Middlesex University
London Sport Institute

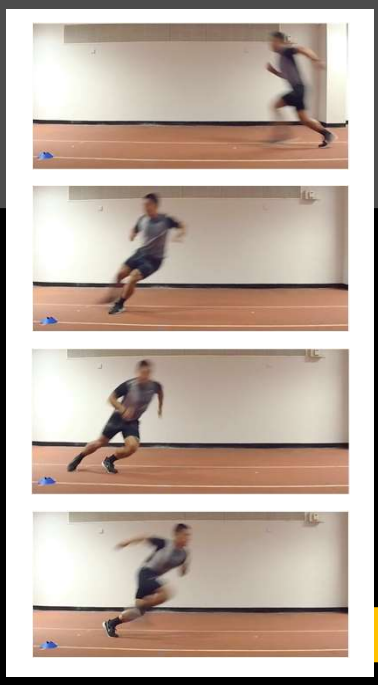
Reverse Engineering In Sport:
Developing a High-Performance Road Map

Prof. Anthony Turner
Professor in Strength and Conditioning
Postgraduate Research Lead
@anthonyturneruk E: a.n.turner@mdx.ac.uk

Training is a means to an end. For many sports, that end is an agile athlete







Presentation outline

- What is RE
- *Our* top-down logic for RE in Agility
- CoDS
- Plyometrics
- Power
- Strength
- Imbalances and movement screening

What even is RE!?

A process in which products are deconstructed to extract design information, so that they may be recreated

Used when a part of a machine is malfunctioning and no longer available

Via deductive reasoning, engineers will try to understand how the part functions and can be made

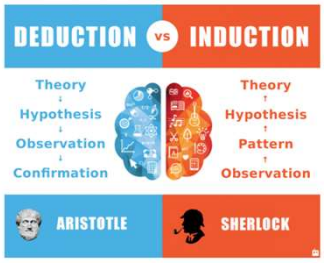
Application to S&C

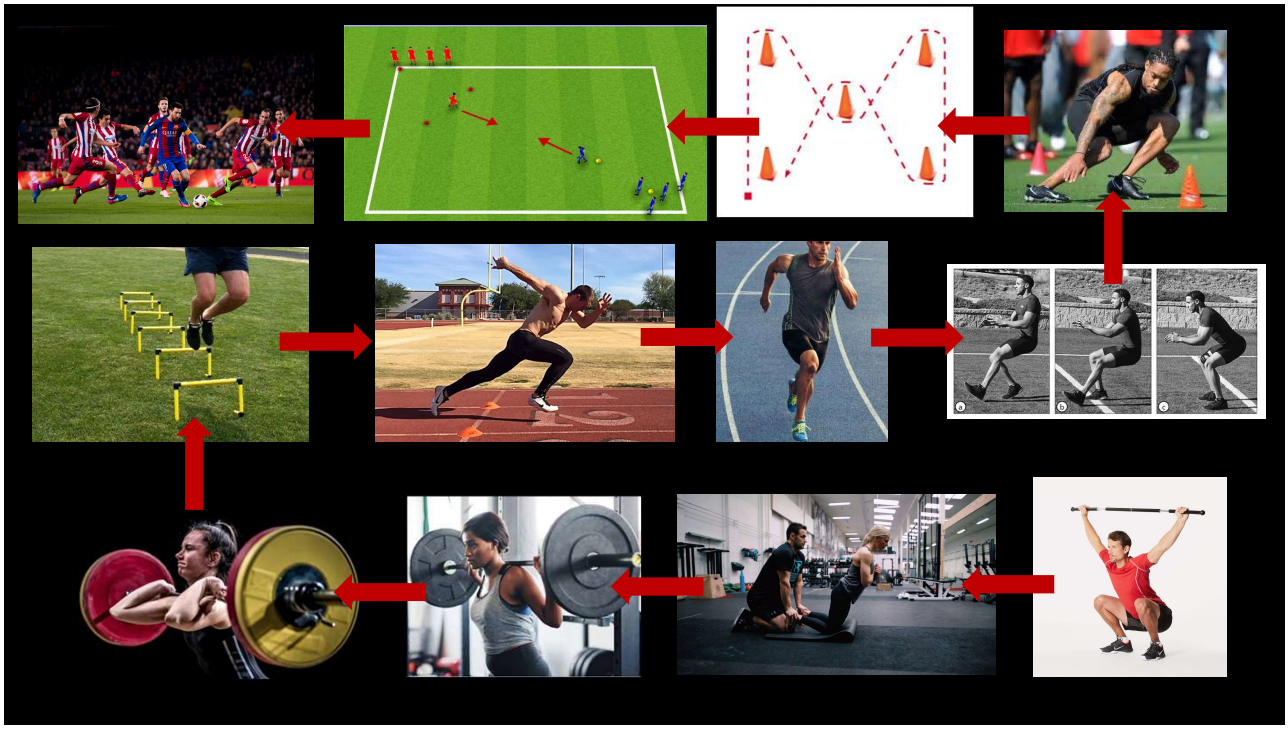
RE is similarly adopted in systems biology and may extend to S&C

