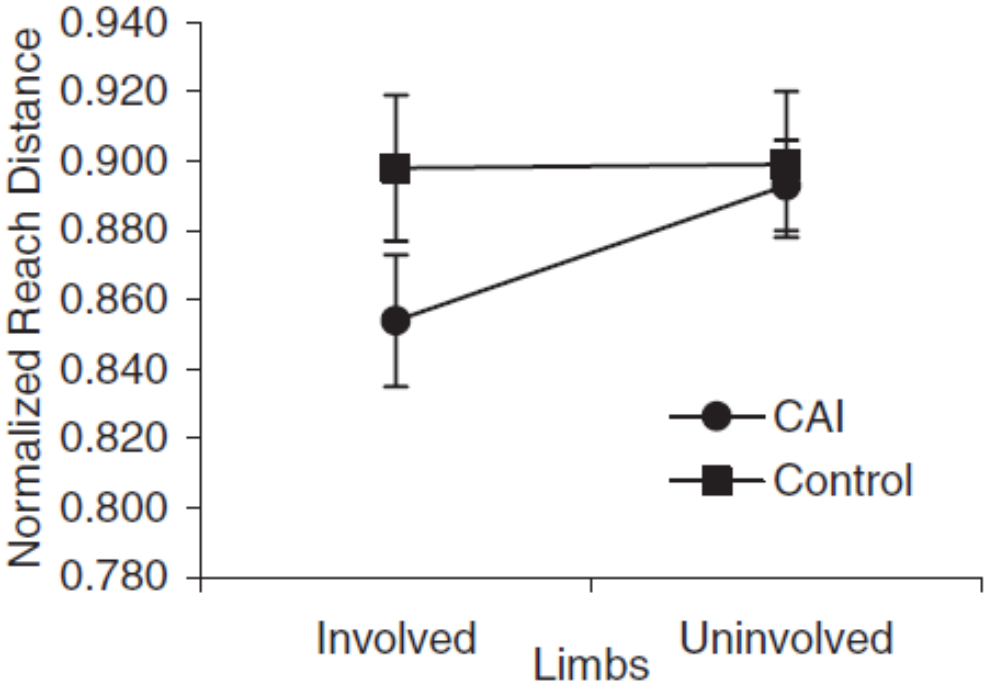


**FIGURE 5.** There was a significant group-by-side interaction for the posteromedial reach direction ($F_{1,85} = 4.97$, $P = .03$). Tukey's HSD post hoc testing revealed that the chronic ankle instability (CAI) group reached significantly less far when balancing on their involved limbs compared to their contralateral uninvolved limbs and both the "sham involved" and "sham uninvolved" limbs of the control group. Error bars represent SE ($P < .05$).

Hertel et al., *JOSPT*. 2006

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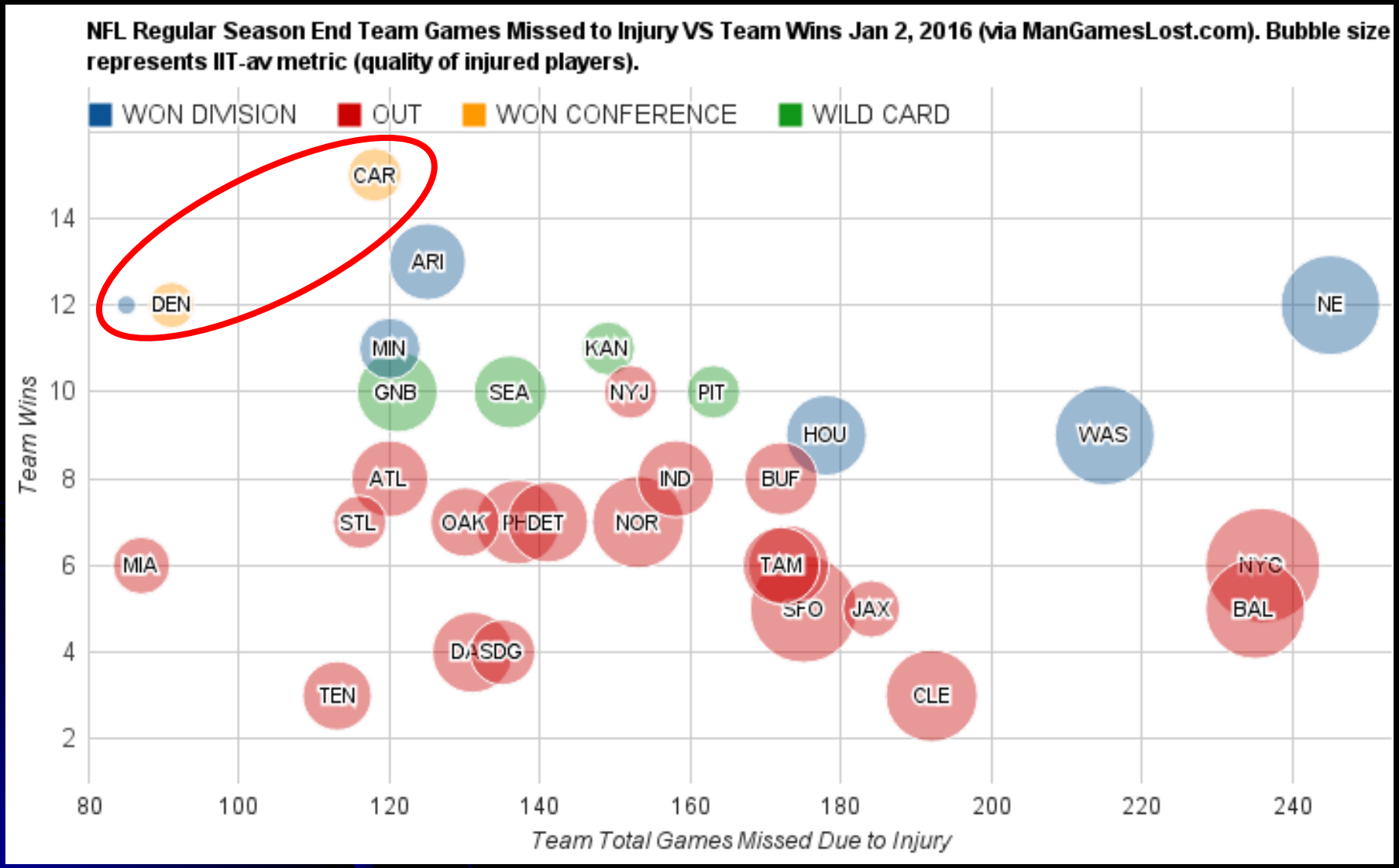


www.mangameslost.com

# Beyond Bar and Line Graphs: Time for a New Data Presentation Paradigm

Tracey L. Weissgerber[1]*, Natasa M. Milic[1,2], Stacey J. Winham[3], Vesna D. Garovic[1]

PLOS | BIOLOGY DOI:10.1371/journal.pbio.1002128 April 22, 2015

- The most common types of graphs in scientific publications are bar graphs & line graphs illustrating means and SD or SE

- Problem: different distributions of scores may produce the same result

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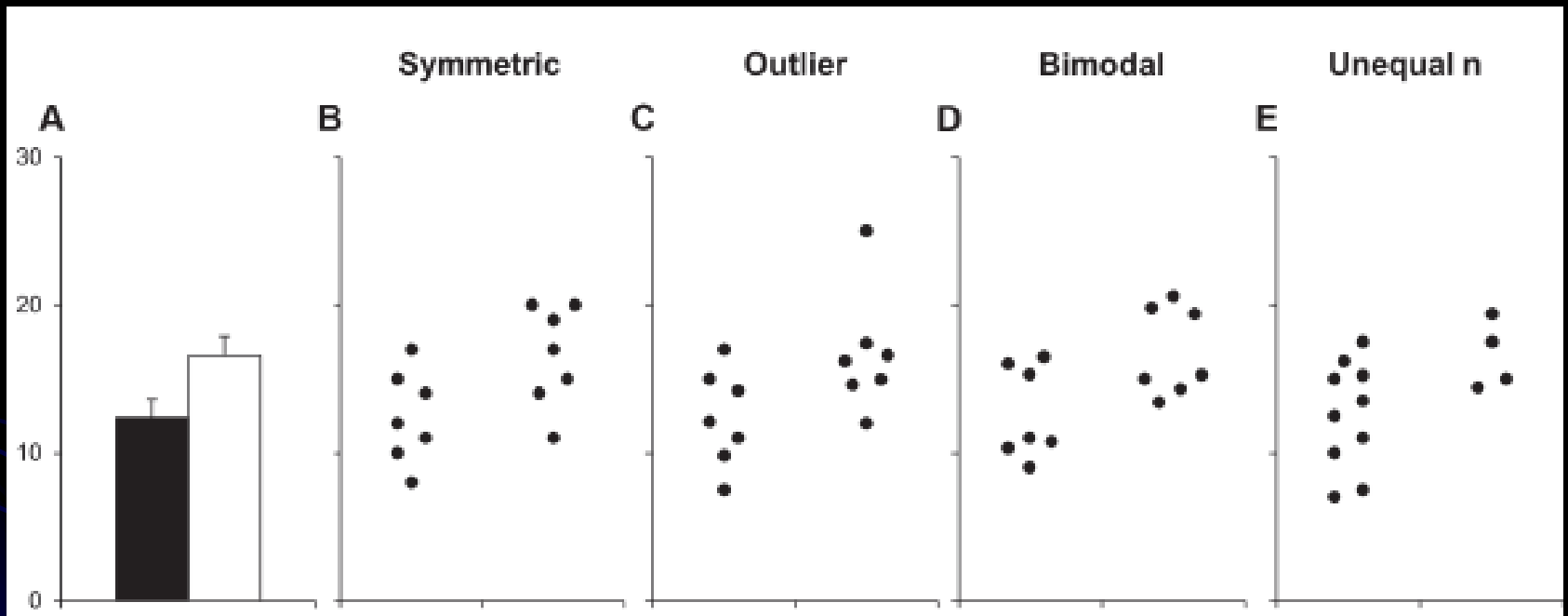


| Test | p value | | | |
|---|---|---|---|---|
| T-test: Equal var. | 0.035 | 0.050 | 0.026 | 0.063 |
| T-test: Unequal var. | 0.035 | 0.050 | 0.026 | 0.035 |
| Wilcoxon | 0.054 | 0.073 | 0.128 | 0.103 |

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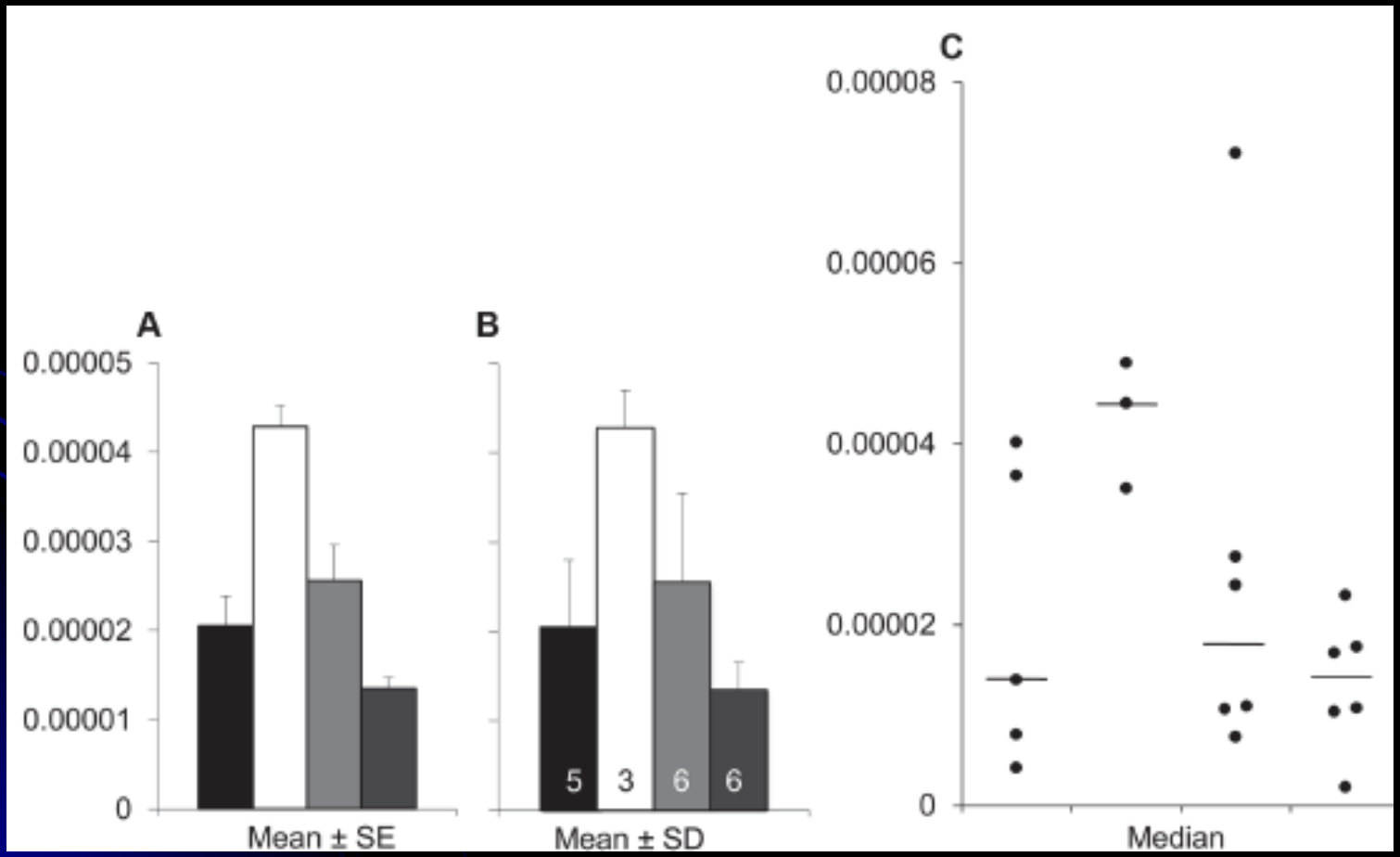

