OBJECTIVES

- Discuss a technical model for sprinting from a dynamic systems perspective
- Discuss an error model for sprinting from a dynamic systems perspective
- Discuss a constrain-based coaching model with emphasis placed on instruction/feedback and practice design

Technical Model: Coordination

co-or-di-na-tion:

Patterning of head, body, and limb movements relative to the patterning of environmental objects and events (Turvey, 1990)
Coordination: Dynamic Systems
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Describes the control of coordinated movement that emphasizes the role of information in the environment and dynamic properties of the body/limbs.
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Views the process of human motor control as a complex system that behaves like any complex biological or physical system.
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Concerned with identifying laws (natural and physical) that govern changes in human coordination patterns.

Coordination: Dynamic Systems
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Attractor State (Motor Program Equivalent):
  - A preferred behavioral state that is said to be stable or homeostatic.
  - Occurs and can change in response to constraints within the human system, environment and/or task.
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Self-Organization:
  - Spontaneous expression of a motor skill in response to specific tasks, environment conditions and biological capabilities (Attractor State).

Dynamic Systems: Sprint Considerations
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Biological:
  - Anatomy and Genetics
  - Mobility, Stability, Strength, Speed-Strength, and Speed.
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Task:
  - High speed linear running
  - Decision making and reaction.
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Environment:
  - Surface: Field, Court, or Track
  - Gravity as a constant.

Dynamic Systems: Sprint Considerations
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Inertial Forces
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Muscular Forces
-
Gravitational Forces

Technical Model: Acceleration
Technical Goal 1
Synchronize explosive arm and leg movement through a "piston like" leg action that maximizes a low leg swing.

Technical Goal 2
Optimize the direction of force in an effort to maximize horizontal velocity.

Critical Position 1: Ankle Cross

Critical Position 2: Toe-Off → Contact

Force-Velocity Goal 1
Generate as much horizontal force as possible in the least amount of time while maximizing technique.

Force-Velocity Goal 2
Optimize the horizontal force that can be generated in excess of the vertical force needed to overcome gravity.
**Force Characteristics**

- $H = 614N$ (138lbs)
- $V = 145N + 800N = 945N$ (212lbs)
- $V = 30mph$ (7.6mph)
- $V = 1.8$ - $2.2$ mph

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**Technical Model: Absolute Speed**

- Synchronize front and backside leg action with arm action in an effort to maximize the peak hip flexion achieved in the front leg.

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**Technical Model: Acceleration**
**Technical Goal 2**: Contact the ground as close to the center of mass as possible in an effort to minimize breaking forces and maximize vertical force.

**Critical Position 1**: Take-Off
- Stance Hip Extension: < 10°
- Stance Knee Extension: 150°
- Recovery Knee Flexion: 80°
- Recovery Hip Flexion: 80°

**Arm Action**: Back Arm: 155°
- Front Arm: 70–80°

**Critical Position 2**: Figure 4
- Stance Hip Extension: < 20°
- Stance Knee Extension: > 160°
- Recovery Knee Flexion: 40°
- Recovery Hip Flexion: 45°

**Arm Action**: Back Arm: 155°
- Front Arm: 70–80°

**Arm Action**: Study Hip: 175°
- Front Arm: 70–80°

**Force Characteristics**
- \( V = 818N + 800N = 1618N \) (364lbs – 2BW)
- \( H_F = 250N \) (avg) (50lbs)
- \( V_F = 0.5m/s \) (1m/s Total) (1mph)
- \( 180lbs = 81.81kgs = 800N \)

**Characteristics**: Frequency: 4.4-5 contacts/sec
- Length: 2.8-2.9yds
- Grd. Time: 0.87s-1.1s
- Pit. Time: 1.23-1.27s

**Technical Model: Absolute Speed**
Attractor States

- Attractor:
  - A stable state of the motor control system that leads to behavior according to preferred coordination patterns

- Characteristics of an attractor:
  - Identified by order parameters (e.g., relative phase)
  - Control parameters (e.g., speed) influence order parameters
  - Minimum trial-to-trial performance variability
  - Stability – Retains present state despite perturbation
  - Energy efficient

Attractors and Movement

Movement Error  Movement Efficiency

Casting Forward  Striking Down

“Butt” Kicking  Knee Lift
Error Model: Absolute Speed

Absolute Speed Error Model

- **ERROR 1**: Excessive Forward Lean
- **ERROR 2**: Excessive Trunk Flexion
- **ERROR 3**: Excessive Trunk Rotation

- **Posture**
- **Butt Kicking**
- **Excessive Trunk Rotation**
- **Low Leg Recovery**

- **Backside Leg**
  - **Action (Flight)**
  - **Delayed Leg Recovery**
  - **Plantarflexion During Leg Recovery**
  - **Lack of Knee Drive & Lift**
  - **Lack of Free Hip Lock & Lift**
  - **Early Opening of Knee Angle >90° “Casting”**

- **Front Side Leg**
  - **Action (Flight)**
  - **Delayed Leg Recovery**
  - **Plantarflexion During Leg Recovery**
  - **Lack of Knee Drive & Lift**
  - **Lack of Free Hip Lock & Lift**
  - **Early Opening of Knee Angle >90° “Casting”**