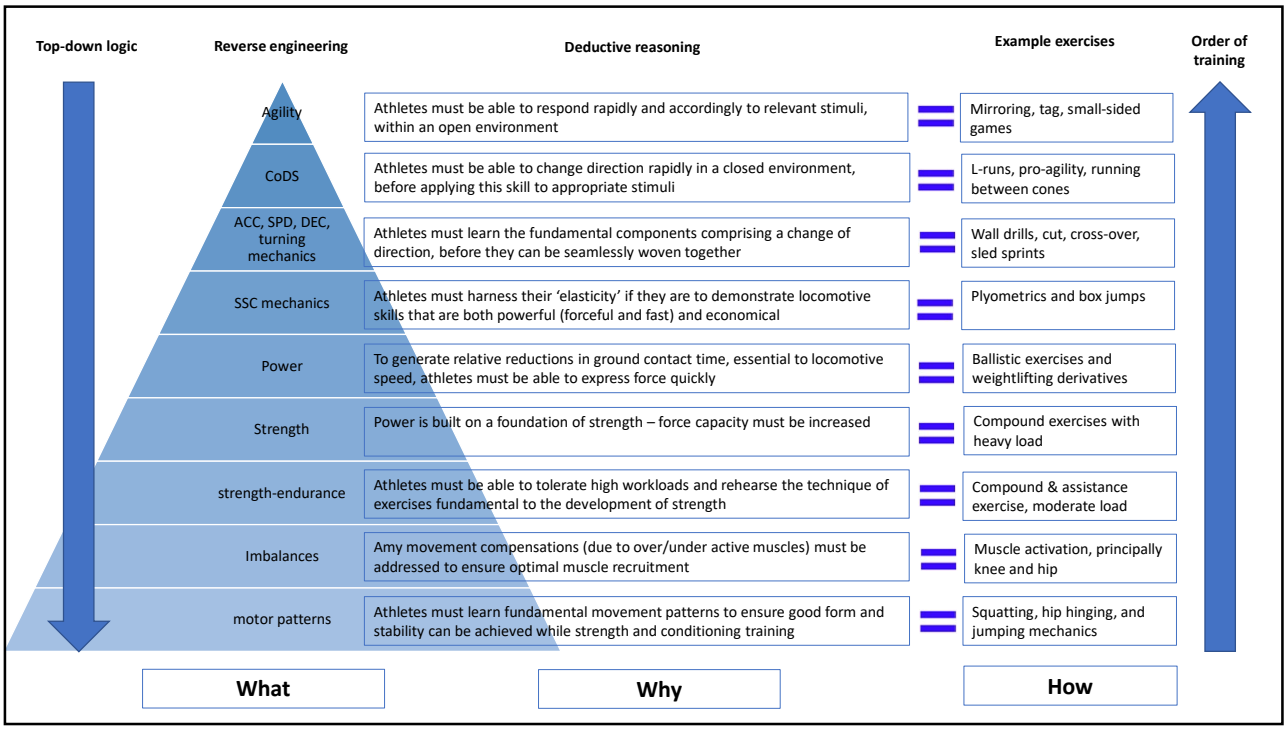
Coaches will design a series of training programmes following a periodized and systematic approach, based on *"where would we like to be this time next year"?*

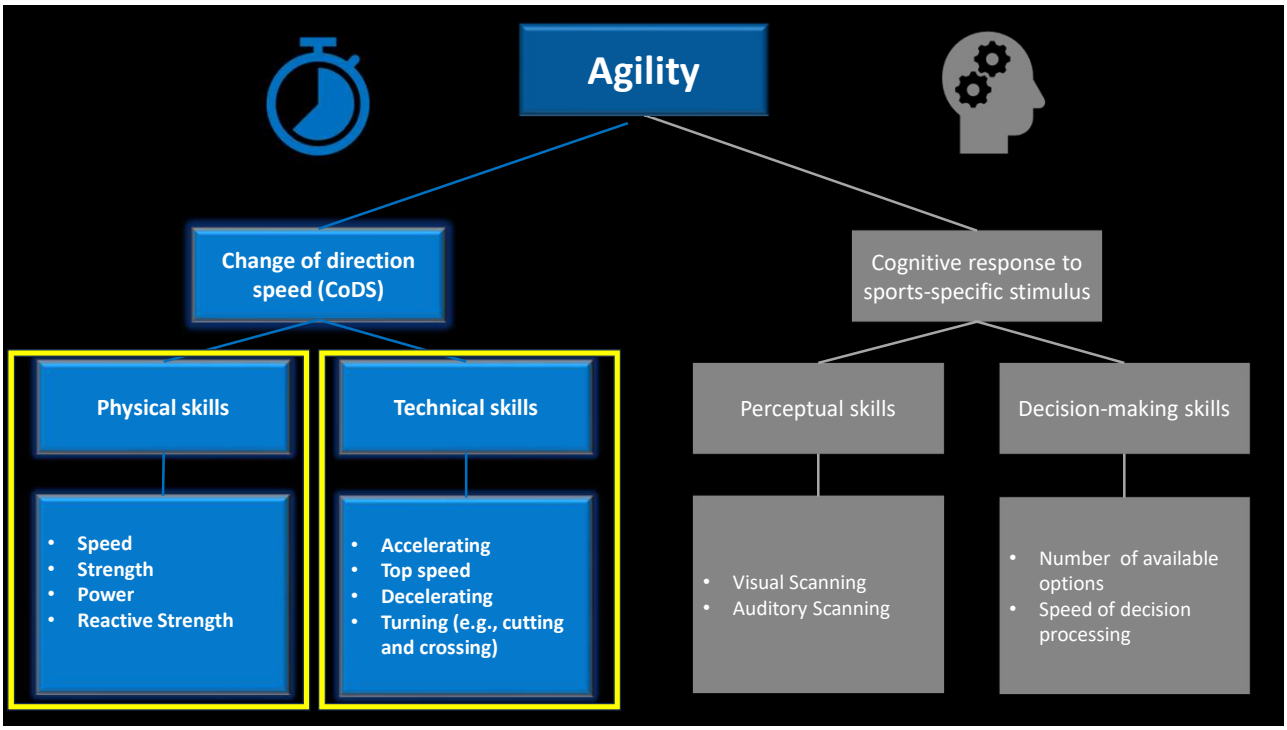
A coach may work backward, identifying KPI's, the physical attributes that map back to them, and then distribute the development of those over the allocated timeframe.

