Utilizing Technology to Identify and Treat Movement Impairments Related to Sports Injury

Amy M. Krahe, PT, MPT, OCS

Overview

Amy M. Krahe, PT, MPT, OCS
• Describe the influence of biomechanics on injury risk
• Discuss effective techniques to enhance motor learning and improve the potential for transfer to sport

Malinda Bragg-Coldsnow, PT, MS
• Review the kinetic link
• 2D and 3D video technology and applications

Lori Ross, PT, MPT
• Pressure biofeedback and level belt technology
• 2 Case Studies

Objectives

1. Describe the influence of biomechanics on injury risk in the young athlete

2. Discuss effective interventions to enhance motor learning and improve the potential for transfer to sport
The Influence of Biomechanics on Injury Risk in the Young Athlete

ACL Injury Risk

- Greater knee abduction angles at IC and max displacement
- Greater peak knee abduction moment (KAM)
- Significant side to side differences in KAM

Knee abduction moments predict ACL injury risk with 78% Sn and 73% Sp

Hewett TE, Myer GD, Ford KR et al. 2005

Knee Injury, Ligament Injury and ACL Injury Risk

- Trunk displacement greater in athletes that sustained knee, knee ligament and ACL injury

Lateral trunk displacement predicted ligament injury in females with 100% Sn and 72% Sp

Zazulak BT, Hewett TE, Bennet NF et al. 2007
Youth Pitching Mechanics and UE Injury Risk

- Greater max shoulder ER angle
- Greater proximal shoulder force

Improper sequencing of pelvis and upper torso increased shoulder and elbow injury risk

Oyama S, Blackburn J, Padua R et al. 2014

Lead foot position and angle

- Open foot angle
- Open foot position

May effect UE kinetics by rotating the pelvis too early and increase shoulder and elbow injury risk

Fortenbaugh B, Fleisig G, Andrews J 2009
Fleisig G, Andrews J, Dillman C et al. 1995

Biomechanics Influence Injury Risk in the Young Athlete

- Studies have demonstrated a relationship between biomechanics, neuromuscular control and injury risk in the adolescent athlete
- Youth identified as high injury risk are more likely to sustain a non-contact injury
Motor Learning
The Acquisition of a Motor Skill

- Focus of Attention
- Observational Practice
- Feedback
- Self-Controlled Practice

Focus of Attention

External Focus of Attention
Internal Focus of Attention

Internal Focus (IF)
directs focus on the movements of body

External Focus (EF)
directs focus to the effect of the movement
External Focus of Attention

- Accelerates learning process by facilitating movement automaticity
- Enhances effective motor patterns (accuracy, balance)
- More efficient movement patterns
- Improves retention and transfer of motor skill to sport
- Distance effect increases effect of EF

Observational Practice

- Visual system is powerful
- Enhanced when combined with physical practice
- Dyad training may be superior to training alone
- Video demonstrations

Feedback

- Emphasis on successful trials or motivational feedback more effective
- Normative feedback with positive comparisons to peers increase motivation
- Motivation has a positive influence on learning
- Real-time visual feedback optimizes movement patterns
Self-Controlled Practice

- Improves motivation and learning
- Athlete may request frequency of feedback
- Encourages active participation in training and planning

Technology in the Clinic

Malinda Bragg-Coldsnow, PT, MS

- Review the kinetic link
- 2D and 3D video technology and applications

UE Injury Risk References


LE Injury Risk References


Motor Learning References


Wulf D. Increased jump height with an external focus due to enhanced sensor-motor processes.
Utilizing Technology to Identify and Treat Movement Impairments Related to Sports Injury

Malinda Bragg-Coldenow, PT, MS, CAFS, CPI, CKTP
Akron Children’s Hospital, Sports Rehab

Objectives

- Technology in the Clinic
  - 2D: What is it and what can it do.
    - Coach’s Eye
    - Dartfish
    - Slow motion
  - 3D: How we use it and why we use it.
    - Kinetic link stabilization
    - Graphs
    - Video samples

Technology Use to Help Evaluate Sports and Sports Injuries

- Slow Motion Technology
  - Cameras
  - Coaches eye app
  - i-pad technology
  - i-phone or i-pad
  - Dartfish
  - Software package/bundles

- 3D Analysis
  - High tech labs
  - Individual packages
  - Bio-medical, bio-mechanical engineers
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BASEBALL PITCH
...REAL TIME

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2D ANALYSIS OF 2 SPRINTER SLOW MOTION
(1 COLLEGE / 1 PROFESSIONAL)

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COACHES EYE APP
• Instantly review slow motion
• 2 player comparison
• Zoom & pan
• Draw on video
• Audio