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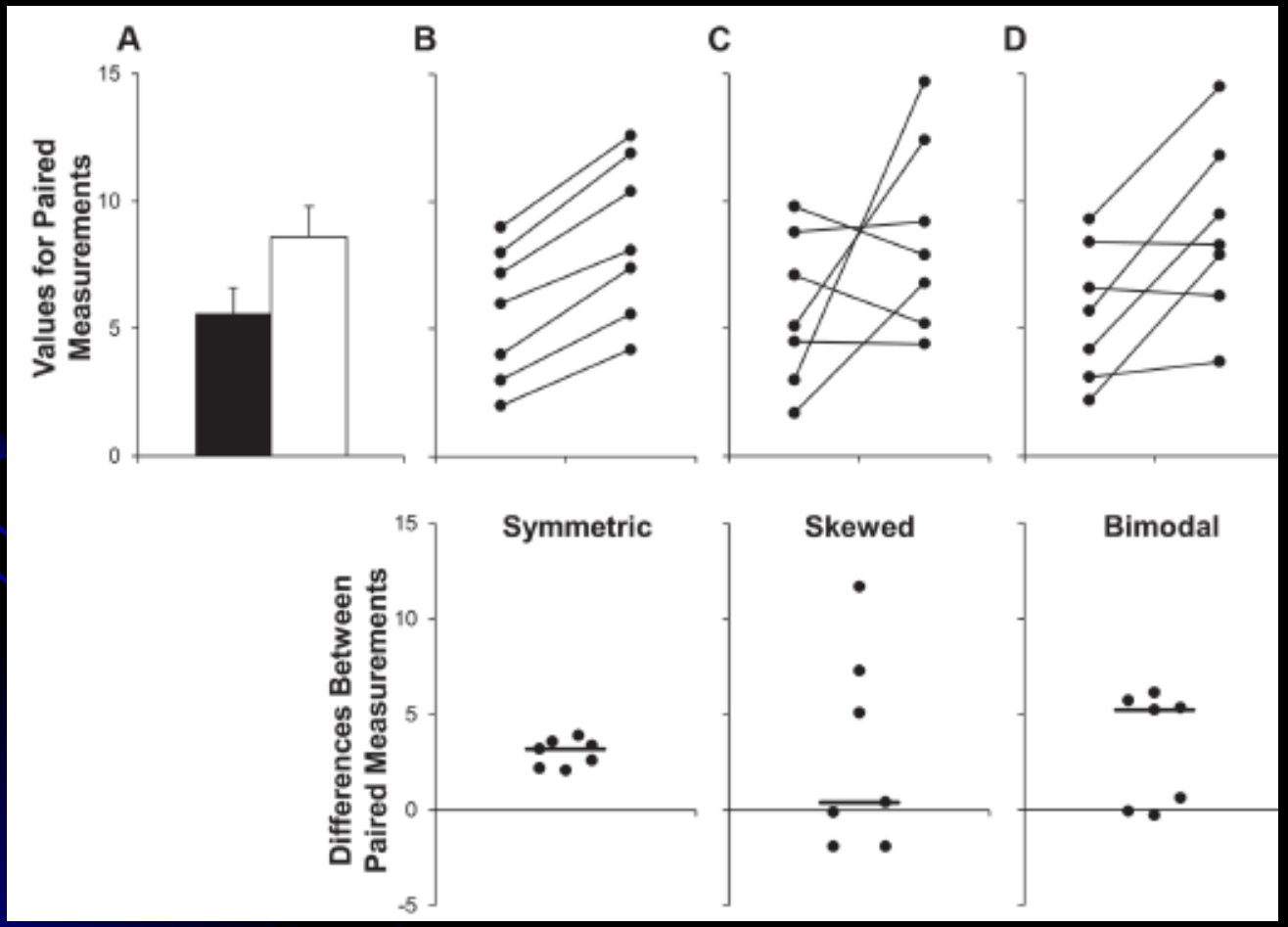

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- Recommendations from the authors:
  - Encourage a more complete presentation of data
  - Change journal editorial policies to discourage bar graphs and instead encourage univariate scatterplots, box plots, & histograms
  - Train investigators in data presentation

# Does this mean bar graphs won't be published in future articles in JAT?

- NO, but reviewers should:
  - critically evaluate graphs in manuscripts they are reviewing
  - think about whether the data is shown in the most informative manner
  - make recommendations if the data could be better presented with a different type of graph

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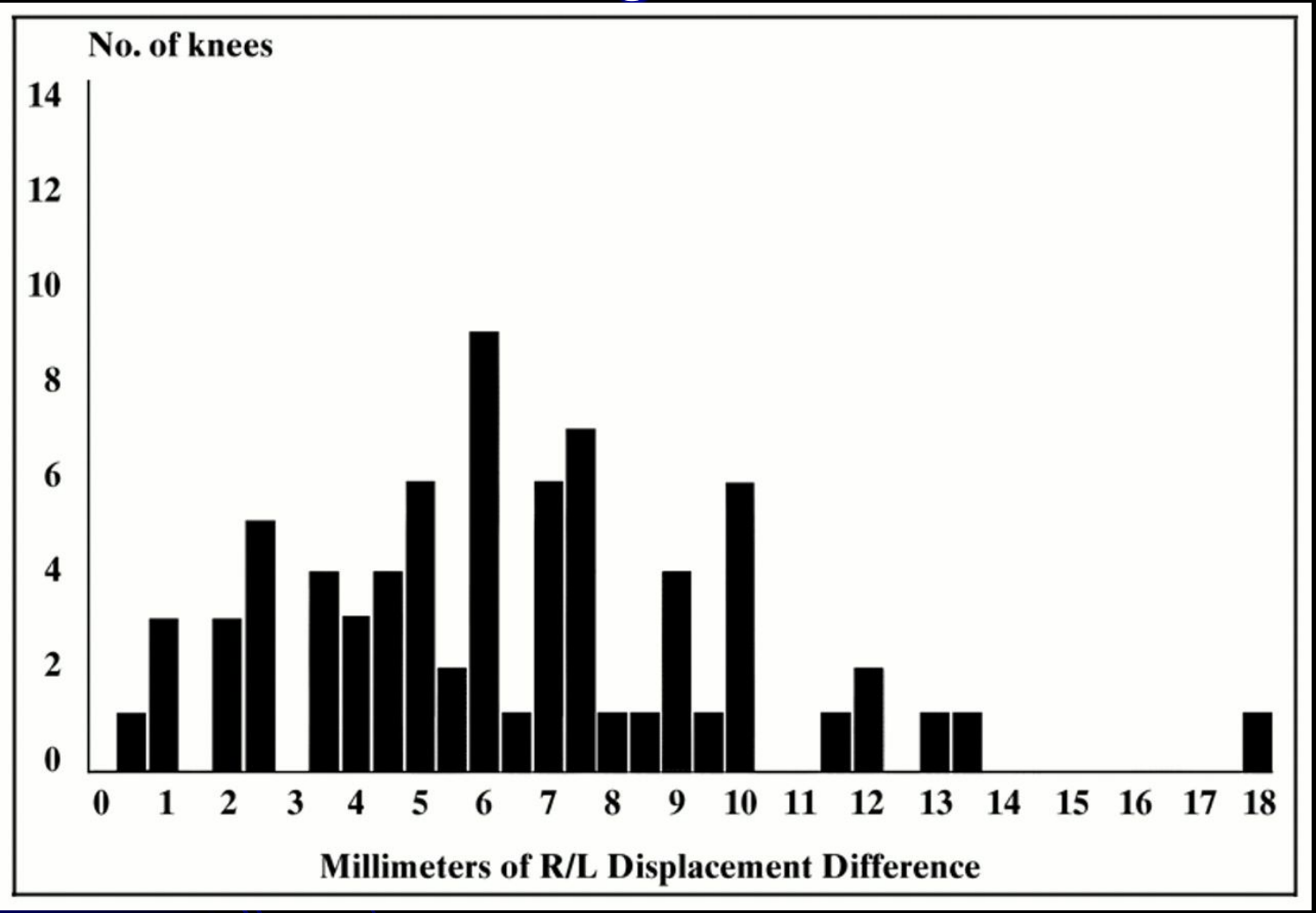
# More Informative Types of Bar Graphs

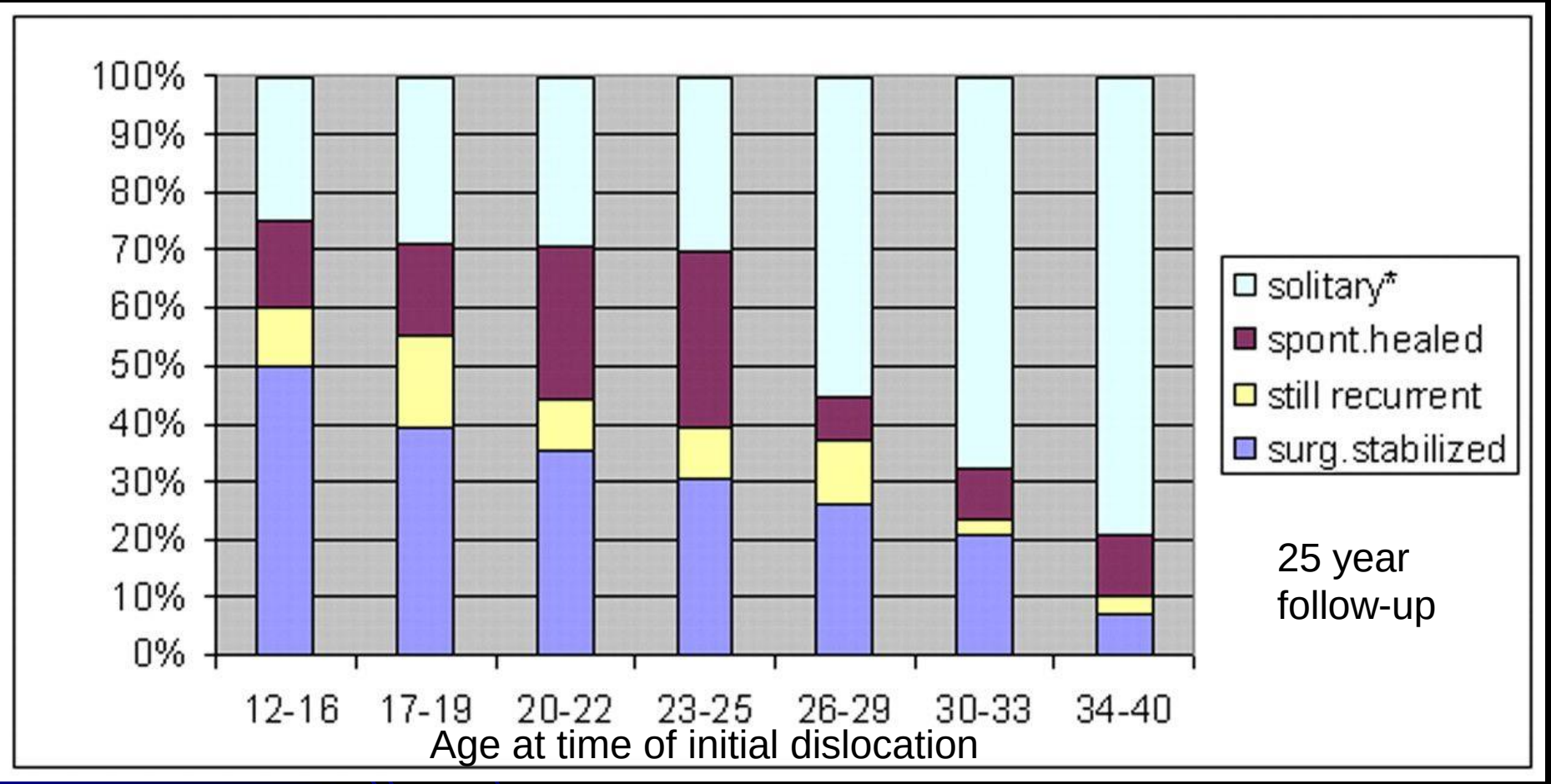
## Histograms




Plancher et al. Reconstruction of the anterior cruciate ligament in patients who are at least forty years old: a long-term follow-up and outcome study. *JBJS (Am)*, 1998

# More Informative Types of Bar Graphs

- Stacked bar graphs to show proportions




Hovellus et al. Nonoperative treatment of primary anterior shoulder dislocation in patients 40 years of age and younger. *JBJS (Am)*, 2006

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# Illustrating individual responses