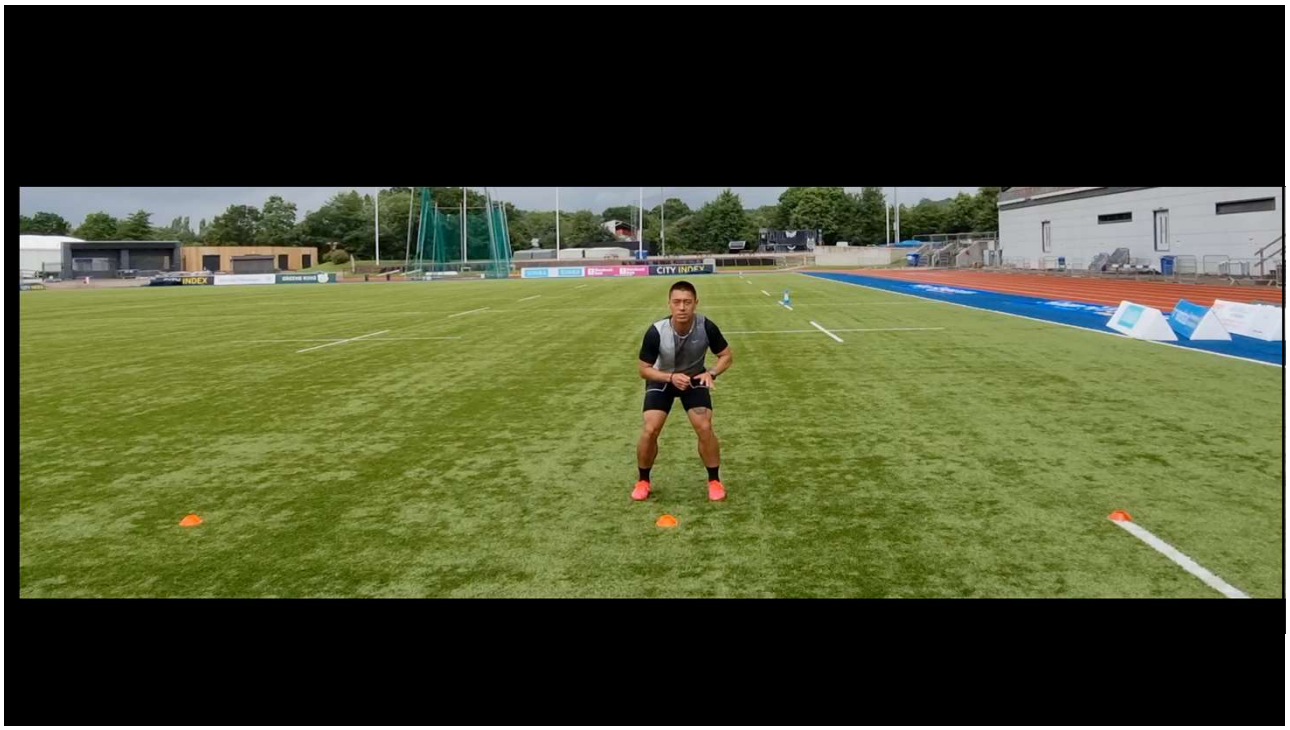
Therefore, exercise selection, frequency, reps, sets, and rest, designed to maximise performance via phase potentiation