Coaches Eye App
Slide 7

COACHES EYE
SAME BASEBALL PITCH

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Slide 8

GOLF COMPARISON
2 DIFFERENT SWINGS

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DARTFISH

- Dartfish is two dimensional video analysis software enabling biomechanical observation, comparison and quantitative measurement of time, distance, angle and position.
- Measurements can be recorded in Data Tables which calculate timings and speeds from position/time data.
- Dartfish ProSuite allows automatic tracking of drawings added to video. Thus an angle drawn on a leg, for example, can track markers placed on it. Should a marker become obscured, or tracking become difficult for any other reason, the drawing can be manually positioned and Dartfish “learns” the correct position for each frame.
RETURN TO SPORT REASONS TO CONSIDER TECHNOLOGY
RETURN TO SPORT MEASUREMENTS WITH SLOW MOTION CAMERAS, FORCE PLATE AND BIOFEEDBACK.
Christopher Powers, PT, PhD, FAPTA

MORE THAN ONE PLANE

WHY USE SPORTS SPECIFIC 3D ANALYSIS

- To identify movement patterns
- Happens at a fraction of a second
- Highlight gross motor sequence deficits
- Overuse of body in improper sequence leads to undue stress on other parts of the body
- Provide essential information to therapist, patient and coach
- Takes the guesswork out of identifying flaws
- Can show restrictions in functional movement
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- Can calculate the actual position and speed of the body during an activity
- Joint forces, torques and power can be calculated
- The bio-mechanical efficiency of your movement can be assessed
- The 3d motion analysis provides the most accurate information about the body's position and forces placed by and onto the body

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WHAT IS NEEDED IN THE SET UP OF 3D ANALYSIS

- Minimal of 2 cameras
- High speed cameras
- Special software
- Good lighting
- Motion sensors or grid
- Biomedical bio-mechanical engineer
- Editing software
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- Determines how efficiently an athlete moves to generate speed and power
- Looks for bio-mechanical breakdown in the body movement pattern which can lead to a decrease in peak efficiency, decrease power = which can lead to muscular fatigue and injury

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**WHAT IS ANALYZED?**

- Performance Profile
- Kinetic link
- Stability
- Muscular loading
- End segment dynamics
- Distal segment speed

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**PERFORMANCE PROFILE**

<table>
<thead>
<tr>
<th>PERFORMANCE PROFILE</th>
<th>normal</th>
<th>difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>arm speed @ release</td>
<td>51</td>
<td>36</td>
</tr>
<tr>
<td>shoulder internal rotation speed @ release</td>
<td>573</td>
<td>4384</td>
</tr>
<tr>
<td>max hips segment speed</td>
<td>932</td>
<td>1340</td>
</tr>
<tr>
<td>max shoulders segment speed</td>
<td>935</td>
<td>1340</td>
</tr>
</tbody>
</table>
Now segments build upon each other creating stored energy and allows for a bigger output.

BATTING KINETIC LINK
--- hip segment
--- shoulder segment
--- arm segment
--- bat segment

WHAT DO THE CHANGES MEAN?
• Now segments move correctly
• Building power, strength and speed on the segment below
• Proper sequencing has been developed
• Increased bat speed by 8 miles per hour.
•Stride length improved 23 units
•Further areas to improve upon were found
•Significant improvement in lower to upper body to upper body kinetic linking
Slide 25

Softball Pitch Kinetic Link

- Shoulder Segment
- Hip Segment
- Arm Segment

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Baseball Pitch Kinetic Link

- Hip Segment
- Shoulder Segment
- Elbow Segment
- Arm Segment

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Collegiate Soccer Analysis

- Evaluated biomechanics of striking the ball
- Comparison of male to male athletes
- Comparison of male to female athletes
- Comparison of female to female athletes

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<table>
<thead>
<tr>
<th>Dominant Kick leg</th>
<th>Male 1</th>
<th>Female 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Foot Speed (mph)</td>
<td>46</td>
<td>42</td>
</tr>
<tr>
<td>Speed at impact (mph)</td>
<td>44</td>
<td>37</td>
</tr>
<tr>
<td>Percent max at impact (%)</td>
<td>95.6</td>
<td>88.1</td>
</tr>
<tr>
<td>Peak pelvis rotational speed (degrees/second)</td>
<td>183</td>
<td>274</td>
</tr>
<tr>
<td>Peak hip flexion speed (degrees/sec)</td>
<td>757</td>
<td>604</td>
</tr>
<tr>
<td>Peak knee extension speed (degrees/sec)</td>
<td>1278</td>
<td>1289</td>
</tr>
<tr>
<td>Knee extension speed at impact (degrees/second)</td>
<td>1228</td>
<td>997</td>
</tr>
<tr>
<td>Percent knee ext speed at impact (%)</td>
<td>96.09</td>
<td>77.35</td>
</tr>
</tbody>
</table>

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**ELITE SOCCER KICK**

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**LEAD LEG STABLEIZATION**

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CAN 3D ANALYSIS HELP A RUNNER?

