Using Kinematic Data as a Surrogate for Impact Forces: Science and Practical Implementation

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EXSS Exercise and Sport Science

MOTION Musculoskeletal Injury Prevention Science Institute

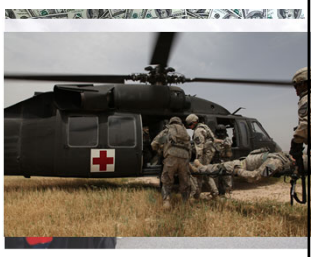
The views expressed in this presentation are our own and are not intended to reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government.

AGENDA

- Background
- Methods
- Results
- Conclusion
- Application: The Injury Mitigation Model

Background & Current State of the Literature

- Musculoskeletal Injuries account for approximately 50% of Disease non-battle injuries (DNBI)[1]
- DNBI accounted for more evacuations from recent theaters of operations than any other injury[2]
- Musculoskeletal Injuries cost the US military >$500,000,000/yr[3]
- ¼ of all medical encounters[4,5]
- 25 million lost duty days[4,5]

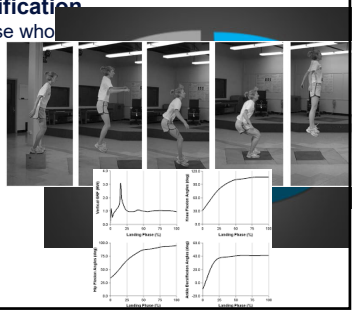


To mitigate..

- STEP 1: Identify those who are prone to injury
- STEP 2: Intervene early to decrease the risk of injury

Background and Current State of the Literature: Identification

- Multiple Common Factors in those who sustain injury
  - Modifiable
  - Non-Modifiable
- Key: Modifiable Risk Factors
  - Movement Profile
  - Impact Forces



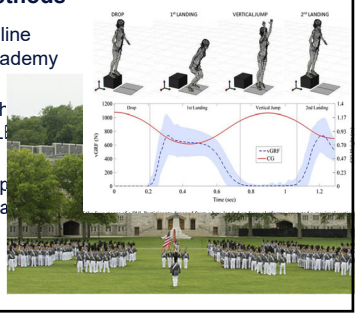
Purpose of this Study

- Movement analysis continues to advance quickly
  - Now easily used in the field
  - Relatively inexpensive
  - Equipment required is often just the cell phone
- Impact forces often require laboratory equipment
- If both are important and modifiable:

  Does the movement profile also give us information about the impact profile?

Methods

- Cross-sectional analysis of baseline data collected on US Service Academy cadets from 2005-09
- Cadets/Midshipmen performed th Landing Error Scoring System (L graded jump landing
- Vertical Ground Reaction Force p was performed during the jump la task



STATISTICAL ANALYSIS

- vGRF was normalized to the person's bodyweight
- Multi-variable linear regression, ANOVA, and ANCOVA analyses
  - Various analyses conducted to control for known, "unmodifiable" variables:
    - Sex
    - BMI
  - LESS scores analyzed both as a continuous and categorical variable
- Alpha set to 0.05 a priori

RESULTS

- N=5579
  - 3413 males (61.18%)
  - 2166 females (38.82%)
- Multi-variable linear regression & ANCOVA:
  - LESS score is a significant predictor of vGRF
  - (p <.001)

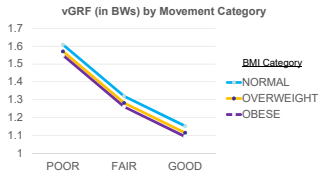
Each error on the LESS

11%

Bodyweight force experienced

RESULTS

- ANOVA:
  - LESS Trichotomized: Good, Fair, & Poor
  - 3x3 factorial ANOVA also took BMI into account
  - Significant among group difference in vGRF
  - (p<.001)



Summary of Results

- ⇧ # of faults on the LESS = ⇧ vGRF when jumping
  - Controlling for sex and BMI
- IMPORTANTLY:
  A field-based movement quality assessment can be used to screen for an important impact risk factor
  - Screening now requires <3 minutes per person
  - Fully automated
  - Corrective exercises automatically generated
- **A rapid, pragmatic movement screen can give information about important kinetic variables without expensive or bulky equipment**

So what: Research → Practice

- Using the screen as part of an Injury Mitigation Model

How it is Applied at UNC: The "Injury Mitigation Model"