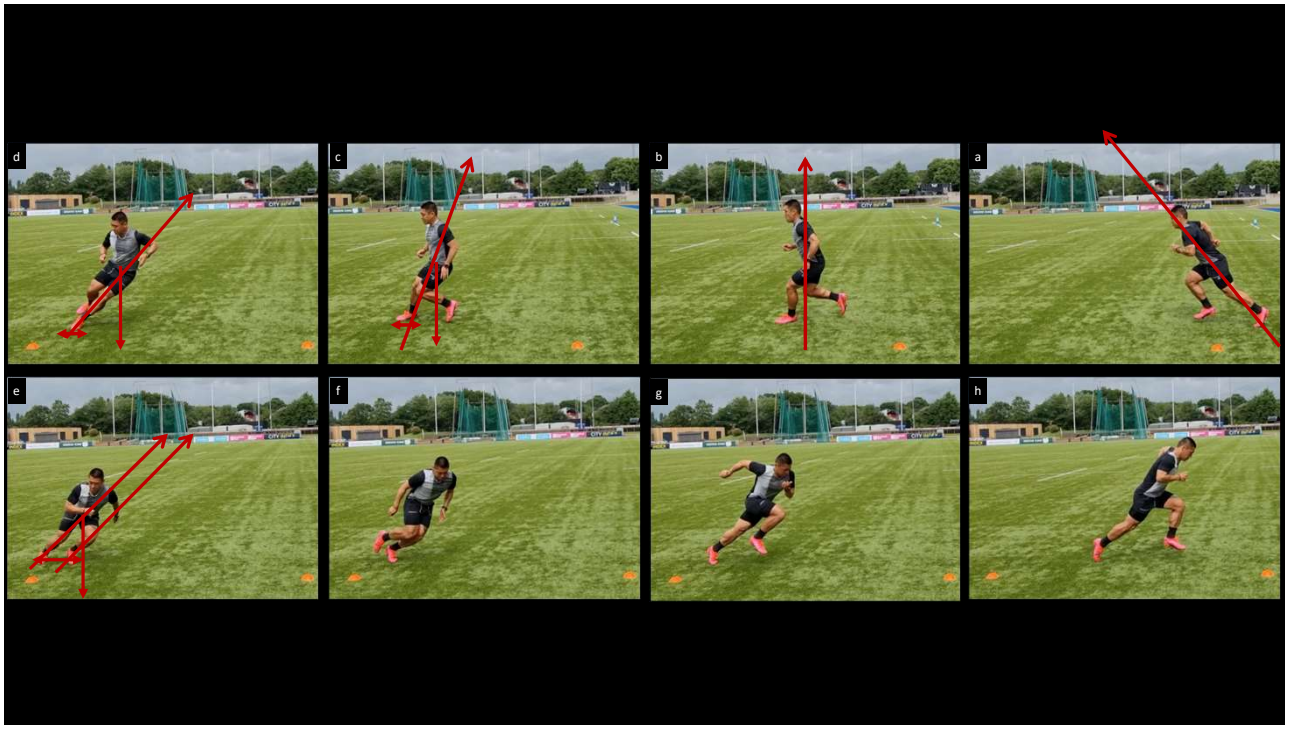


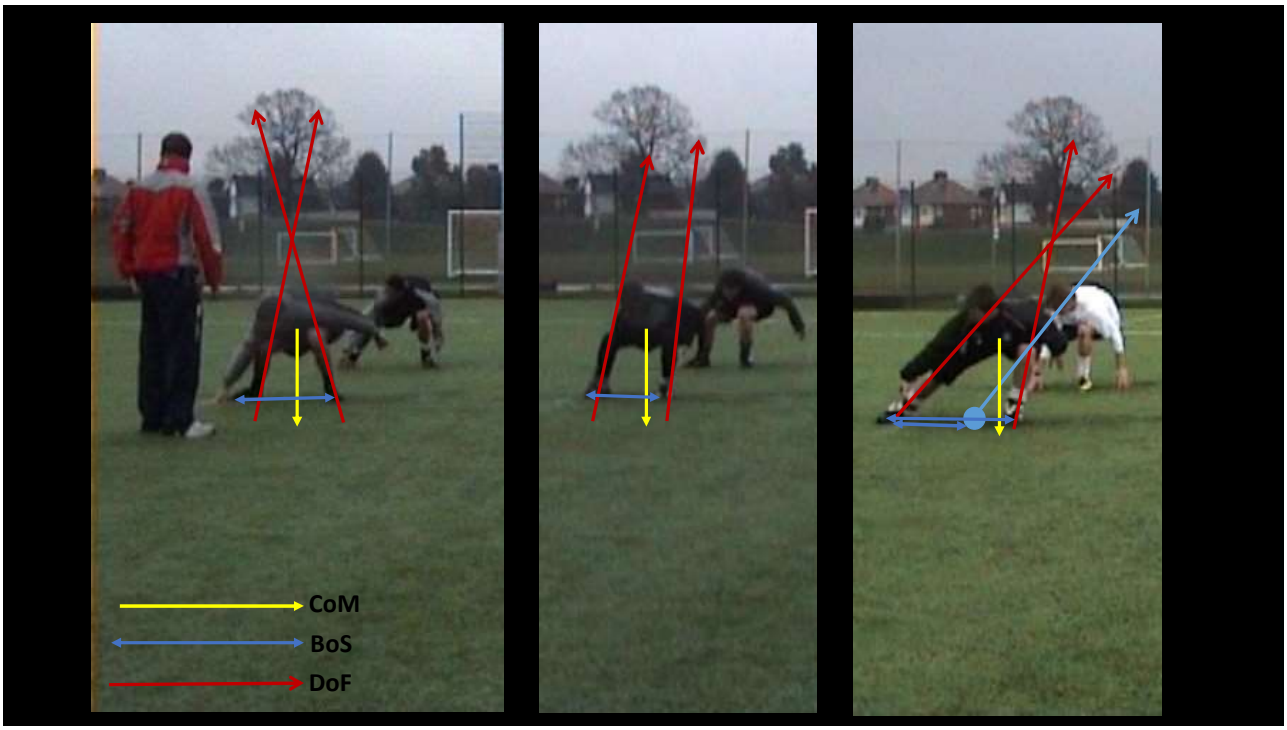


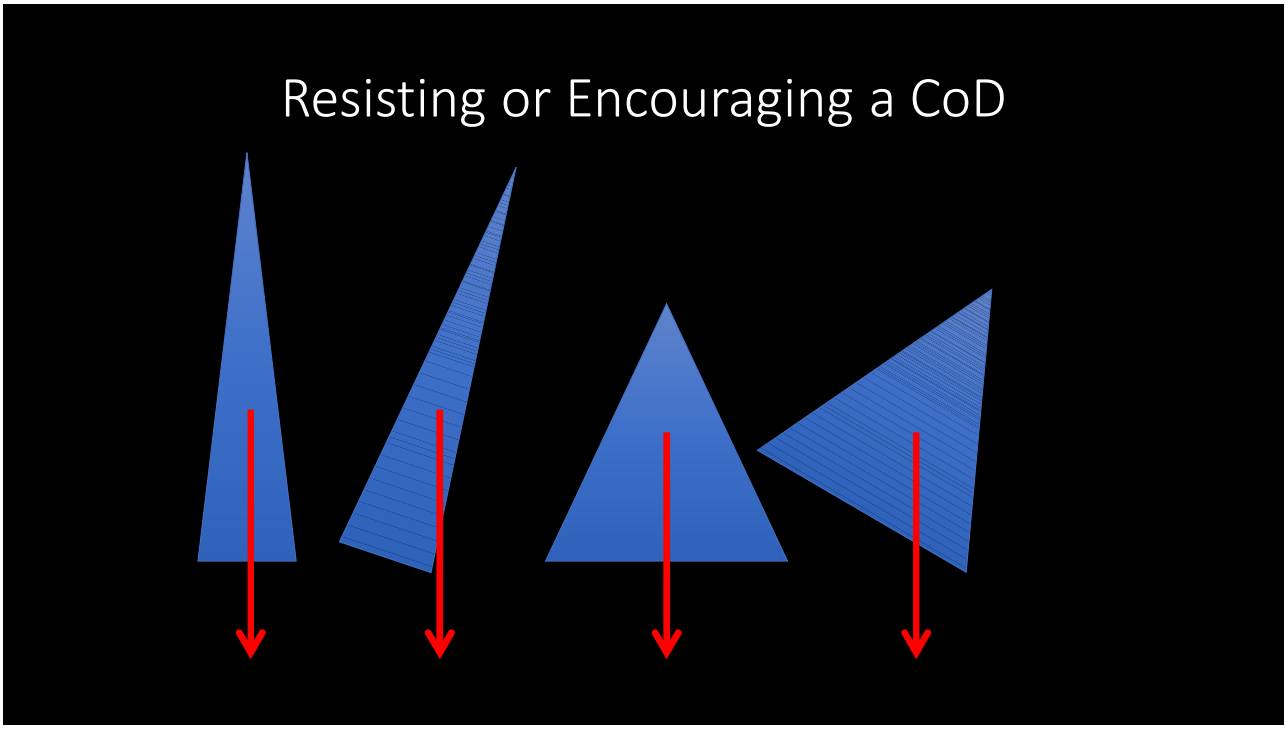

Top-down logic
Reverse engineering
Deductive reasoning
Example exercises
Order of training
Agility
Athletes must be able to respond rapidly and accordingly to relevant stimuli, within an open environment
Mirroring, tag, small-sided games
CoDS
Athletes must be able to change direction rapidly in a closed environment, before applying this skill to appropriate stimuli
L-runs, pro-agility, running between cones
ACC, SPD, DEC, turning mechanics
Athletes must learn the fundamental components comprising a change of direction, before they can be seamlessly woven together
Wall drills, cut, cross-over, sled sprints
SSC mechanics
Athletes must harness their 'elasticity' if they are to demonstrate locomotive skills that are both powerful (forceful and fast) and economical
Plyometrics and box jumps
Power
To generate relative reductions in ground contact time, essential to locomotive speed, athletes must be able to express force quickly
Ballistic exercises and weightlifting derivatives
Strength
Power is built on a foundation of strength – force capacity must be increased
Compound exercises with heavy load
strength-endurance