- Right knee flexion
- Left knee flexion
- Hip segment
- Shoulder segment

WHY 3D?
- Concrete numbers
- Specific high speed capabilities
- Comparison to elite level athletes
- Improve movement patterns
- Improve coordination of movement
- Can be better than own eyes
- Can be better than slow motion cameras
- Helps with determining more than just flexibility and strengthening needed

NOW WHAT?
- Attempt to establish correct gross motor patterns
- Want ground reaction forces to be efficiently transferred through the core
- Want neuromuscular activation to translate into increased speed and power
- Body segment dissociation helps to decrease the load on unnecessary body segments
- What can you do with all this data?
Attempts to initiate good sequencing patterns
Want to improve proper stability
We need the ability to dissociate body segments
Use of strength and conditioning exercises along with the knowledge of gross movement patterns to train the body to be more effective in optimal functional movements

Why?

NEURO - MUSCULAR RE - EDUCATION EXERCISES

NEXT UP / AFTER BREAK

- Lori Ross, PT, MPT, CPI, CAFS, CKTP
  - Clinical application of technology/Research to support
    - Pressure Biofeedback Unit (Stabilizer)
    - Podiat
    - Two Case studies
    - 3D results pre and post neuromuscular exercises
    - Neuromuscular exercises
  - Lab component (3 stations):
    - A. Practice using coaches eye for common testing methods
    - B. Utilizing medication for core activation initiation
    - C. Utilizing pro-belt for therapeutic exercises
Slide 1

CLINICAL APPLICATIONS

INCORPORATING NEUROMUSCULAR TRAINING IN THE CLINIC

LOKI ROSS, PT, MPT, CPI, CAPS

Slide 2

Objectives

- Identify economical tools to use in the clinic to provide visual and/or auditory feedback.
- Observe basic exercises that facilitate neuromuscular control and kinetic link patterns.
- Review two case studies using effective neuromuscular training and 3D analysis.

Slide 3

Pressure Biofeedback Unit

- The Stabilizer/blood pressure cuff
  - Relatively inexpensive/common clinic tool
  - Easy to use
  - Can be used for patients with low back dysfunction, neck pain and concussions.
Prone Position Test

2012 study showed poor concurrent validity of PBU compared to superficial EMG...

2013 study assessing inter and intra rater reliability of lumbar stability...

Of the 5 leg positions in supine and prone, the hip flexion to 90° was the most reliable.

Promoting Proximal Stability

When a patient presents with pain that has begun to interfere with ADLS, our approach begins way before sport specific activity. We use a combined approach for proximal stability that emphasizes hip strength originating from a stable trunk.

As the patient moves from acute to chronic phases, we progress them from nwb to wb and then to sport specific.

Assessment tool

PBU set at 40 mmHg
Positioned at the level of the PSIS in hooklying

Level 0: wide fluctuations
Level 1: 10 mmHg above or below 40 mmHg.
Level 2: 5 mmHg above or below 40 mmHg.
Level 3: 2 mmHg above or below 40 mmHg.

Assessment tool becomes the HEP.
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**The Level Belt**

- Biofeedback App for integrated exercise training using your iphone/ipod.
- Can be used in supine, quadruped, sitting and standing.
- Measures pelvic movement in frontal and sagittal planes.
- Latest version gives sport specific ideas for functional neuromuscular retraining.
- Affordable: $49.99 belt and app.

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**Research Level Belt**

- 75 healthy professional baseball pitchers assessed at last week of Spring training of 08-09.
- Transitioned from double leg to single leg and held for 2 seconds
- Maximum sagittal pelvic tilt was recorded during motion
- The median level score was 7*
- Subjects scoring less than 7* on the test:
  - Had decreased walks
  - Increased innings pitched
  - Better performance (based on opponents' batting average)
- No difference in incidence of injury

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**Belt application**

- The belt is positioned at the level of the anterior and posterior superior iliac spines.
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Advanced Level Belt Exercises

Dance specific

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Case Study #1
13 y/o female
Softball pitcher, plays year round
Initial evaluation 11/11/15
Presented with left sided low back pain that began in mid July while pitching in a tournament
ATC applied muscle energy techniques which initially resolved pain, but came back and with shorter resolution of symptoms.
Lumbar AROM was WNL, mild pelvic asymmetry.
Mild flexibility deficits, and hip weakness throughout.
(-) special tests for sacrum and low back.