## Pre-post plots of individual changes

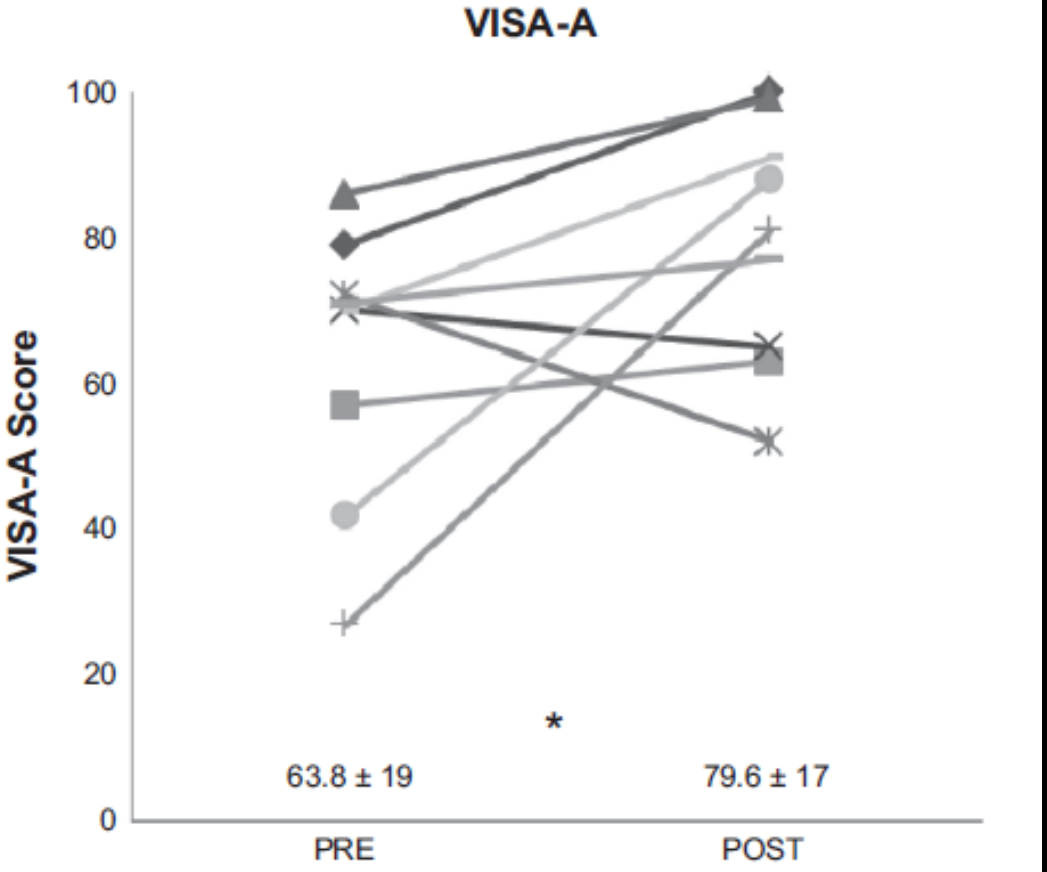
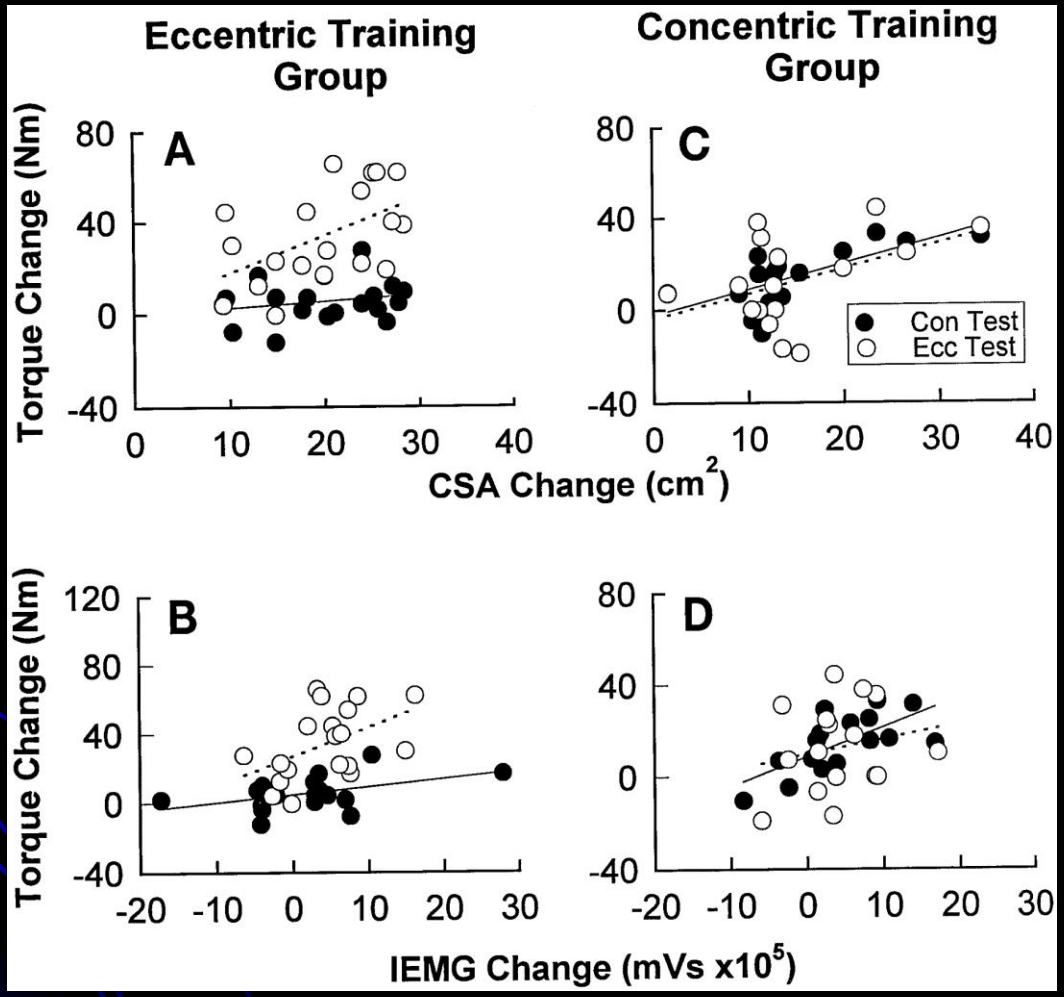



Fig. 2. Victorian Institute of Sports Assessment-Achilles (VISA-A) questionnaire scores Pre and Post. *Significant difference between mean Pre and Post scores ($P < 0.05$).

Masood et al. Effects of 12-wk eccentric calf muscle training on muscle-tendon glucose uptake and SEMG in patients with chronic Achilles tendon pain. *J Appl Physiol.* 2014

# Illustrating individual responses

## Scatter plots of individual changes




Higbie et al. Effects of concentric and eccentric training on muscle strength, cross-sectional area, and neural activation . *J Appl Physiol. 1996*

# Illustrating individual responses

## Box & whisker plots

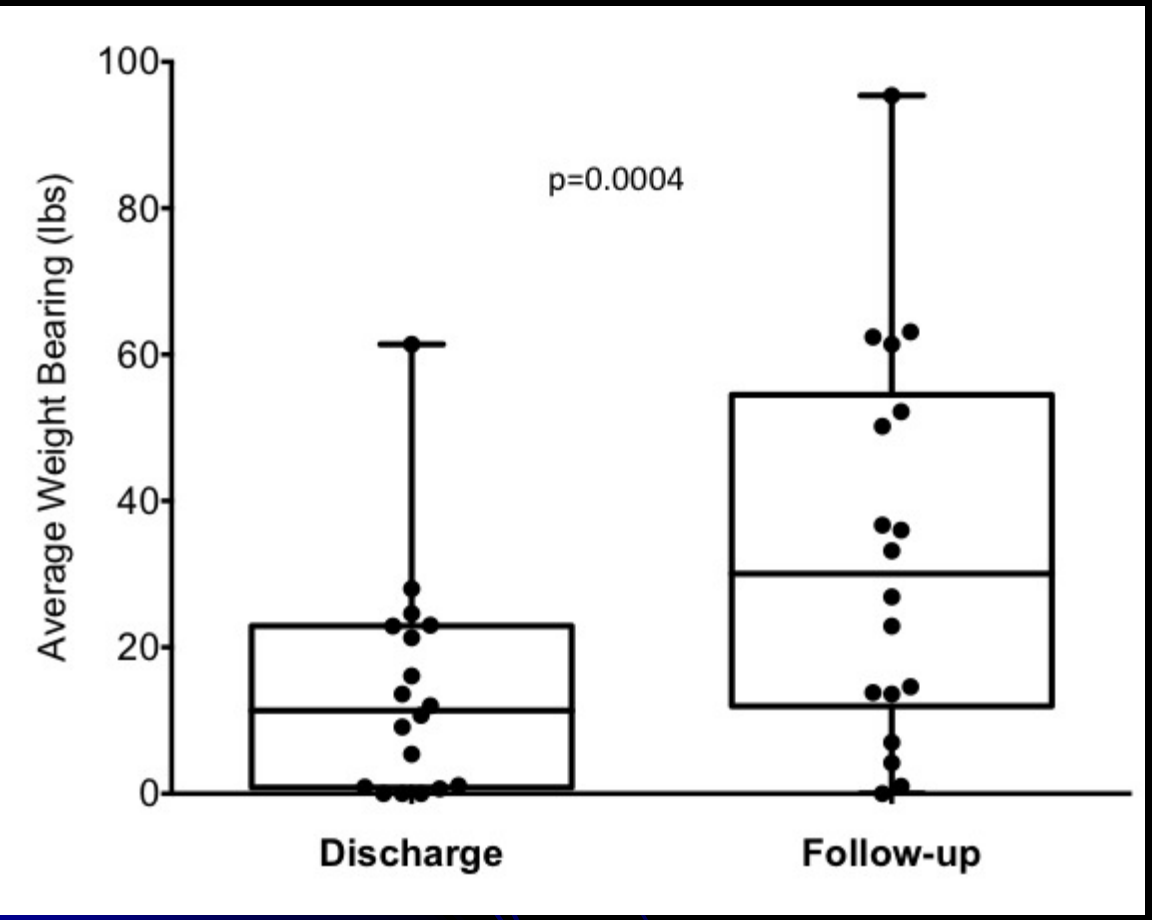



**Figure 2:** Box-and-whisker plots of the patients' average weight bearing at discharge and at follow-up. The individual patients' averages are shown as black dots. The horizontal lines inside the boxes represent the median, the box edges show the lower and upper quartiles, and the whiskers show the minimum and maximum values. The *P* value is comparing the 2 means via a paired *t* test.

Ruiz et al. Patient compliance with postoperative lower extremity touch-down weight-bearing orders at a level I academic trauma center. *Orthopedics.* 2014

# Visualizing Individual Differences

z-scores for individual scores in comparison to normative values

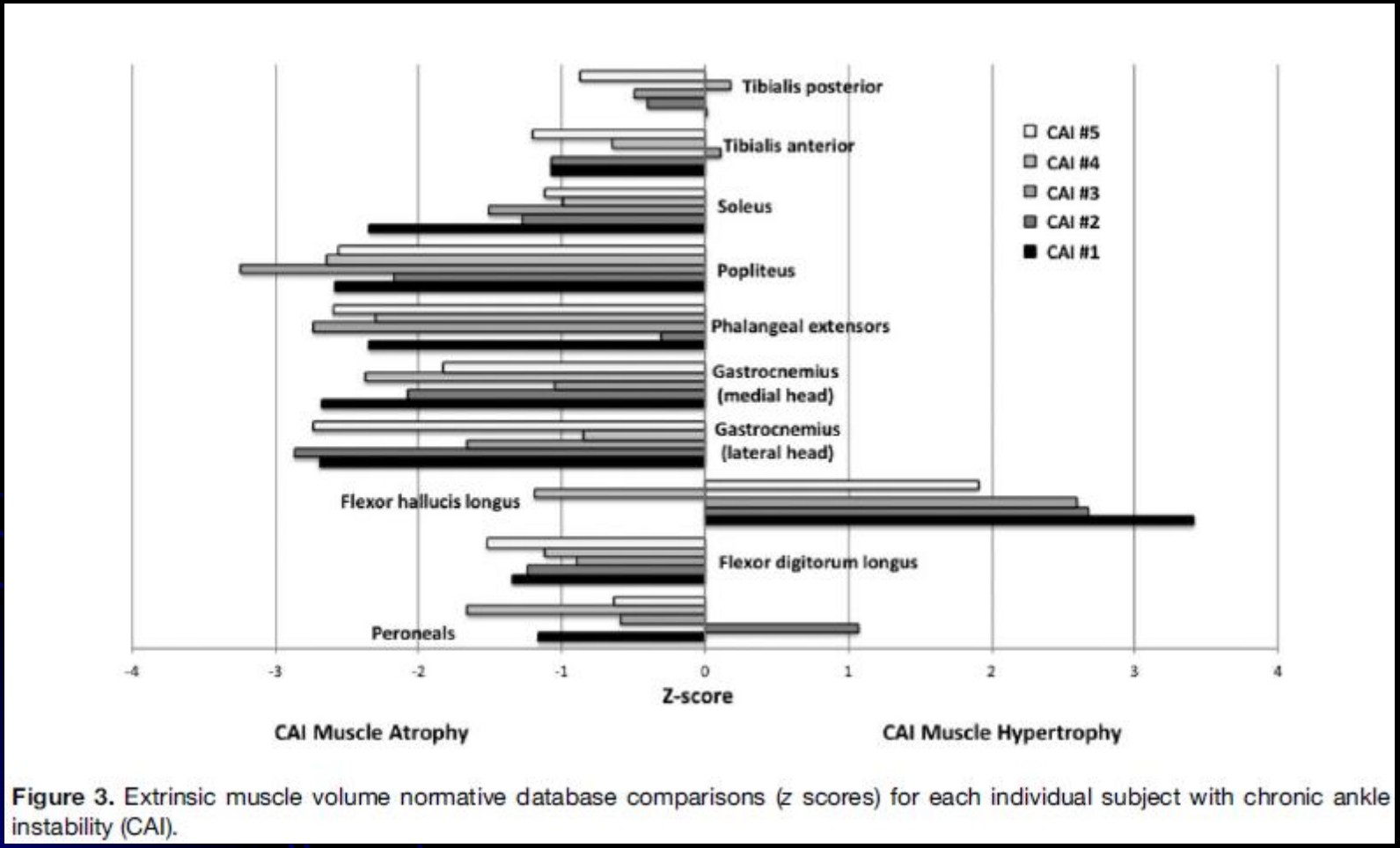



**Figure 3.** Extrinsic muscle volume normative database comparisons (z scores) for each individual subject with chronic ankle instability (CAI).

