Human simulation addressing physical performance & injury prevention

Karim Abdel-Malek
Kevin Kregel
Landon Evans
Integration of Human Physiology and Santos
What is Human Simulation?

Task

Modeling

Simulation

Analysis
Center for the Intrepid
No Backpack

90 Kg (198 lb) Backpack

100 Kg (220 lb) Backpack
Human simulation can reduce injuries

- Majority of injuries (~ 86.5%) are non-battle injuries.
- In 2006 (Hauret, et al.) reported 743,547 MSK injuries
Knee Model

Contact surfaces

Loading
Factors To Be Modeled

- Multiple terrain options
- Different fitness levels
- Walking inclines
- Walking speeds

Energy expenditure and other physiology parameters as outputs

Environmental conditions (heat, humidity, wind, altitude)
Relevant Physiology Parameters

Physiological Performance

• Heart rate
• Energy expenditure
• Perceived exertion
• Hydration status
• $\text{O}_2$ consumption & work capacity
• Thermal outputs (core temperature)
Injury Overlap – Military vs Athletics

Body areas injured during 12-mo deployment to Afghanistan

- Low back
- Knee
- Shoulder
- Head
- Ankle
- Hand

Top body areas injured in sports

- Knee
- Ankle
- Hand
- Head
- Face
- Heel
Process of Operations

Step 1: Assessment

Step 2: Diagnosis

Step 3: Intervention

Step 4: Monitoring & Evaluation
Monitoring

What we want it to be like

What we know is reality
“The responses from any training will not result in readily predictable fitness outcomes.” — JOHN KIELY
Complicated vs Complex
What is Monitoring?

**MONITORING**

**Dosage of Work**
- Training and Competition Load
- Life Load

**Athlete**
- Physical
- Psychological
- Technical
- Tactical

**Response**
- Performance
IOWA Monitoring

Some ways we utilizing monitoring to better support our student-athletes

INTERNAL

EXTERNAL
IOWA Monitoring – Heart Rate Variability

INTERNAL Applications

945 ms  895 ms  932 ms  908 ms
IOWA Monitoring – Local Muscle

INTERNAL Applications
IOWA Monitoring – Local Oxygen Sensor

INTERNAL Applications

![Graphs showing SmO2, Wattage, and Heart Rate over time.](image)
IOWA Monitoring – Player Tracking

EXTERNAL Applications
IOWA Monitoring – Jump Analysis
EXTERNAL Applications
IOWA Monitoring – Weight Room

EXTERNAL Applications
FUTURE with VSR

MALUM TERMINUS

Analytical Injury Prediction simulation framework

Propensity for Injury
Physiological performance
Biomechanical performance

Subject 1
- Age, Gender
- Weight
- Strength
- Flexibility
- Physiology
- Training Load
- Past injuries
- ...

Heuristics and Intuition