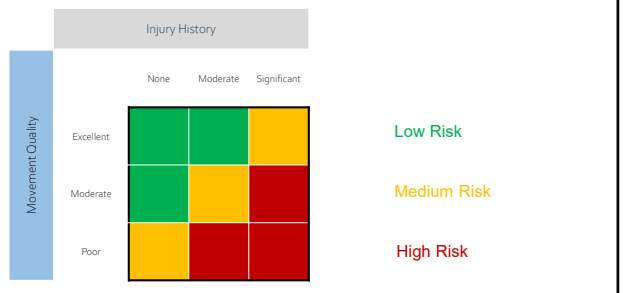
1. Identify Risk Level of Athletes
   - Injury history
   - Movement quality profile

Movement Quality Score Range = 0 - 36
LESS Total Possible = 17
2 Leg Squat Total Possible = 7
1 Leg Squat Total Possible = 12

Construct	Classification	Definition
Movement Quality	Excellent	>90% Total Assessment Score
	Moderate	75-89% Total Score
	Poor	<75% Total Score
Injury History	None	NO days lost to injury in past year
	Moderate	<7 Days lost to injury in past year
	Significant	≥7 Days lost to injury or prior major surgery in past year

Modifiable depending on population

Consider Movement Quality & Injury History



2. Implement injury prevention programming model

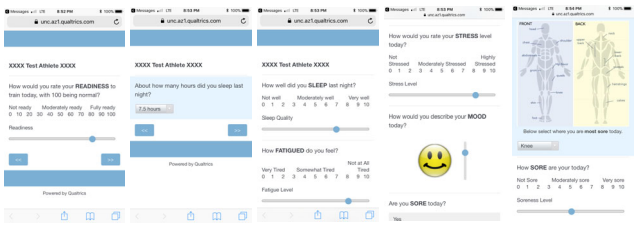
Programming Model	
Low Risk	• Team Warm-Up • Strength & Conditioning Programming • Team / Position Programming
Medium Risk	+ Personalized Self-Care Corrective Ex. • Team Warm-Up • Strength & Conditioning Programming • Team / Position Programming
High Risk	+ Personalized Self-Care Corrective Ex. + Hands-On Corrective Ex. • Team Warm-Up • Strength & Conditioning Programming • Team / Position Programming

PEAKc Program

3. Daily Readiness Monitoring

This technology could be scaled but feasibility of use is questionable particularly in larger units

Ready | Sleep | Fatigue | Stress | Soreness



4. Daily Load Monitoring

0	Rest
1	Very, very easy
2	Easy
3	Moderate
4	Somewhat hard
5	Hard
6	
7	Very hard
8	
9	
10	Maximal

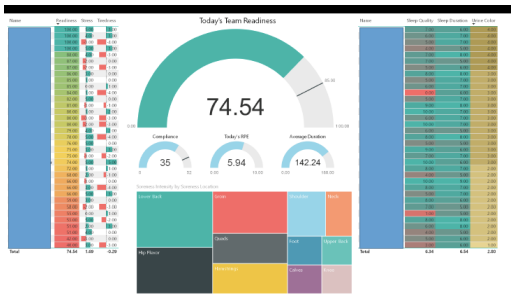
Record the following information:
(training, practices & games)

- RPE within 30 minutes of training/game
  - How was training today?
  - Focus on feeling of exertion (not pain or shortness of breath)
- Total minutes of exercise

RPE x Minutes of Exercise = Training Load (AU)

5. Communicate with Coaches

Alternative Dashboard for Coaches



Dynamic Load – Response Model for Athlete Management

Load

- Duration
- Frequency
- Intensity

Mileage amount and type

Response

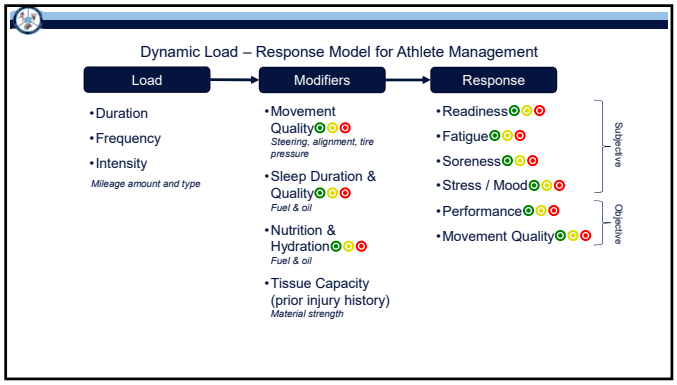
- Readiness
- Fatigue
- Soreness
- Stress / Mood
- Performance
- Movement Quality