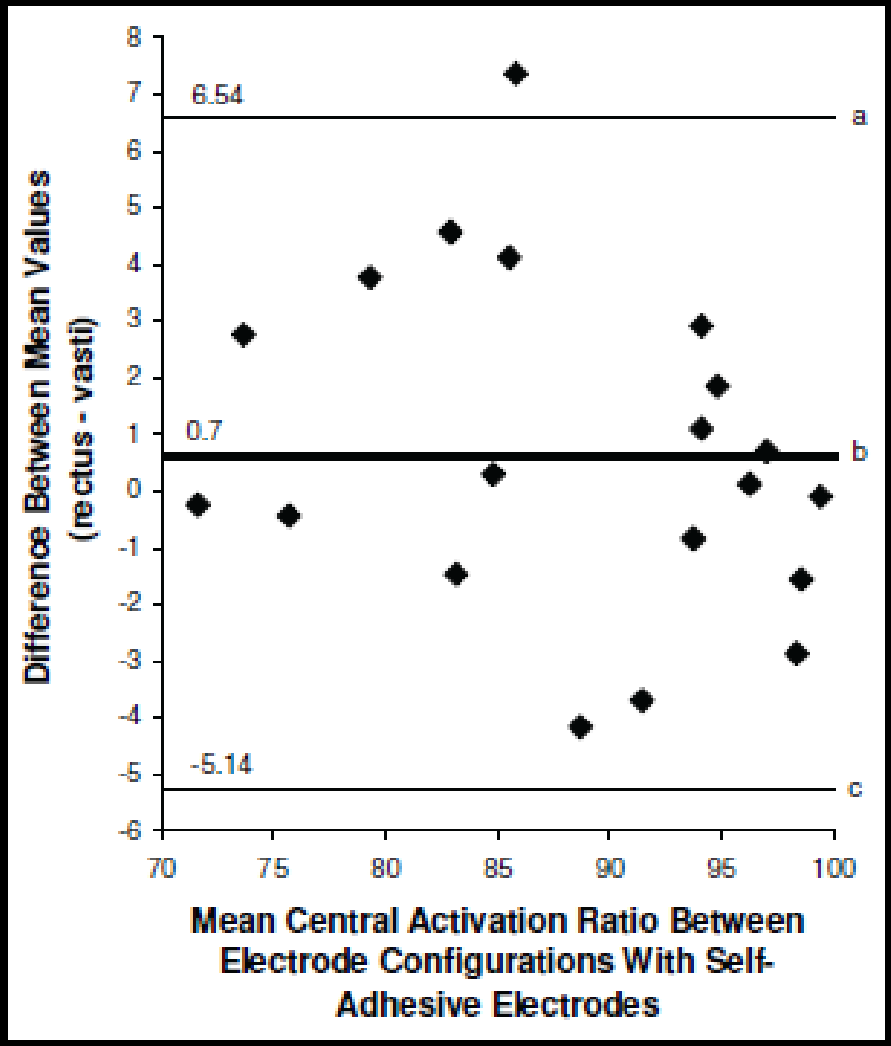
Feger et al. Diminished foot and ankle muscle volumes in young adults with chronic ankle instability. *Orthop J Sports Med*. 2016

# BLAND-ALTMAN PLOT

Graphing of individual scores in reliability studies

X-axis: mean of 2 measures

Y-axis: difference between two measures




- Pietrosimone et al. Electrode type and placement configuration for
- quadriceps activation evaluation. *JAT*. 2011

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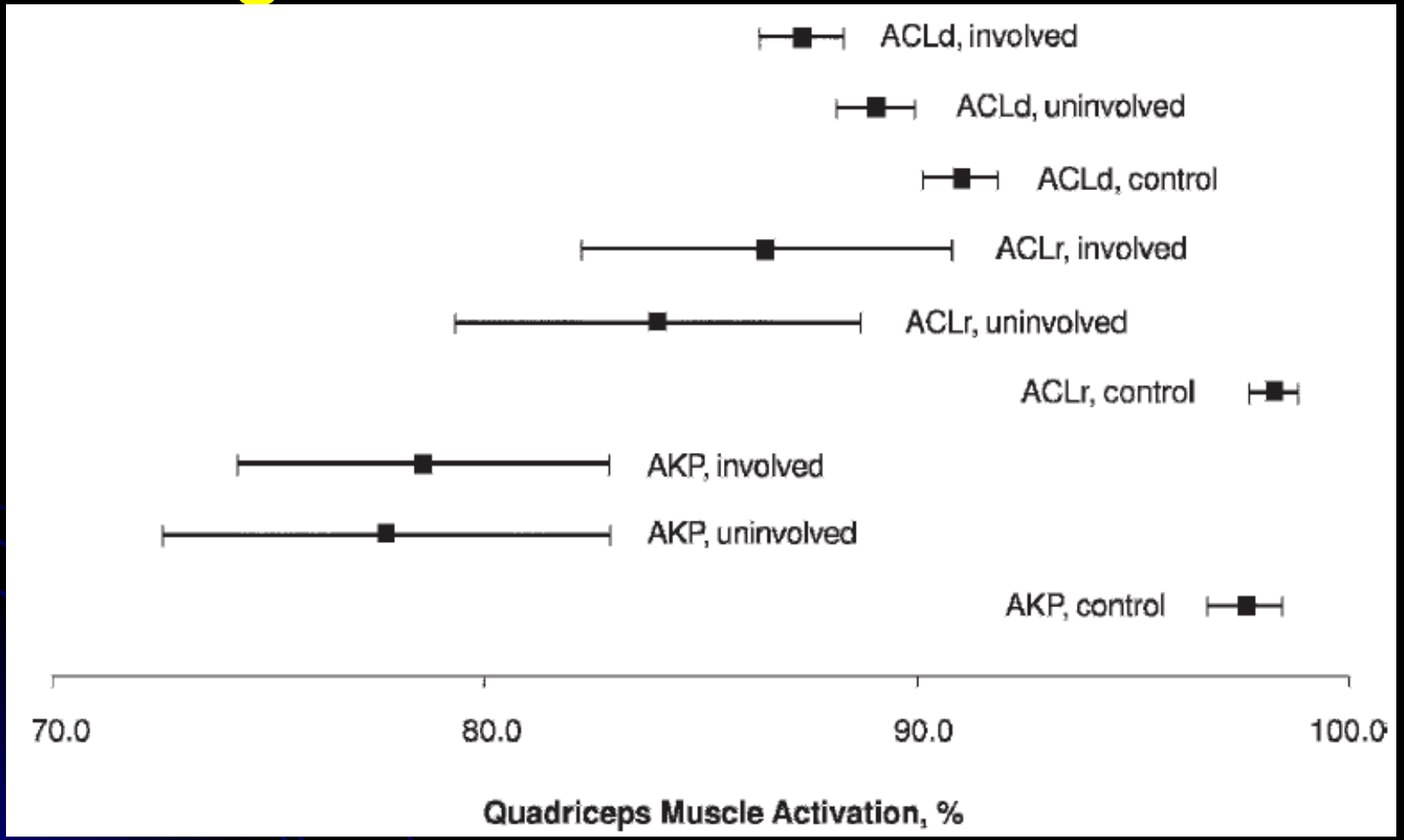
# Reporting and Interpreting Magnitudes of Difference

- If the unit of measure is easy to clinically interpret, reporting the *mean difference* is appropriate
  - ie, degrees of motion, cm of vertical jump,…

- If unit of measure is **NOT** easy to clinically interpret OR the goal is to compare the magnitude of change across multiple different measures, reporting a standardized *effect size* is appropriate
  - Cohen's *d*, Hedges *g*,…

# Visualizing Means: Weighted Means Forest Plot




Hart et al. Quadriceps activation following knee injuries: a systematic review. *JAT*, 2010

# Visualizing Mean Differences: Meta-analysis Forest Plot

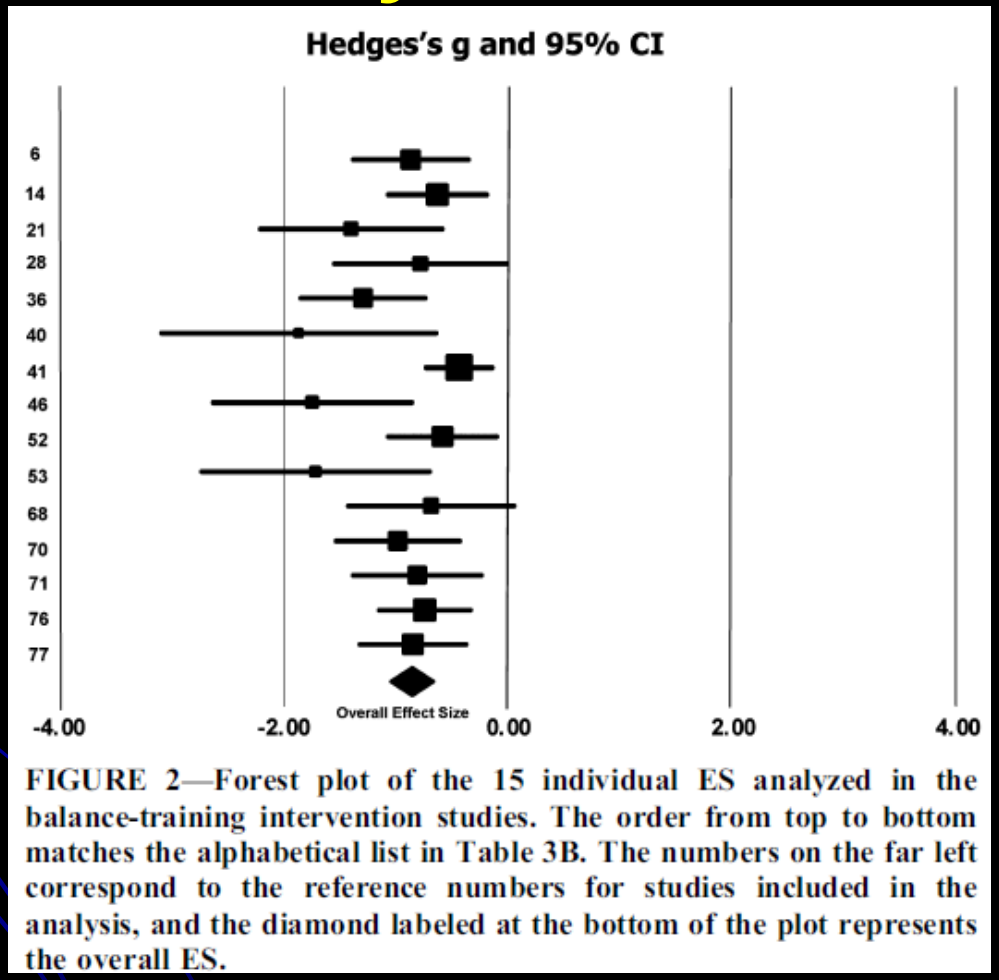



FIGURE 2—Forest plot of the 15 individual ES analyzed in the balance-training intervention studies. The order from top to bottom matches the alphabetical list in Table 3B. The numbers on the far left correspond to the reference numbers for studies included in the analysis, and the diamond labeled at the bottom of the plot represents the overall ES.

Wikstrom et al. Balance capabilities after lateral ankle trauma and intervention: a meta-analysis. *MSSE*, 2009