Athletes must be able to tolerate high workloads and rehearse the technique of exercises fundamental to the development of strength
Compound & assistance exercise, moderate load
Imbalances
Amy movement compensations (due to over/under active muscles) must be addressed to ensure optimal muscle recruitment
Muscle activation, principally knee and hip
motor patterns
Athletes must learn fundamental movement patterns to ensure good form and stability can be achieved while strength and conditioning training
Squatting, hip hinging, and jumping mechanics
What
Why
How


Agility
Change of direction speed (CoDS)
Cognitive response to sports-specific stimulus
Physical skills
Technical skills
Perceptual skills
Decision-making skills
Speed
Strength
Power
Reactive Strength
Accelerating
Top speed
Decelerating
Turning (e.g., cutting and crossing)
Visual Scanning
Auditory Scanning
Number of available options
Speed of decision processing

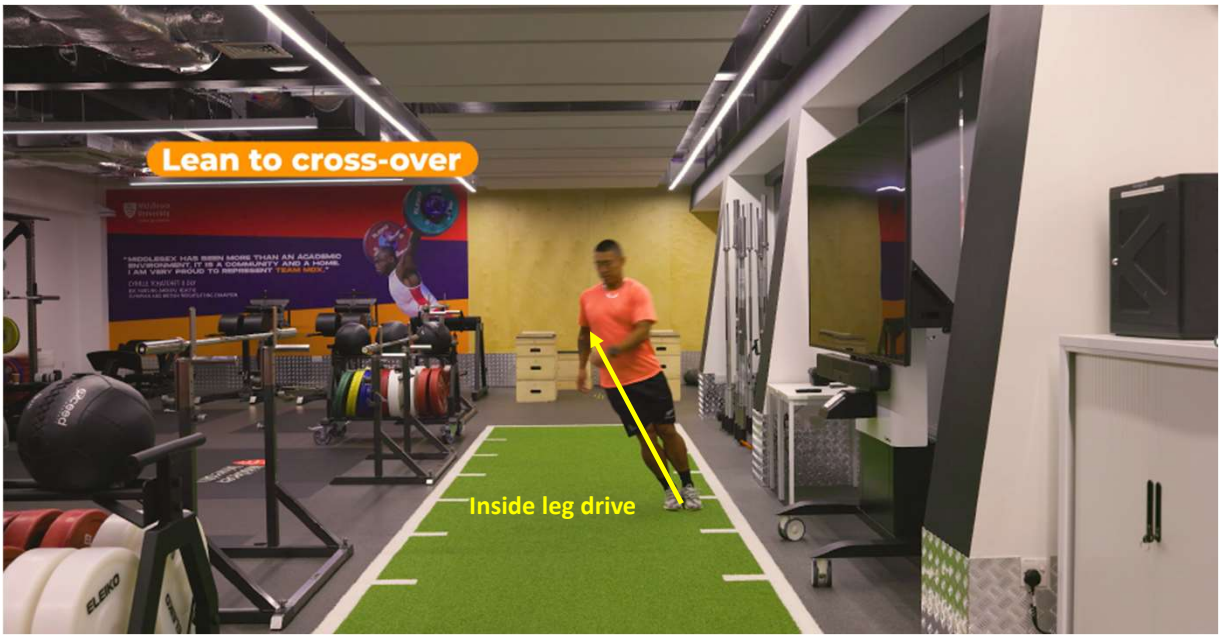



d
c
b
a
e
f
g
h

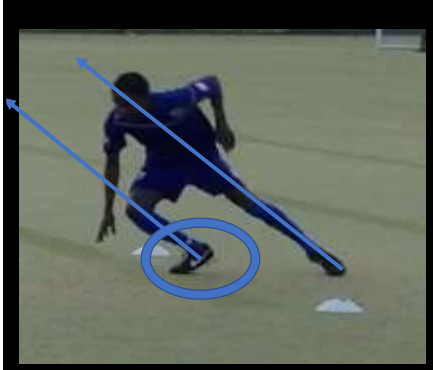

CoM
BoS
DoF


Resisting or Encouraging a CoD

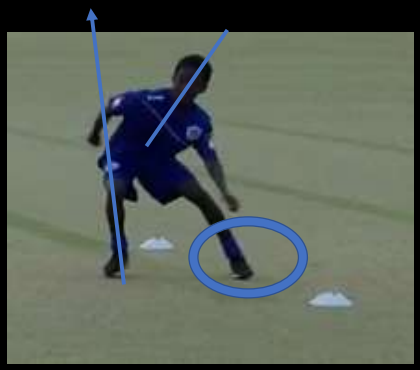

"MIDDLESEX HAS BEEN MORE THAN AN ACADEMIC ENVIRONMENT, IT IS A COMMUNITY AND A HOME. I AM VERY PROUD TO REPRESENT TEAM MDX."
ELEIKO