- **Ground/Contact (Stance)**
  - **Excessive Forward Contact “Casting”**
  - **Low Stiffness “Sitting >15° at Knee”**
  - **Excessive Hip/Back Extension at Toe Off**

Special Thanks (Bosch, 2013)
**Absolute Speed Error Model**

- Posture
- Backside Leg Action (Flight)
- Front Side Leg Action (Flight)
- Ground Contact (Stance)

**Prioritization**

- Error 1
- Error 2
- Error 3

**Special Thanks (Bosch, 2013)**

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**03 Linear Speed: Coaching Model**

- Influencing Attractor States
- Instruction/Feedback
- Practice Design

- The use of variability is critical to guide the motor system from a non-functional "stable state" to a functional "stable state"

- Drills can be designed to constrain or restrict an error, which allows for the possibility of a new movement pattern

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**Influencing Attractor States**

- "Errors must become unstable for efficiency to emerge"
"The optimal pattern of coordination is determined by the interaction among constraints specified by the person, the environment, and the task" (Newell, 1986)

**Self-Organization (Constraint-Based) Model**

- **Body**
- **Environment**
- **Task**

**Perception**

**Coordinative Pattern**

**Action**

**Task Constraints**

**Spatial**
- Manipulate the amount of space the movement can be performed in (e.g. hurdle distances)

**Temporal**
- Manipulate the amount of time the movement can be performed in (e.g. jump mat or athletes racing)

**Rules/Equipment**
- Change the rules to constrain choices and/or introduce equipment to constrain the movement options

**Environmental Constraints**

**Ground**
- Manipulate the surface to constrain motor system (e.g. sand, grass, and track)

**Gravity**
- Manipulate the orientation of the body to constrain motor system (e.g. inverted positions)

**Body Constraints**

- **Position**
  - Athletes ability to attain proper stability and mobility relative to the movements being performed

- **Pattern**
  - Athletes ability to coordinate the limbs of the body relative to task and environment constraints

- **Power**
  - Athletes ability to express the appropriate strength qualities relative to the movements being performed

**Verbal Instruction**

- Provide 1-2 focus cues to build awareness
- Limit unnecessary information ("Over-Coaching")
- Start and finish instruction with what you want versus what you don’t want
- Focus attention externally on the outcomes opposed to internally on the body process
**Verbal Instruction: Cueing**

- **Internal Cueing:** Focused on “Body Movement”
  - Joint reference: “Squeeze your shoulder blades”
  - Muscle reference: “Squeeze your glutes”

- **External Cueing:** Focused on “Movement Outcome”
  - Environment reference: “Explode off the ground”
  - Outcome reference: “Jump as high as you can”

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**Internal vs. External Cueing Applied to Sprinting**

- **Internal**
  - “Explode through your hips”

- **External**
  - “Explode off the ground/blocks”

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**Instructional Coaching Model**

“Cues should be mapped to desired biomechanics based on prioritized error”

- **Instruction & Feedback Model**
  - **Distance**
    - Proximal (Close)
    - Distal (Far)
  - **Direction**
    - Toward vs. Away
    - Up vs. Down
  - **Description**
    - Action Words (Visual)
    - Analogy (Feel vs. Be)

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**Coaching “Cueing” Pyramid**

- **POSTURE**
  - “Stand tall”
  - “Lean into the wind”
  - “Drive belt buckle forward”

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17 Years of research has shown that internal focus constrains the motor system, while external focus allows the motor system to self-organize efficiently to improve performance.
Leg Action: Front
- "High heels"…"Step over"
- "Snap laces to the sky"
- "Knees up"…"Explode glass"

Leg Action: Back
- "Drive down through ground"
- "Snap the ground away"
- "Spin the earth"

Leg Action: Arms
- "Hammer back"
- "Snap down and back"
- "Throw... insert word... back"

Putting It All Together
- "Fight gravity and stay tall"
- "Cycle action... "Scissor"
- "Stay on top of cyclical action"

In Sum:
- Instruction should guide not prescribe
- Provide feedback on outcomes over process
- Say the most with the least
- Ask a question before you provide an answer
- What you want vs. what you don’t want

Coaching: Practice Design
In Sum:

- Drills create context for athlete understanding
- Drills should create affordances that allow optimal technical changes to emerge
- Drills should be self-limiting, which allows errors to become variable to change
  
  “Let the drill do the talking and the athlete do the walking”
COORDINATION EMERGES:
Movements are a reflection of the environment; therefore, movement emerges in response to environmental affordances, task demands, and biological capabilities.

PRIORITIZE:
- Map error models to technical models and identify technical limiting factors across position, pattern, and power.

LESS IS MORE:
- Limit all unnecessary instruction/feedback.
- Optimize feedback using external focus cues.

CONSTRAINTS:
Optimize the practice environment through the use of constraints across task and environment. Create the right amount of “struggle/variation” to support consistent learning.

Thank You
nwinkelmann@teamexos.com
@NickWinkelmann
@TeamEXOS