# Heat maps: Effect sizes

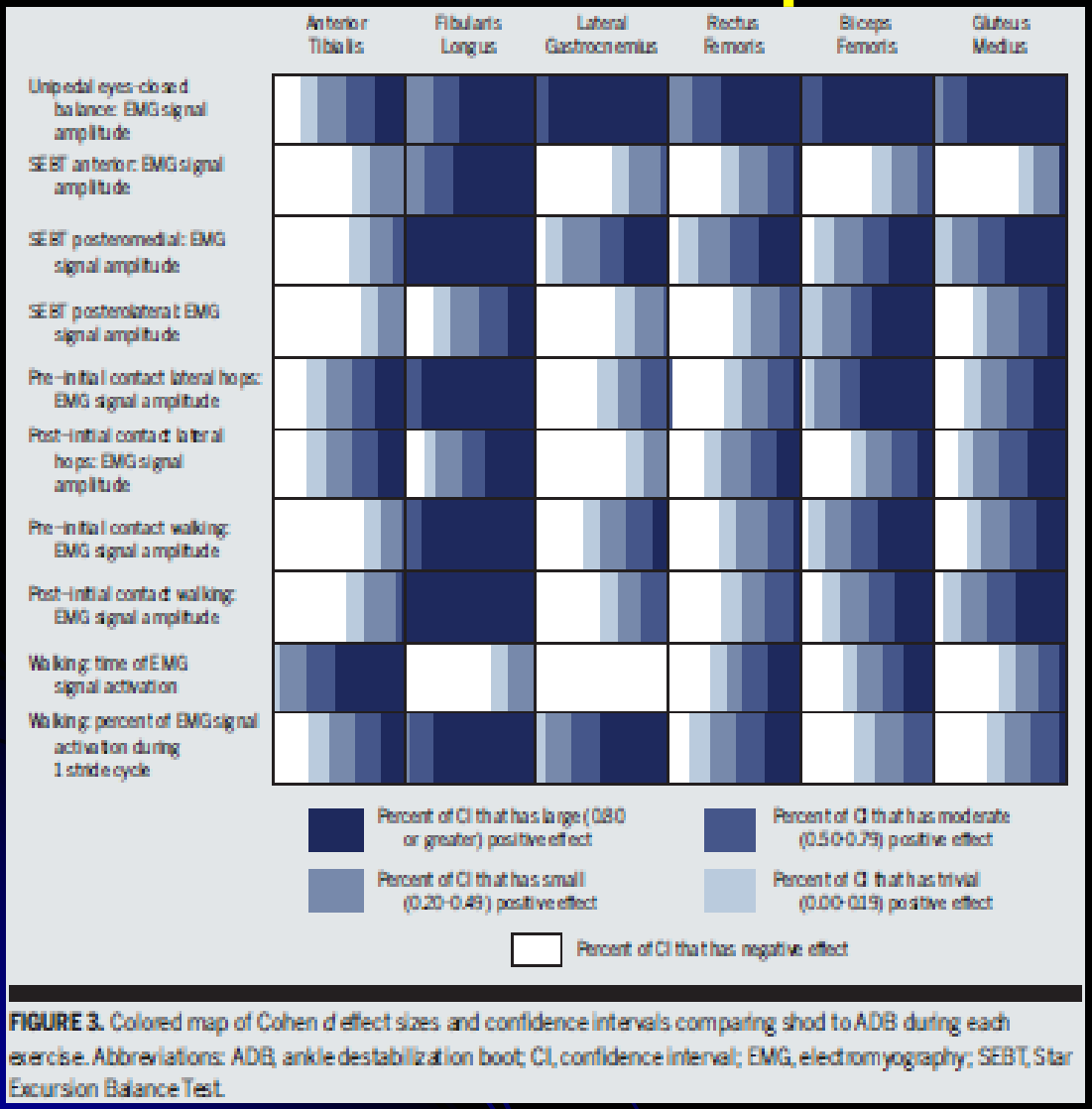
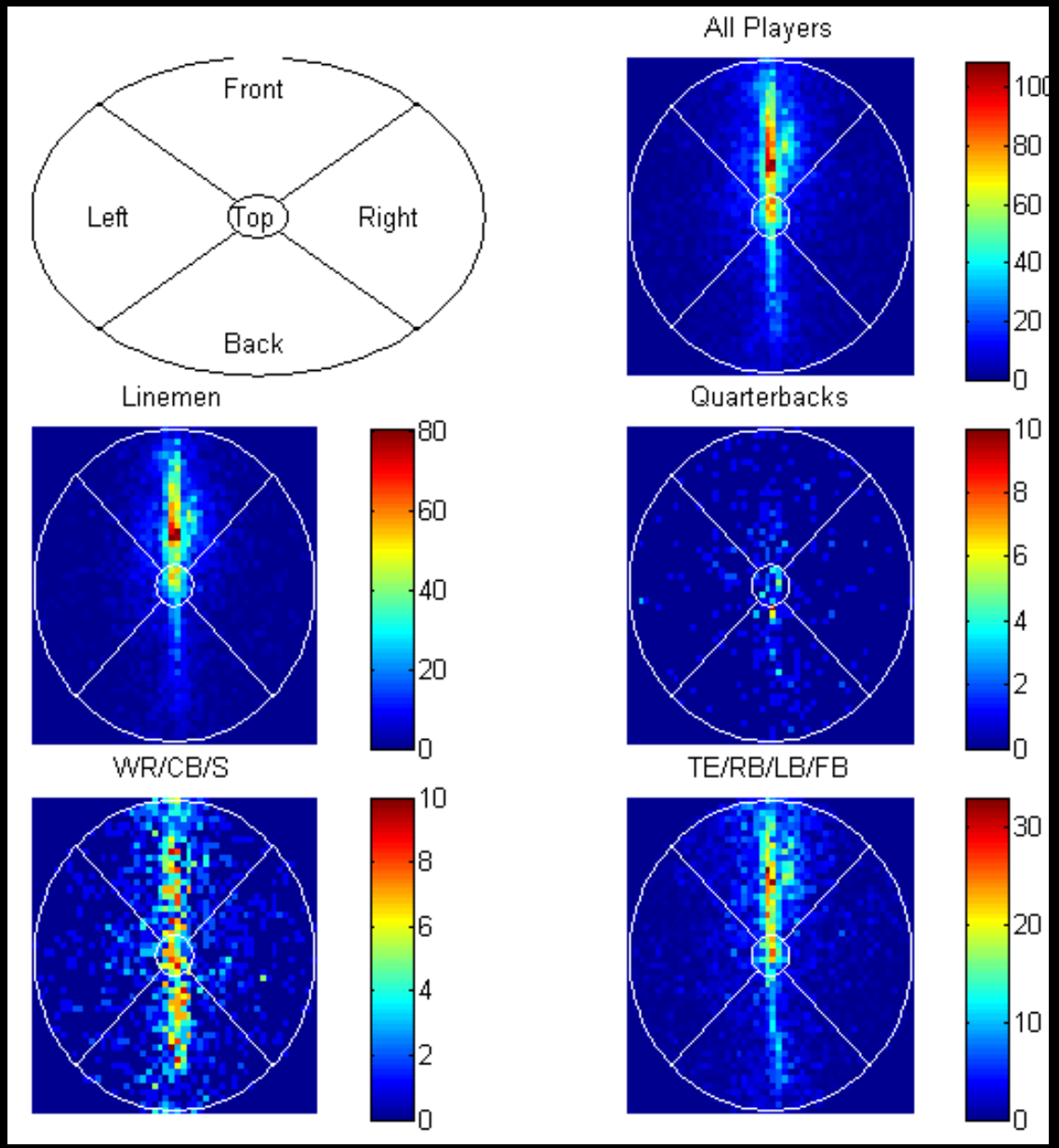



**FIGURE 3.** Colored map of Cohen *d* effect sizes and confidence intervals comparing shod to ADB during each exercise. Abbreviations: ADB, ankle destabilization boot; CI, confidence interval; EMG, electromyography; SEBT, Star Excursion Balance Test.


Donovan et al. Effects of 2 ankle destabilization devices on EMG measures during functional exercises in individuals with chronic ankle instability. *JOSPT*, 2015

# Heat maps: Density of Head Impacts

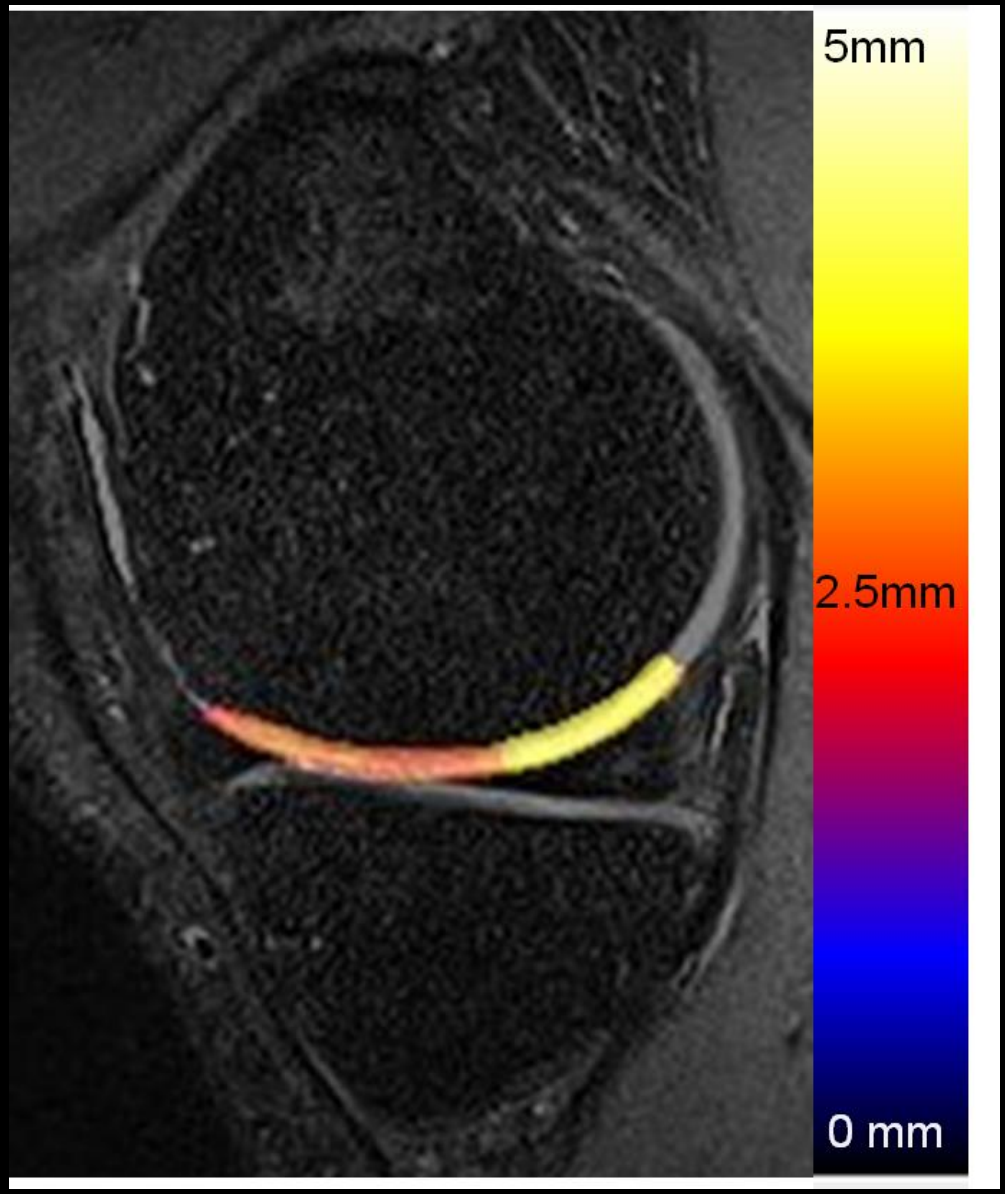
- Image courtesy of Steve Broglio (in press JAT)



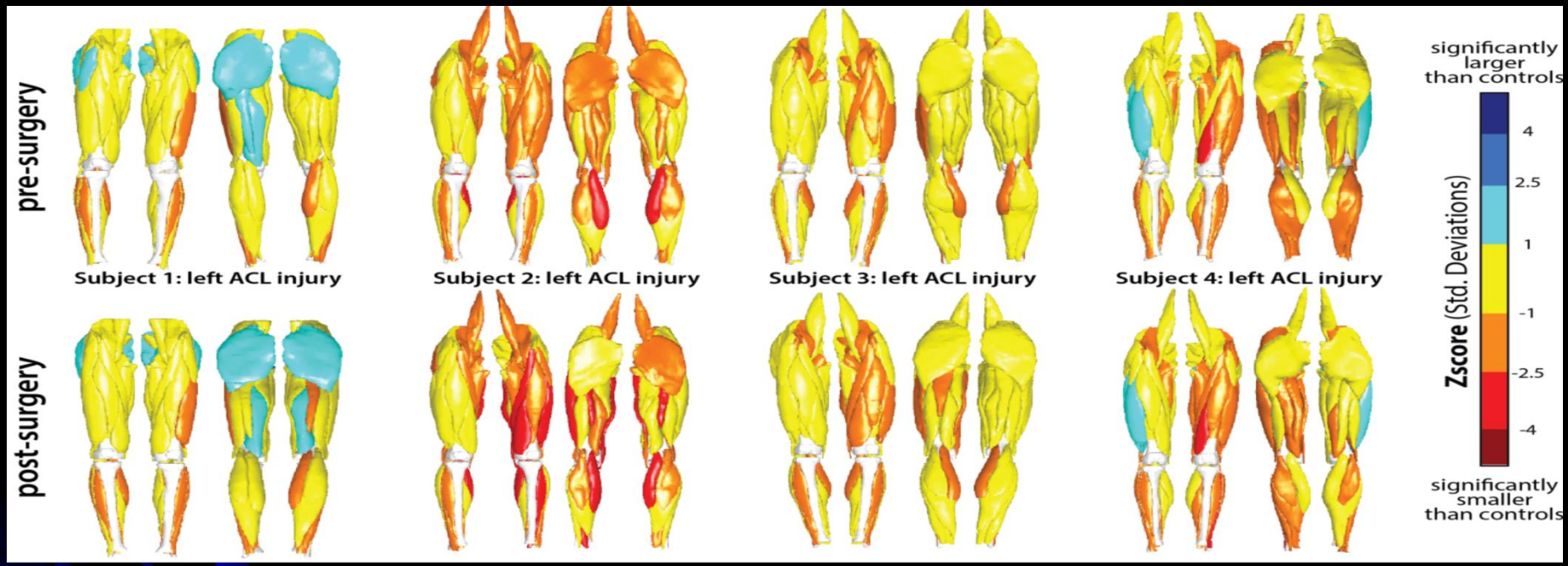
# Heat maps

Heat map of cartilage thickness

Image courtesy of Randy Schmitz (being presented this week)



# Heat maps: Muscle Volume




Heat map of  muscle volume pre and post ACLR compared to normative values

Image courtesy of Joe Hart (being presented this week)