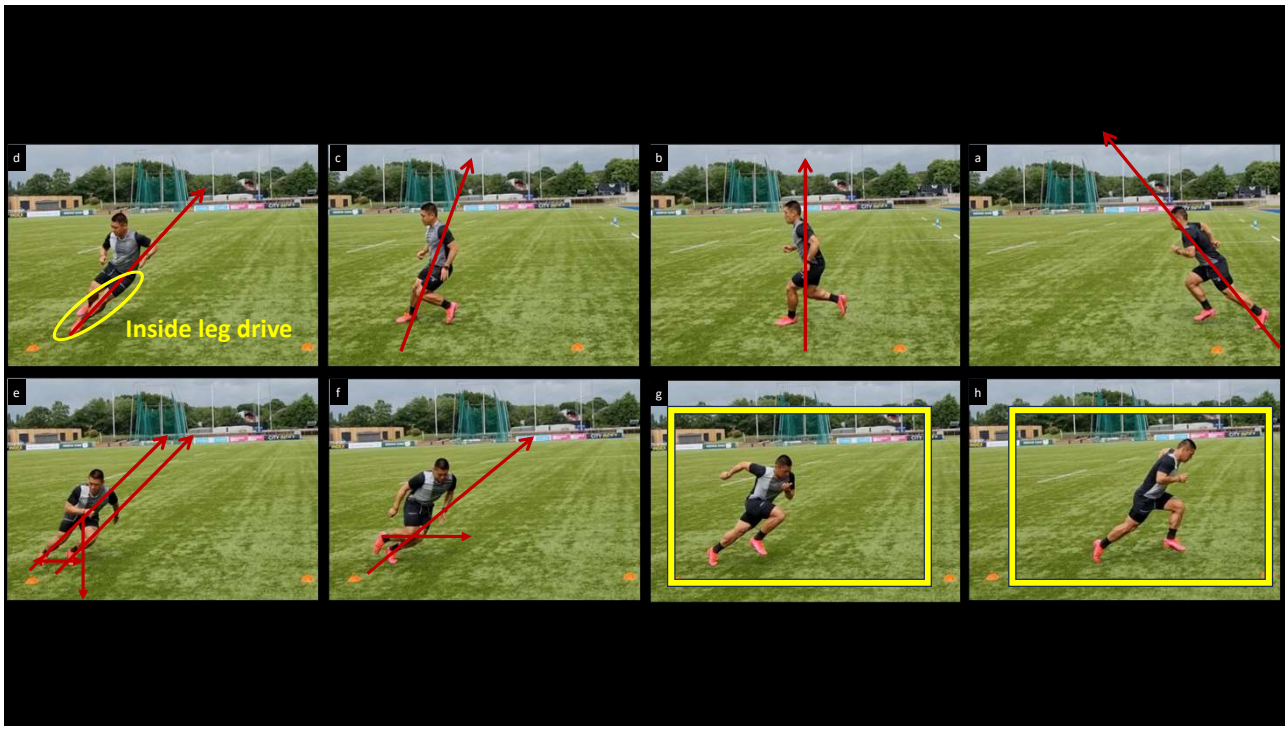
Inside vs. Outside leg



Inside leg

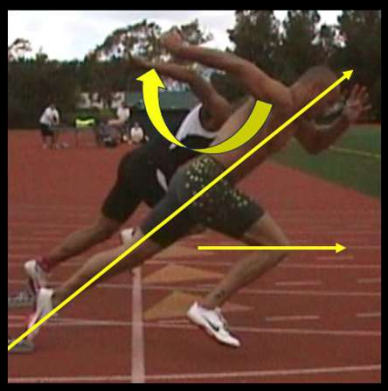


Outside leg

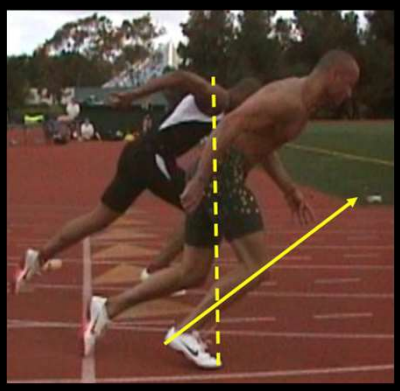

d
c
b
a
Inside leg drive
e
f
g
h

To Summarise

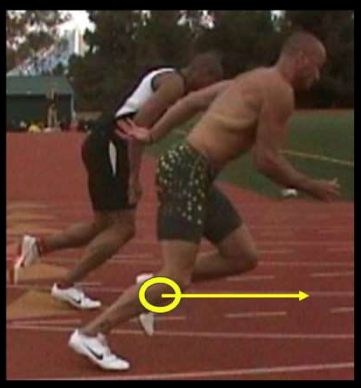
~ 45° lean, knee (~ 90°) through glass, arm snap

