Learning to Sprint:
The Art of Coaching Meets the Science of Motor Learning

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Thank You

tennerakademie köln

EXOS™
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

01 Linear Speed: Technical Model

- Coordination
- Absolute Speed
Technical Model: Coordination

coordination:

Patterning of head, body, and limb movements relative to the patterning of environmental objects and events (Turvey, 1990)
Coordination: Dynamic Systems

† Describes the control of coordinated movement that emphasizes the role of information in the environment and dynamic properties of the body/limbs

† Views the process of human motor control as a complex system that behaves like any complex biological or physical system

† Concerned with identifying laws (natural and physical) that govern changes in human coordination patterns

Coordination: Dynamic Systems

† 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

† Self-Organization:
  - Spontaneous expression of a motor skill in response to specific tasks, environment conditions and biological capabilities (Attractor State)
Dynamic Systems: Sprint Considerations

- Biological:
  - Anatomy and Genetics
  - Mobility, Stability, Strength, Speed-Strength, and Speed

- Task:
  - High speed linear running
  - Decision making and reaction

- Environment:
  - Surface: Field, Court, or Track
  - Gravity as a constant

Technical Model: Absolute Speed
Technical Goal 1

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

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°

Mann, 2011

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

Mann, 2011
Force Characteristics

\[ F = 818N + 800N = 1618N \]  
(364lbs – 2BW)

\[ F = 250N \text{ (avg)} \]  
(50lbs)

\[ V = 0.5m/s \]  
(1m/s Total)

\[ V = 0.5m/s \]  
(1mph)

\[ H = 250N \text{ (avg)} \]  
(50lbs)

\[ V = 0.5m/s \]  
(1m/s Total)

Gravitational, Inertial, Muscle

\[ 180lbs = 81.81kgs = 800N; .1s GCT \]

Characteristics:

- Frequency: 4.4-5 contacts/sec
- Length: 2.8-2.9yds
- Grd. Time: .087-.11s
- Fit. Time: .123-.127s

Mann, 2011
Linear Speed: Error Model

- Attractor States
- Absolute Speed

**Error Model: Attractor States**
**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

“Butt” Kicking
Knee Lift

Casting Forward
Striking Down
Error Model: Absolute Speed

Movement Error Model

- POWER
- PATTERN
- POSITION
Absolute Speed Error Model

POSTURE

<table>
<thead>
<tr>
<th>Error 1</th>
<th>Error 2</th>
<th>Error 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive Forward Lean</td>
<td>Excessive Trunk Flexion</td>
<td>Excessive Trunk Rotation</td>
</tr>
<tr>
<td>Delayed Leg Recovery &quot;Butt Kicking&quot;</td>
<td>Plantarflexion During Leg Recovery</td>
<td>Low Leg Recovery</td>
</tr>
<tr>
<td>Lack of Knee Drive &amp; Lift</td>
<td>Lack of Free Hip Lock &amp; Lift</td>
<td>Early Opening of Knee Angle &gt;90° &quot;Casting&quot;</td>
</tr>
<tr>
<td>Excessive Forward Contact &quot;Casting&quot;</td>
<td>Low Stiffness &quot;Sitting &gt;15° at Knee&quot;</td>
<td>Excessive Hip/Back Extension at Toe Off</td>
</tr>
</tbody>
</table>

PRIORITY

Special Thanks (Bosch, 2013)

Linear Speed: Coaching Model

- Influencing Attractor States
- Instruction/Feedback
- Practice Design
Coaching: Influencing Attractor States

Influencing Attractor States

† 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
"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)

Adapted From: Davids, K., Button, C., and Bennett, S., 2008
**Body Constraints**

- **Position**: Athlete's ability to attain proper stability and mobility relative to the movements being performed.
- **Pattern**: Athlete's ability to coordinate the limbs of the body relative to task and environment constraints.
- **Power**: Athlete's ability to express the appropriate strength qualities relative to the movements being performed.

**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)

**Coaching: Instruction/Feedback**
**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”
16 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

(Wulf, 2012)
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)

Winkelman, 2014

Cueing Model: Absolute Speed
Coaching “Cueing” Pyramid

Posture

- “Stand tall”
- “Lean into the wind”
- “Drive belt buckle forward”
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
Practice Design

♦ Goal
- Optimize learning and retention in an effort to reach maximum transfer to the sporting environment

♦ Key Terms
- Practice Variability
- Contextual Interference
- Differential Learning

Practice Design

♦ Practice Variability:
- The variety of movement and context characteristics a person experiences while practicing a skill

♦ Contextual Interference (CI):
- The memory and performance disruption that results from performing multiple skills or variations within the context of practice

♦ Contextual Interference Effect (Battig, 1979):
- Learning benefit from performing multiple skills in a high CI practice schedule (i.e. Random), rather than skills in a low CI practice schedule (i.e. Blocked)
**Contextual Interference Applied**

**Practice Design**

- **Set 1:** 10m Sprint
  - Rep 1: Sled Sprint
  - Rep 2: 10m Sprint
  - Rep 3: Skip Pattern

- **Set 2:** 10m Sprint
  - Set 2: Sled Sprint
  - Set 3: 10m Sprint

- **Set 3:** 10m Sprint

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**Differential Learning**

† Schöllhorn introduced differential training to improve skill acquisition

† Differential training:
  - "noise" (random irrelevant movements) is introduced during practice of a target skill

† Differential training induces continuous changes in movement executions by avoiding repetitions, removing corrective instructions and emphasizing discovery practice
  - Positive benefits of differential training (e.g. shot putting, soccer skills, basketball, hurdles, speed skating, and skiing)
Challenge Point Hypothesis (Guadagnoli & Lee, 2004)

Potential for Learning

Low Beginner

Intermediate

Skilled

Expert

Task Difficulty (Progression-Variation)

Optimal Task Difficulty

COGNITIVE STAGE

ASSOCIATIVE STAGE

AUTONOMOUS STAGE

Practice Timeline

(Fitts and Posner, 1967, Davids et al., 2008, and Magill, 2011)
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-EXTERNAL:
- 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

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