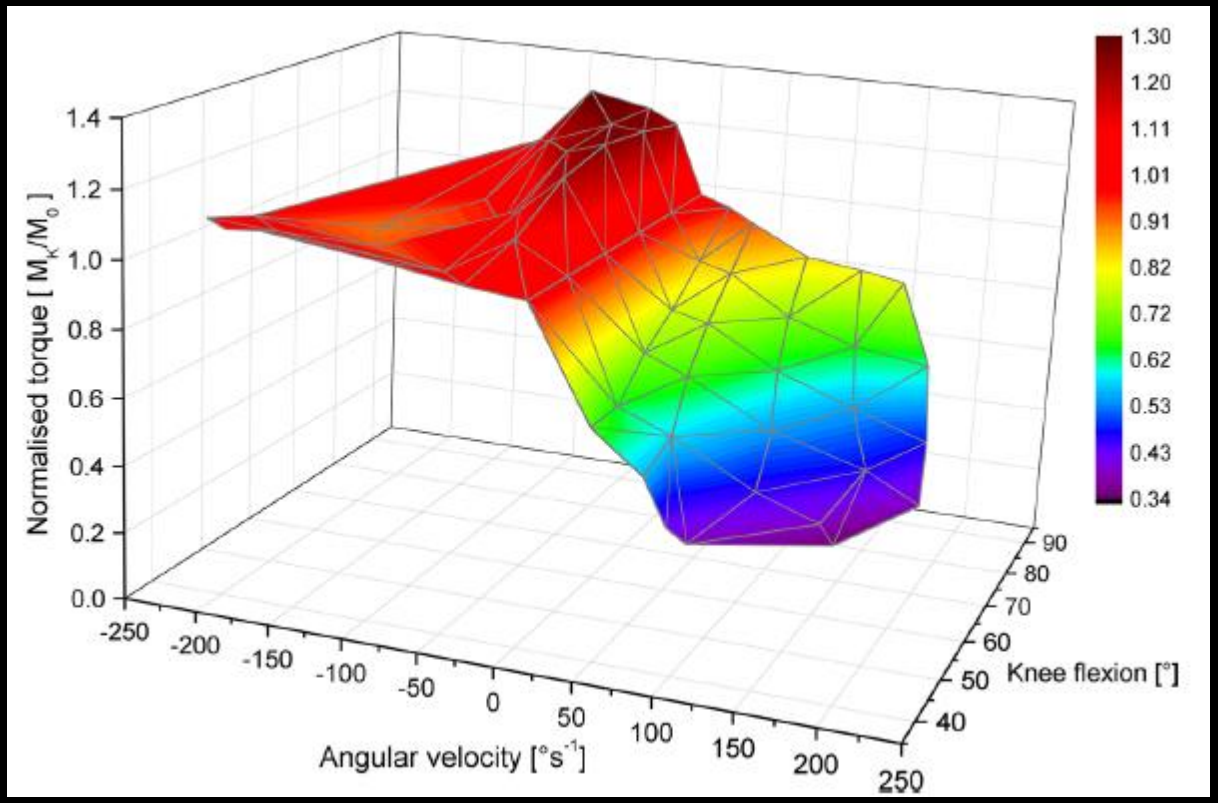
# Heat maps

Muscle activation with short foot exercises in the intrinsic foot muscles

(Gooding et al, *JAT*, in press)

# 3D Heat maps

**Fig. 5** Three-dimensional torque–angle–angular velocity relation from group data to indicate the interdependence of normalised knee joint torque (*y*-axis), joint angle (*z*-axis), and angular velocity (*x*-axis). Positive *x* values represent concentric and negative values eccentric muscle action. All data points have been normalised to their corresponding angle-specific isometric maximum and the colour scale indicates normalised knee joint torque. Knee flexion of 0° refers to the straight leg




Hahn et al. Interdependence of torque, joint angle, angular velocity and muscle action during human multi-joint leg extension. *Eur J Appl Physiol.* 2015.

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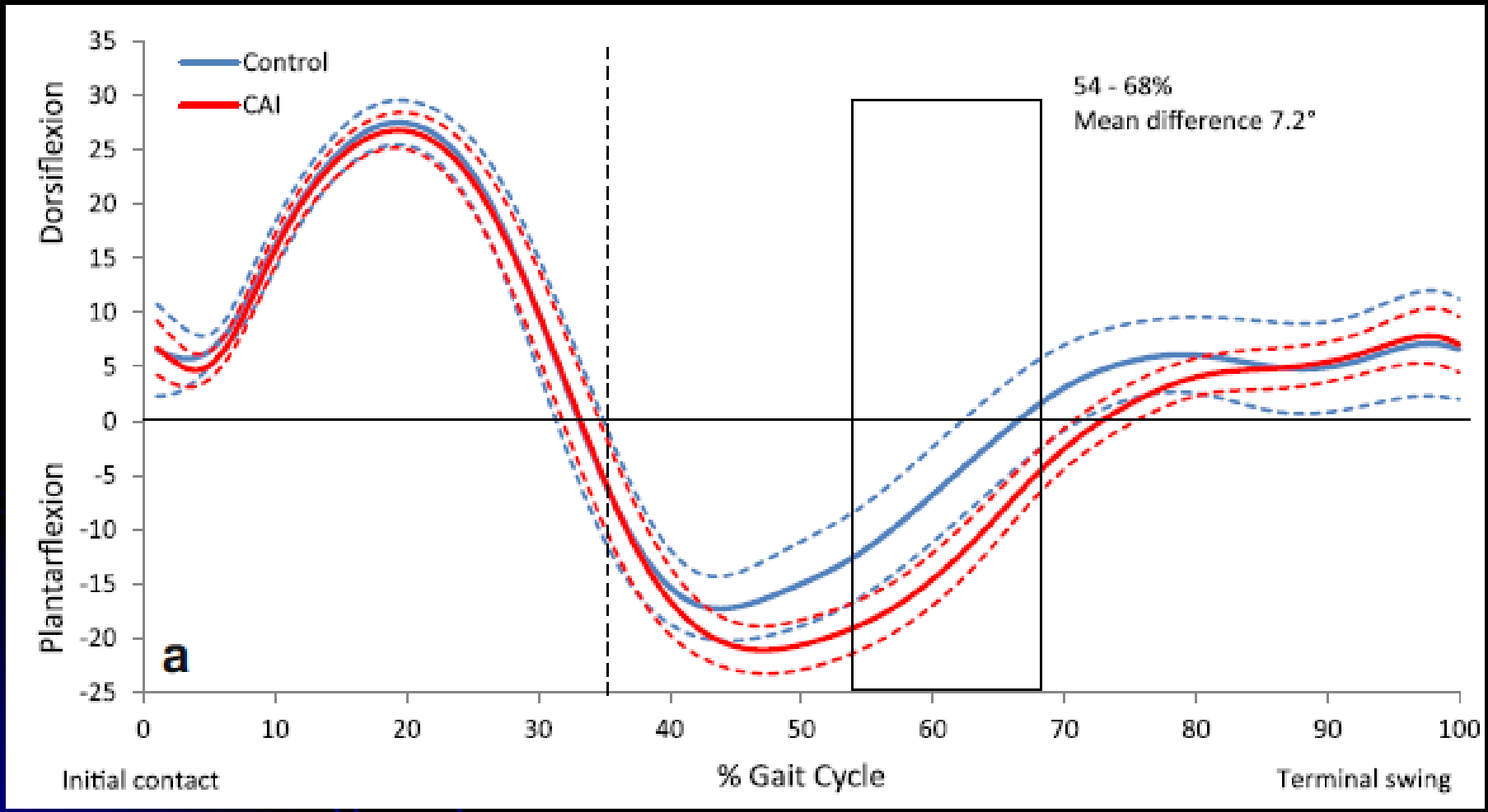
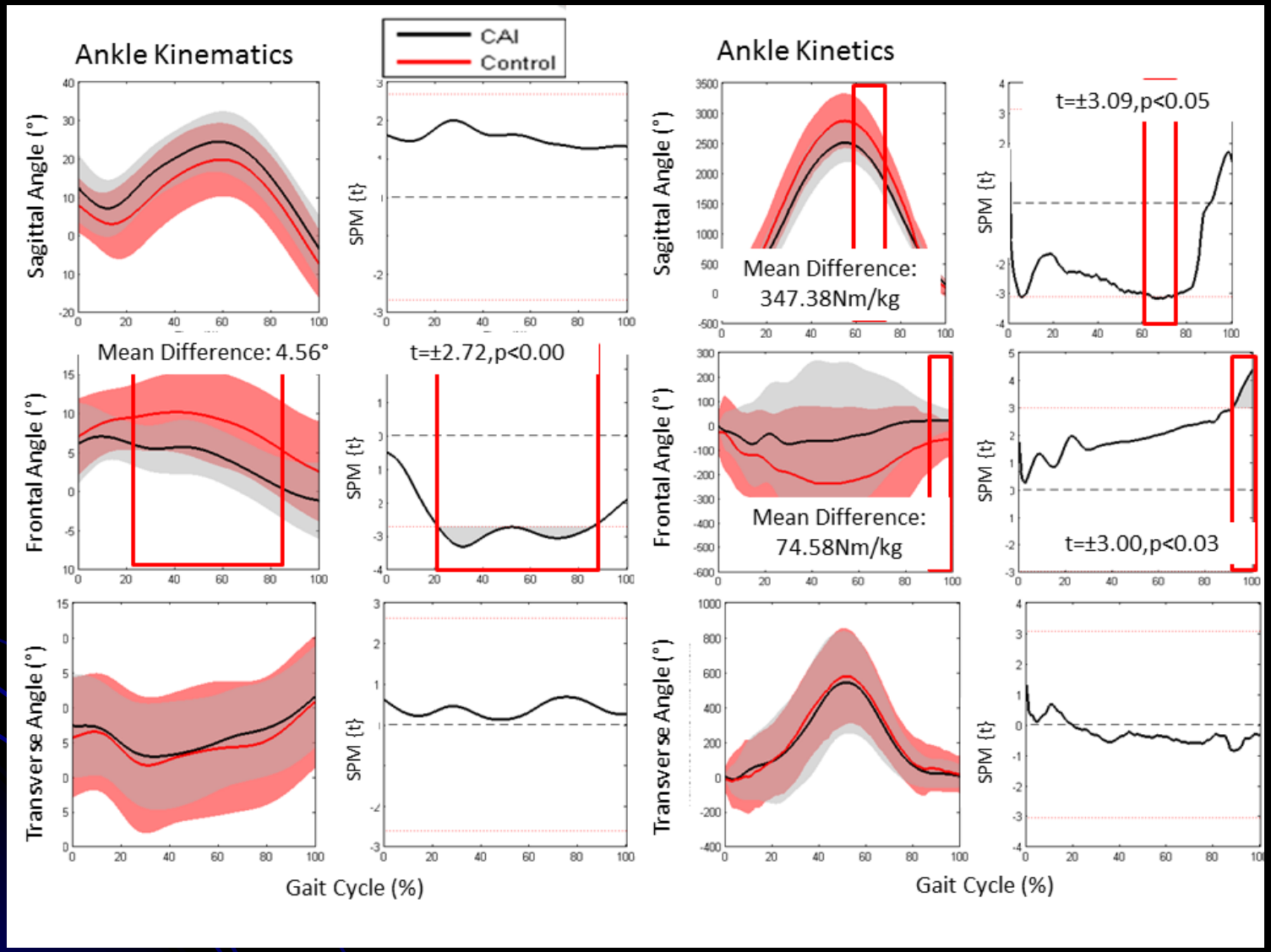
# CONFIDENCE INTERVAL GRAPHS OVER TIME




- Chinn et al. Ankle kinematics of individuals with chronic ankle instability while walking and jogging on a treadmill in shoes. *Phys Ther Sport*. 2013

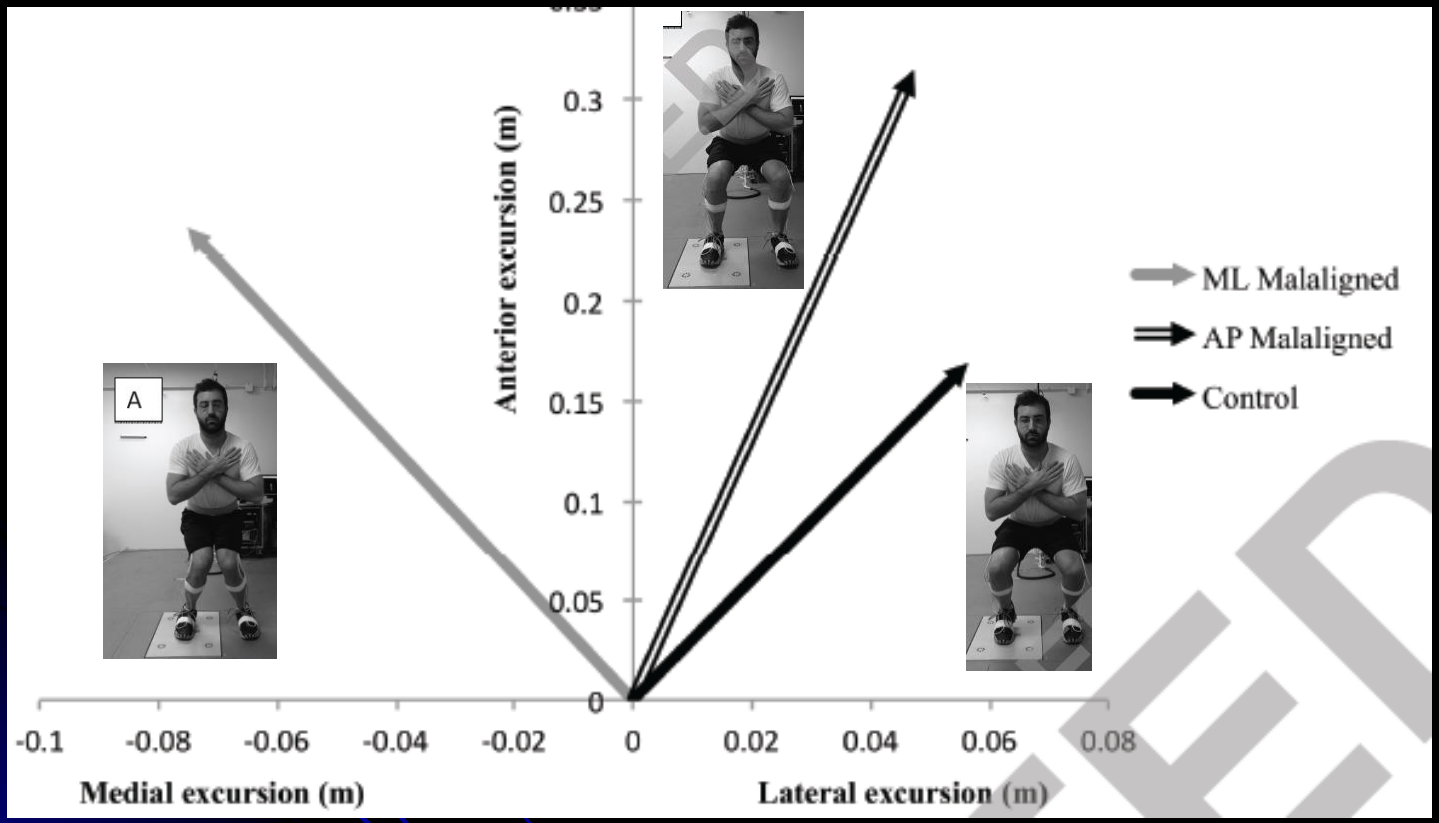
# STATISTICAL PARAMETRIC MAPPING




CAI vs. Healthy Ankle Mechanics in Jogging.