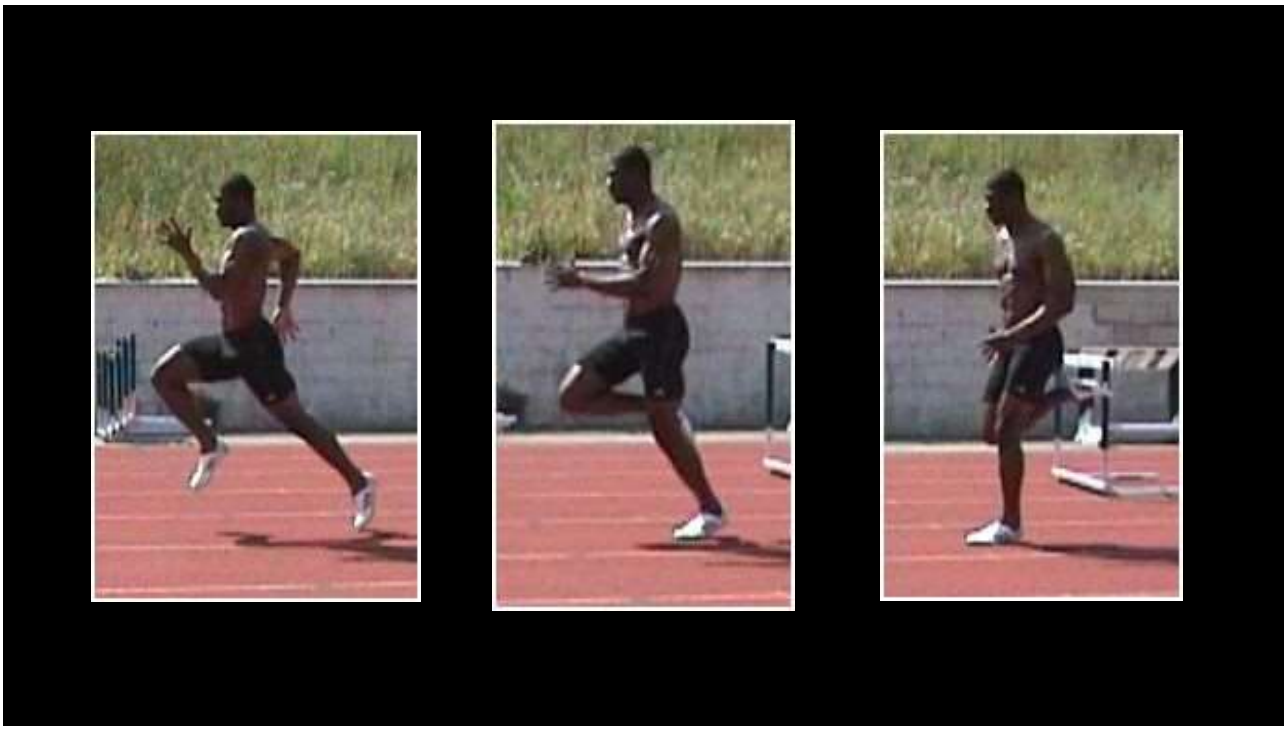


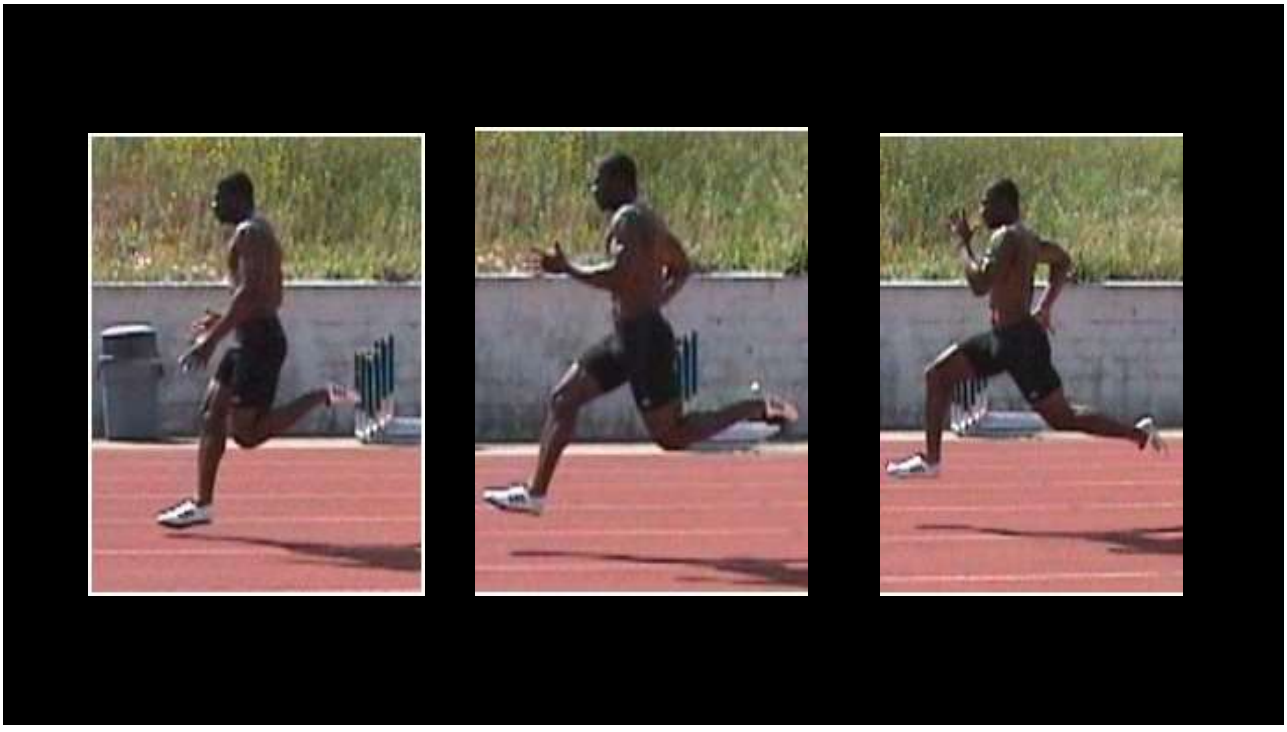
~ Land under hips, +ve shin angle



Low recovery (~ under knee) at ankle cross







High knee
(with Dorsiflexion)