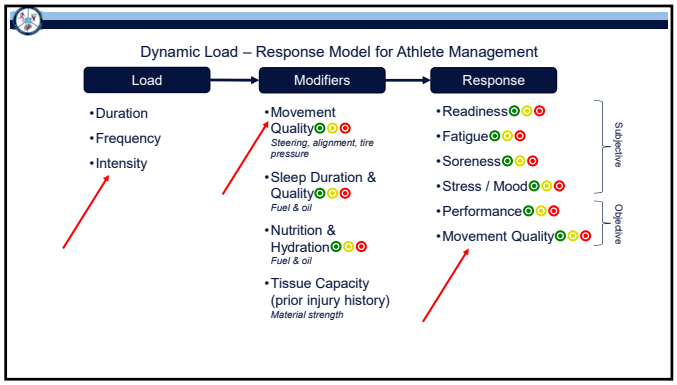
Subjective

Objective

Anabolic

Catabolic


Dynamic Load – Response Model for Athlete Management
Load
Modifiers
Response
•Duration
•Frequency
•Intensity
Mileage amount and type
•Movement Quality
Steering, alignment, tire pressure
•Sleep Duration & Quality
Fuel & oil
•Nutrition & Hydration
Fuel & oil
•Tissue Capacity (prior injury history)
Material strength
•Readiness
•Fatigue
•Soreness
•Stress / Mood
•Performance
•Movement Quality
Subjective
Objective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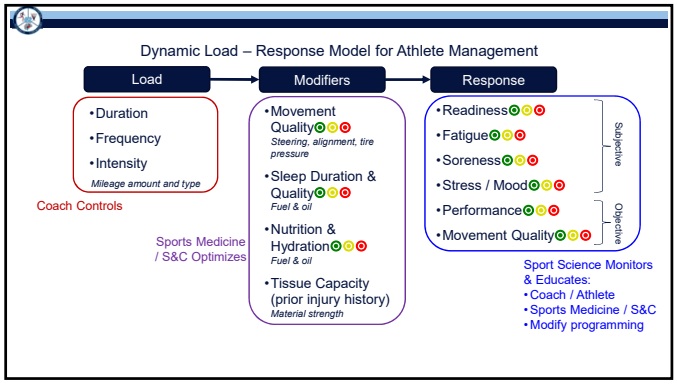
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•Frequency
•Intensity
Mileage amount and type
Coach Controls
•Movement Quality
Steering, alignment, tire pressure
•Sleep Duration & Quality
Fuel & oil
•Nutrition & Hydration
Fuel & oil
•Tissue Capacity (prior injury history)
Material strength
Sports Medicine / S&C Optimizes
•Readiness
•Fatigue
•Soreness
•Stress / Mood
•Performance
•Movement Quality
Subjective
Objective
Sport Science Monitors & Educates:
•Coach / Athlete
•Sports Medicine / S&C
•Modify programming

Conclusion: How Movement Quality Fits Into the Larger Picture

- Movement Quality:
  - Gives us information on Kinetic Load using field expedient equipment
  - Helps us Identify those at greater risk for injury
  - Guides early and ongoing intervention
  - Enhances the holistic view of the load our Soldiers experience by informing the team

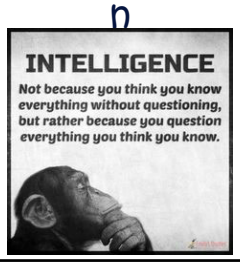
Thank you

For what you do

For your time

For allowing me to speak

Questions?/Discussion



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2. Daily Readiness & Load Monitoring

	Construct	Classification	Definition
Daily	Recovery Behaviors & Readiness	Fully Ready / Recovered	>90% Recovery / Readiness Scores
		Moderately Ready / Recovered	75-79% Recovery / Readiness Scores
		Not Ready / Recovered	<75% Recovery / Readiness Scores
	Training Load	Positive Load Exposure / Response	0.8 – 1.45 Acute-to-Chronic Workload Ratio
		Sub-Optimal Load Exposure / Response	<0.8 or 1.46-1.52 Acute-to-Chronic Workload
		Overload Exposure / Response	>1.53 Acute-to-Chronic Workload Ratio
		Underload Exposure / Response	<0.8 Acute-to-Chronic Workload Ratio