Image courtesy of Collin Herb

# 2-D Motion Vector Graph

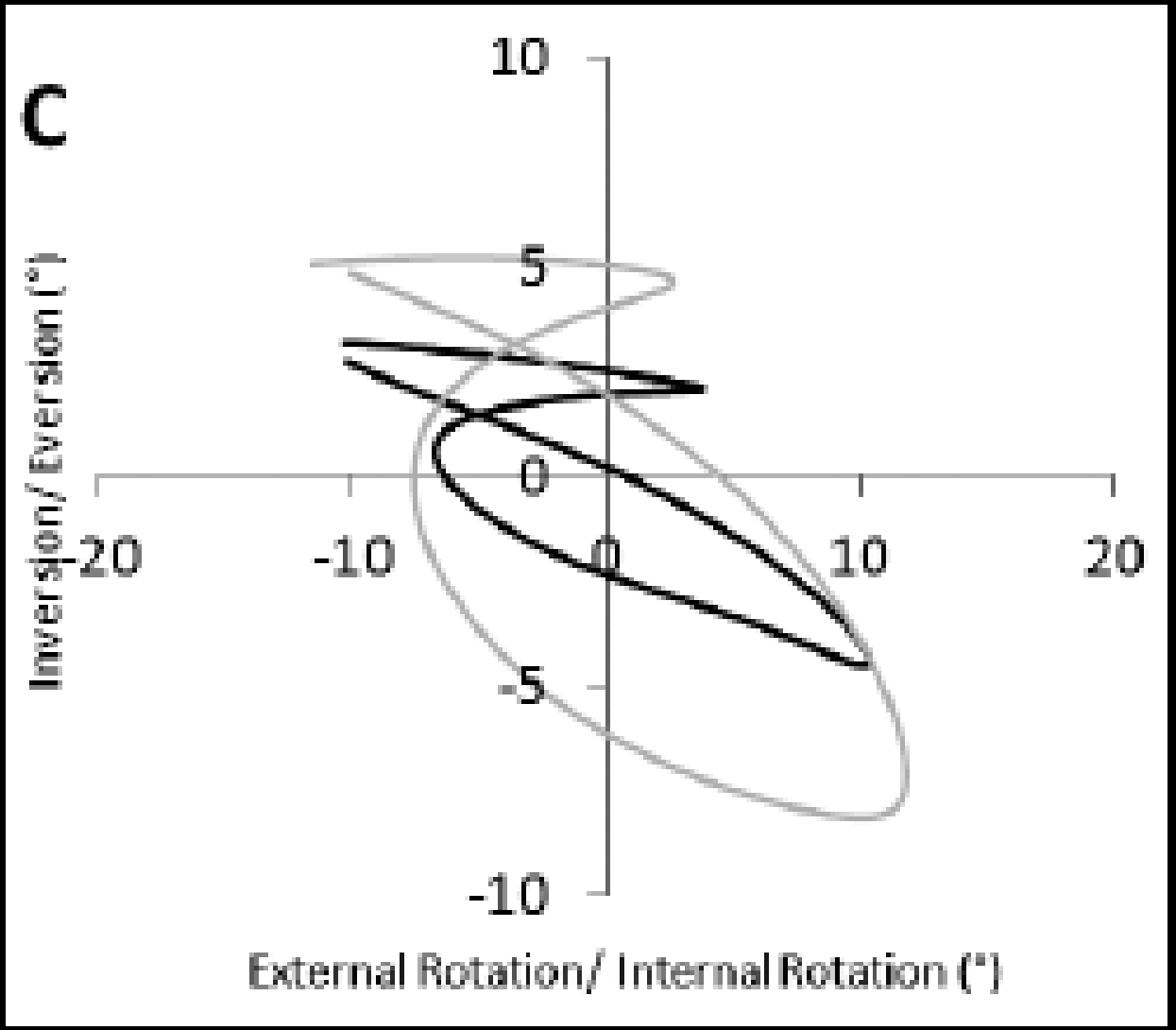



Peak knee joint excursion from full knee extension at the beginning of the squat.

Slater et al. Muscle activation patterns during different squat techniques. *J Strength Conditioning Res*. (in press)

# ANGLE-ANGLE PLOTS

Visualize motion in two planes simultaneously




Herb et al. Shank-rearfoot joint coupling with chronic ankle Iinstability. *J Appl Biomech*. 2014

# RADAR GRAPHS (aka K-Flakes)

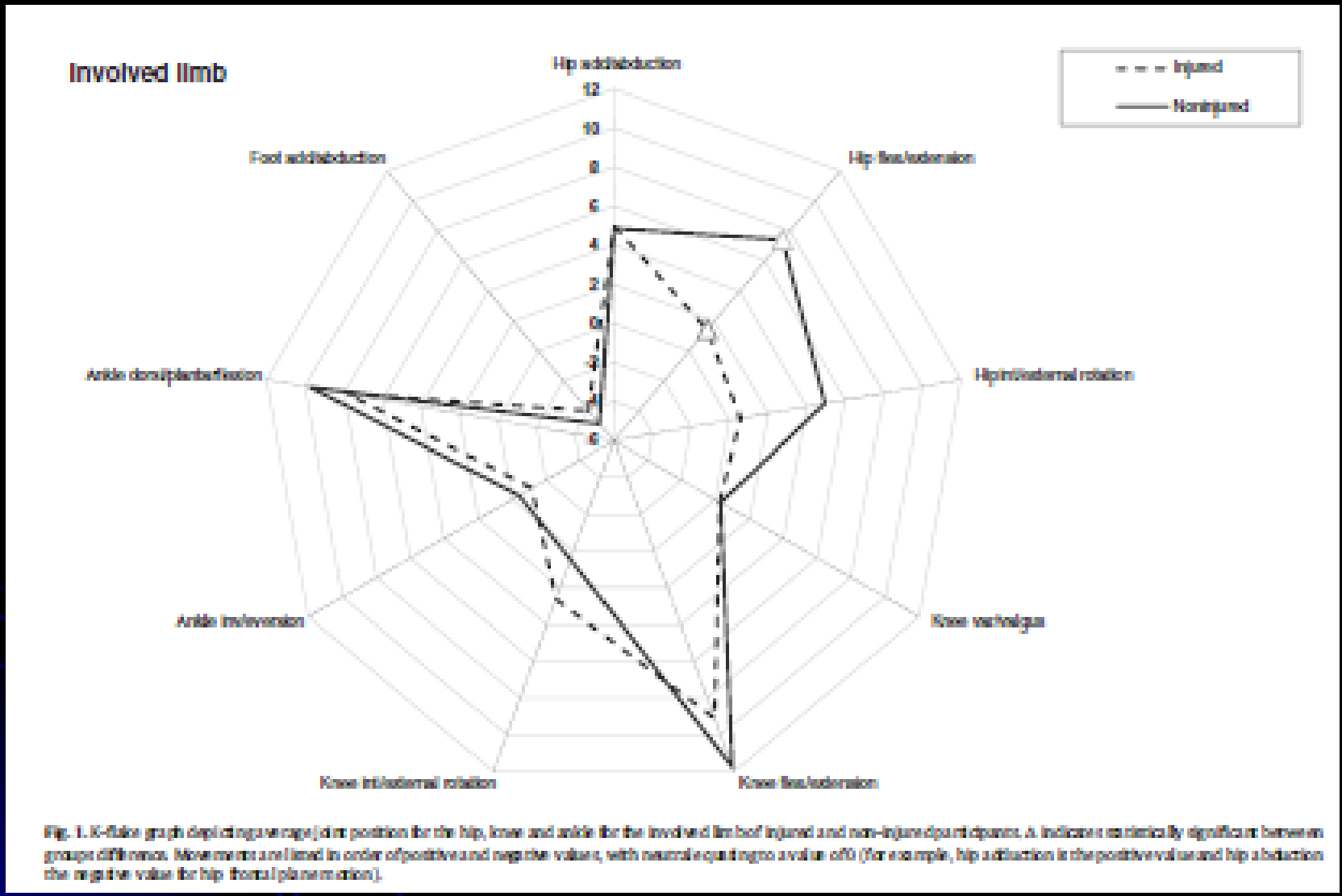



Fig. 1. K-flake graph depicting average joint position for the hip, knee and ankle for the involved limb of injured and non-injured participants. A indicates statistically significant between groups difference. Movements are listed in order of positive and negative values, with neutral equating to a value of 0 (for example, hip adduction is the positive value and hip abduction the negative value for hip frontal plane motion).

Doherty et al. Postural control strategies during single limb stance following acute lateral ankle sprain. *Clin Biomech*. 2014

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# TIME TO EVENT GRAPH (SURVIVAL ANALYSIS)

When did injuries occur in two different groups?

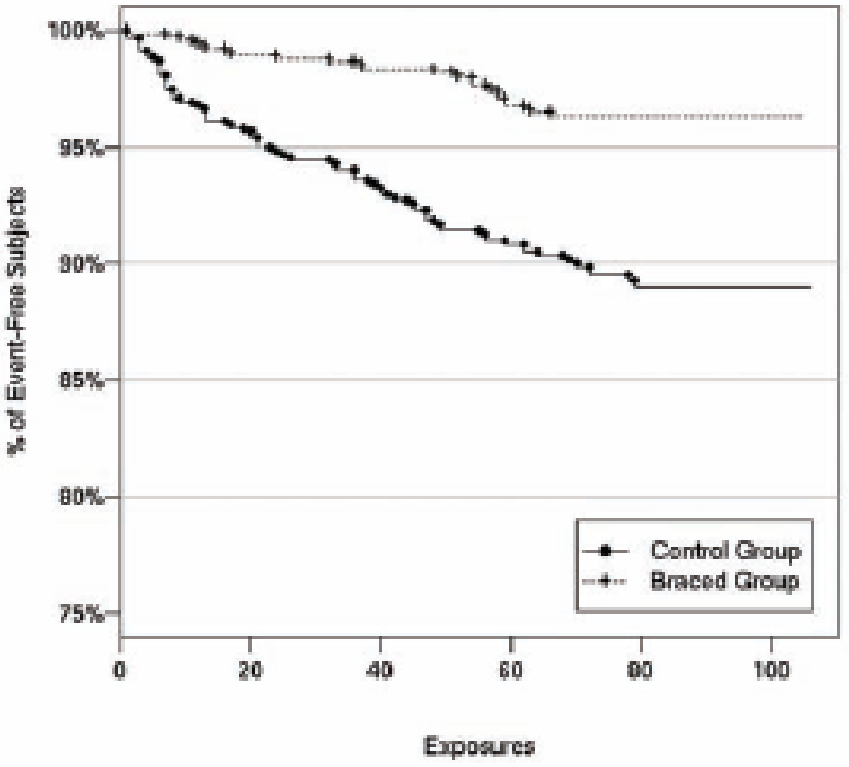
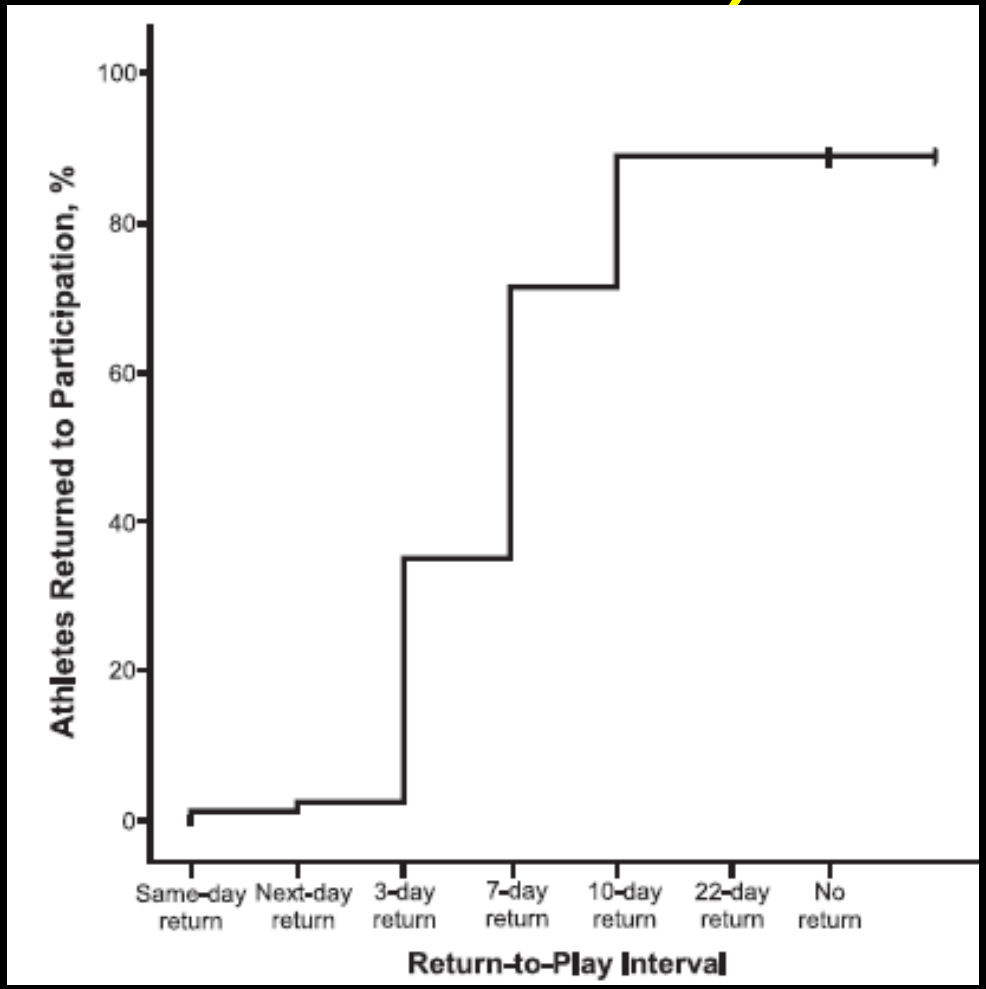



**Figure 3.** Percentage of acute ankle injury–free participants over time. Dots (controls) and crosses (braced) show times (number of exposures) of first injury.