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Initial Treatment Interventions

MET correction
Hip strengthening
Core stabilization with plank work
Referral for 3D analysis as patient was painfree when not pitching.
Her initial video capture was performed on November 30, 2015. We edit the clips and upload to our biomechanist. We then create a report based on the graphs, tables and Progressive Skills Training (PST) as well as a DVD with the verbal analysis and PST demonstrations. Usually about a 3-5 week turnaround.

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Initial 3D results

Parent, Patient (and Coach, if invited) are brought into the clinic. We review and discuss the 5-10 minute tape describing their results, as well as their PST’s.
Progressive Skills Training

Based on the findings, Madison was assigned 9 PSTs to be performed 2-3 times per week. She is to increase her repetitions from 1 set of 10 to 3 sets of 10 over the course of 6 weeks. These should be done with at least 2 days of rest in between and can be done on alternate strength/work-out days. We call these “Brain Exercises.” We had Madison come in every 2-3 weeks for compliance of HEP and PST, as well as for technique.

Lunges
Bulgarian split squat
Follow-up 3D Results

Follow-up Video Capture at about 6 weeks (February 25, 2016)

Varies from 4-8 weeks depending on compliance, scheduling, level of difficulty with PST's.

Follow-up 3D Results

Madison Follow-up 3D Shoulder IR

Madison Follow-up 3D Lead Leg Stability
What does this tell us?

- Madison's torso relationship to her arm is significantly better.
  - Evidenced by significant improvement in IR.
- Lead leg stabilization is better.
  - Which leads to improved trunk control (decreased knee movement, results in decreased trunk flexion and lateral bending).
  - This stability should result in decreased low back pain with pitching.
- Individual PST's based on new findings.

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Progressive Skills post follow-up

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Case Study #2
16 y/o female
Year round golfer, with college aspirations
Initial Evaluation: 9/1/15
Presented with left-sided lBP mostly with deceleration phase of golf swing
Chronic: off and on since 2013
Limited lumbar arom
Decreased flexibility of hamstrings and hip flexors
Mild pelvic asymmetry
9/9 Beighton Hypermobility (-) radicular symptoms (+) slr bilaterally
32% disability on Modified Oswestry
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Initial treatment interventions:

- Manual therapy, including ART.
- Initiation of core stabilization with PBU.
- Began training of neck stabilizers with PBU.
- Progressing stabilization training with Pilates Reformer.
- Progression of core stabilization training with function with use of the Level Belt.

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Functional Training with Level Belt

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Level Belt Exercises
Alyssa was seen in the clinic twice per week initially. She was reduced to once per week, as indicated based on pain level and independence with HEP. At this point she was not golfing regularly but was painfree. Initial video capture was done on November 30th, 2015.

What does this tell us?
- Confirms hypermobility
- Highlights excessive pelvic movement
- Impaired kinetic link
- Long transition from back swing to follow-through.
- PST’s progress from simple-complex-sport specific.


F o l l o w - u p 3 D  r e s u l t s
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Alyssa Follow-Up 3D - Linear Displacement

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Alyssa Follow-Up 3D - Kinetic Link

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What does this tell us?

The good news:
- Better arm to club relationship
- Improved linear displacement
- Has returned to golf without reports of low back pain

The not so good news:
- Kinetic link is still impaired
- Long transitions persists: Normal is 160 frames/sec, hers is 250 (and it increased from initial to follow-up.)
- She has internalized the motor components of the swing to her detriment.

“...contract my TA, the ball goes straighter!”
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Where are they now?

In Summary:

- Biomechanics do affect injury risk
- Efficient and effective interventions can impact motor learning
- 2D and 3D technology can play a significant role in the rehab of athletes
- Simple tools and appropriate cues are important learning for all patients

Questions?!
Breakout Lab Session

GROUP 1: STABILIZER - MINDY BRAGG

GROUP 2: LEVEL BELT - LORI ROSS

GROUP 3: VIDEO ANALYSIS - AMY KRAHE

References


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Malinda Bragg-Coldsnow PT, MS, CAFS, CPI, CKTP
Amy Krahe PT, MPT, OCS
Lori Ross PT, MPT, CAFS, CPI
Lab Assistants:
Michael Ross PT, MPT

Stabilzer (bio-pressure feedback unit)

Finding neutral
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Hip release

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Leg Slides

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Knee Fold
Application of Level Belt:
apply belt at level of anterior and posterior superior iliac spines.

Setting Exercise Parameters
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Minibands:
This will train pelvic alignment in frontal and sagittal planes.

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Kettle bell carries:
Good for core as well as shoulder stabilization.

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Trunk dissociation
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Step downs:
Can assess pelvic alignment in frontal and sagittal planes

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Kneeling Overhead Reaches or Throws:
Can vary the surface, weight, and distance reached.

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Lunges:
Can do with or without resistance and vary the amount of excursion.
Slow Motion Camera
Benefits