- McGuine et al. Effect of lace-up ankle braces on injury rates in high school basketball players. *Am J Sports Med*. 2011

# TIME TO EVENT GRAPH (SURVIVAL ANALYSIS)

What is the probability of return to play after injury?




Medina McKeon et al. Trends in concussion return-to-play timelines among high school athletes from 2007-2009. *JAT*. 2013

# TIME TO EVENT GRAPH (SURVIVAL ANALYSIS)

When was a critical threshold in tissue temperature reached with two different cryotherapy treatments?

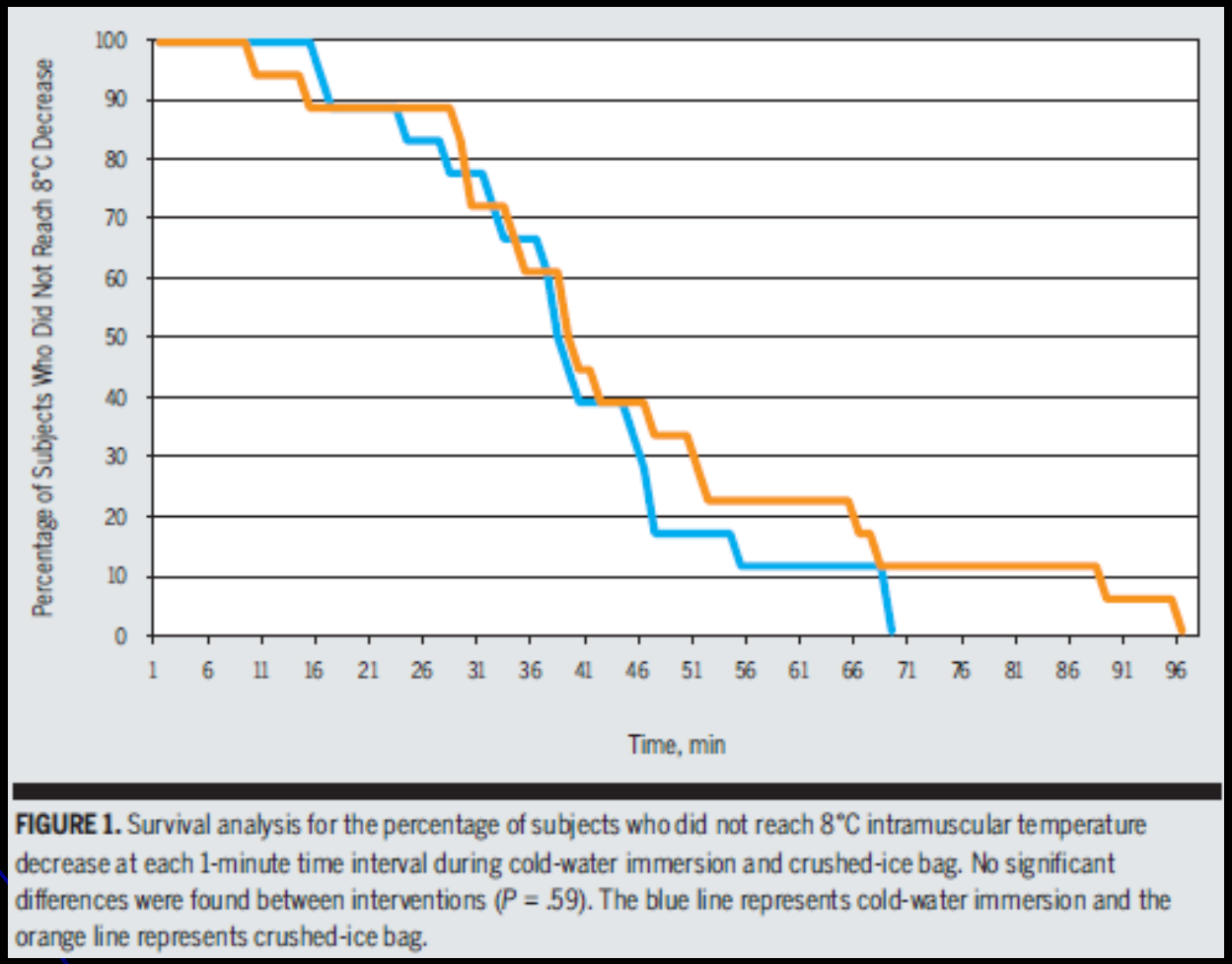



**FIGURE 1.** Survival analysis for the percentage of subjects who did not reach 8°C intramuscular temperature decrease at each 1-minute time interval during cold-water immersion and crushed-ice bag. No significant differences were found between interventions ($P = .59$). The blue line represents cold-water immersion and the orange line represents crushed-ice bag.

Rupp et al. Intramuscular temperature changes during and after 2 different cryotherapy interventions in healthy individuals. *JOSPT*. 2012

# RECEIVER OPERATOR CURVE (ROC)

Identify optimal cutoff scores for diagnostic tests based on sensitivity and specificity

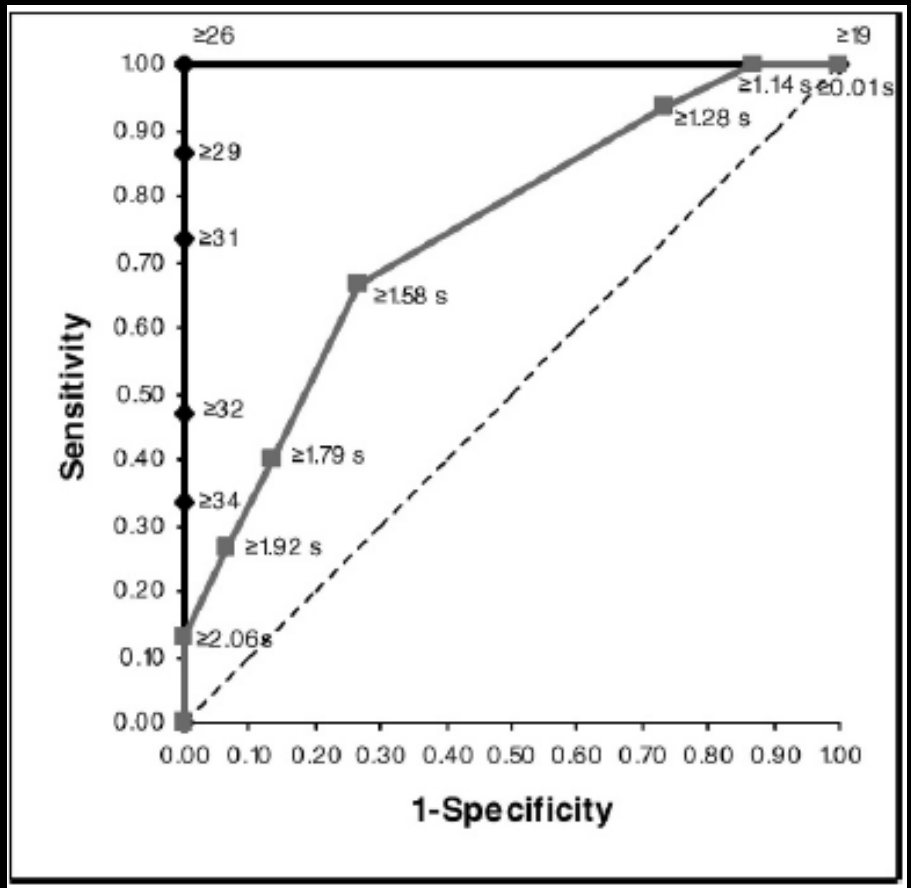
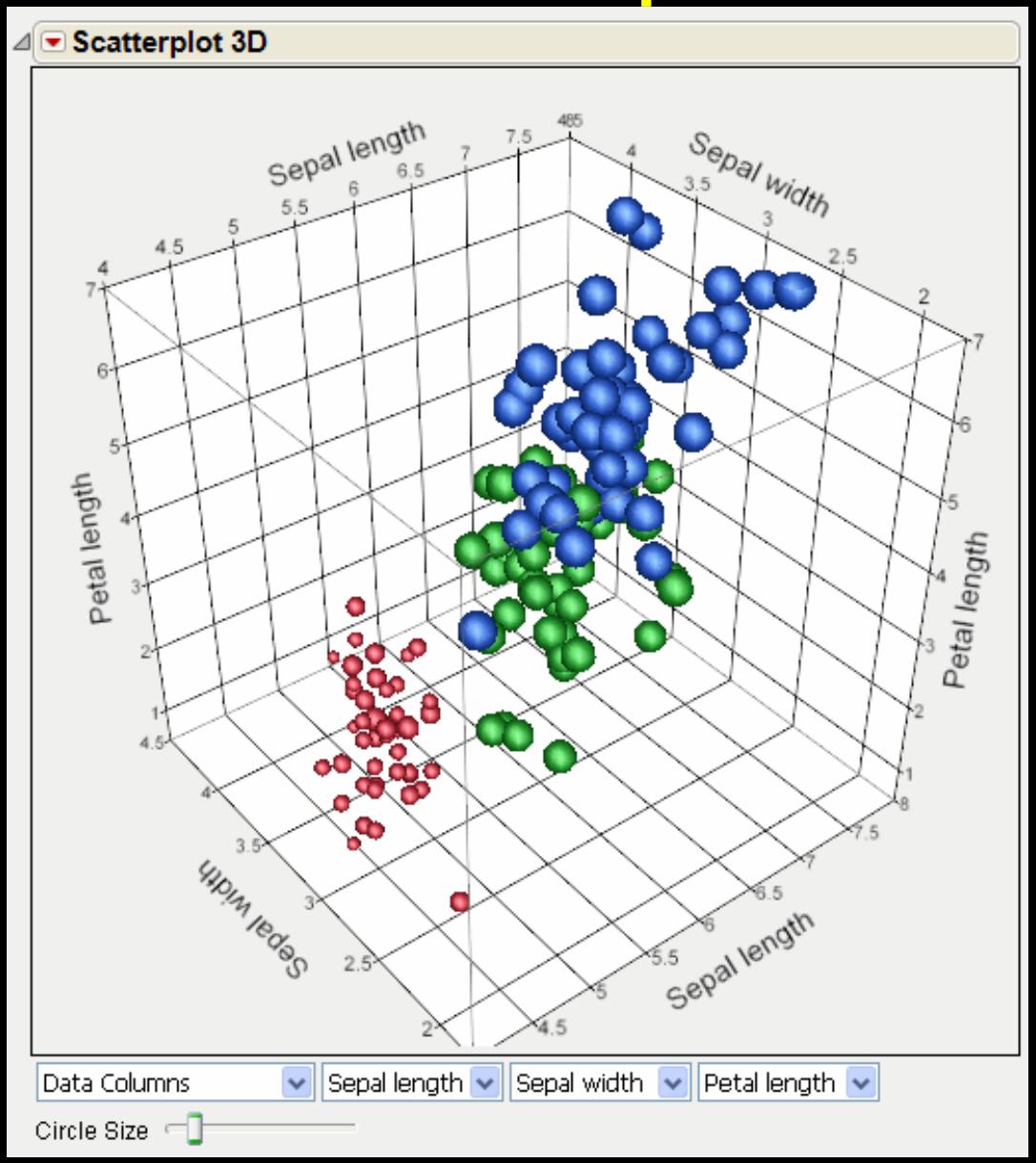



Figure 1. Receiver operating characteristic (ROC) curve. The ROC curve for the Ankle Joint Functional Assessment Tool is the black line running vertically from points 0,0 to 0,1 and then horizontally from points 0,1 to 1,1. The ROC curve for resultant vector time to stabilization is the grey line.

- Ross et al. Assessment tools for identifying functional limitations associated with functional ankle instability. *JAT*. 2008

# 3D Scatter plots

- Simultaneous graphing of 3 different measures
- Ability to rotate the graph to look at from different angles
- Variety of software programs & websites to do this



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# Reviewer Recommendations

- Does the figure best explain the results for the reader?

- Points of emphais:
  - Illustrate Individual scores
  - Demonstrate magnitude of differences
  - Show multiple outcomes simultaneously

- Think in color

# THANK YOU

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@Jay_Hertel

- http://gravyanecdote.com/category/blog/makeovermonday/