Ankle cross

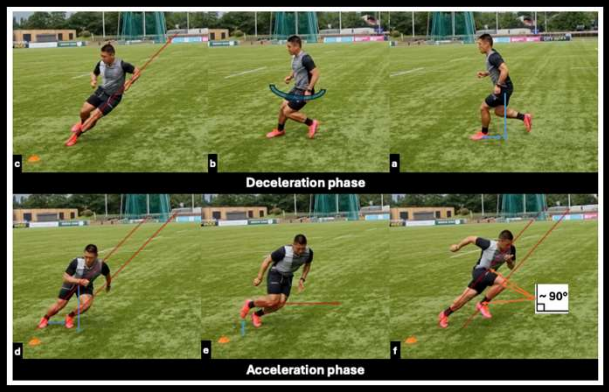
Knee cross at TD

Focus on technique not just time!

Process driven outcome

5-2-180 check sheet

THE FITNESS FORMULA



Phase		Movement sequence	Left Turn	Score	Right Turn	Score
Deceleration	a	Distance between CoM (hips) and CoP (foot) increases as athlete "sits"	Yes ☐ No ☐		Yes ☐ No ☐	
	b	Athlete re-orients themselves into a side-on position	Yes ☐ No ☐		Yes ☐ No ☐	
	c	Penultimate foot contact: inside leg performs a shallow squat with DoF orientated toward intended direction of travel	Yes ☐ No ☐		Yes ☐ No ☐	
Acceleration	d	At final foot contact: - upper body and shins are aligned to direction of travel (~ 45°) - CoM (belly button) falls outside narrow BoS (feet); At turn, "head never goes between toes" - Outside leg "bounces" off ground	Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No ☐		Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No ☐	
	e	Outside leg: - knee drives ~ horizontally forward - foot stays close to ground, and will pass ~ below opposite knee	Yes ☐ No ☐ Yes ☐ No ☐		Yes ☐ No ☐ Yes ☐ No ☐	
	f	Athlete achieves acceleration posture: - ~ 90° at ankle (dorsiflexion) - ~ 90° at knee - ~ 90° at hips - Shins run ~ parallel	Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No ☐		Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No ☐	
Total score (out of 24, 12 points per side)			**Left Total**		**Right Total**	

Principles first

- The Key is to understand the mechanics.
- With this you can train all CoD manoeuvres (e.g., 60°, 90° cut)
- It's about manipulating:
  DoF, BoS and CoM

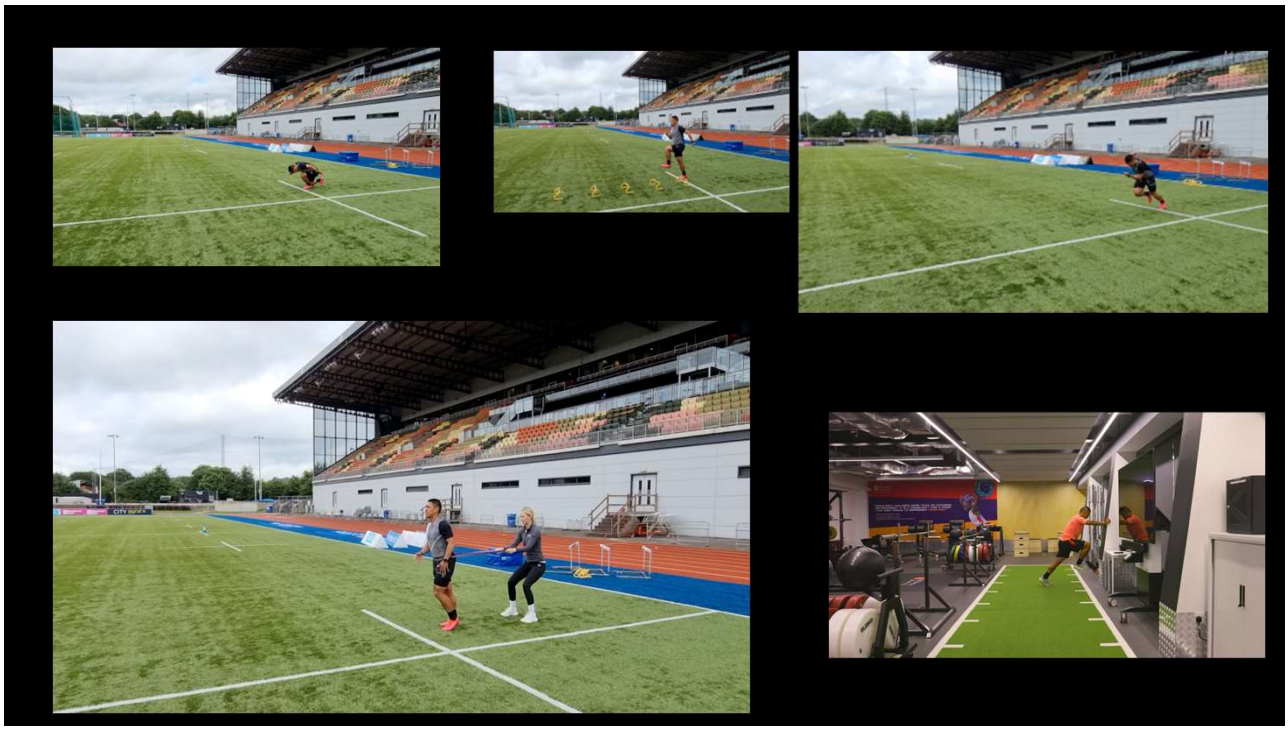
"Head never goes between toes"

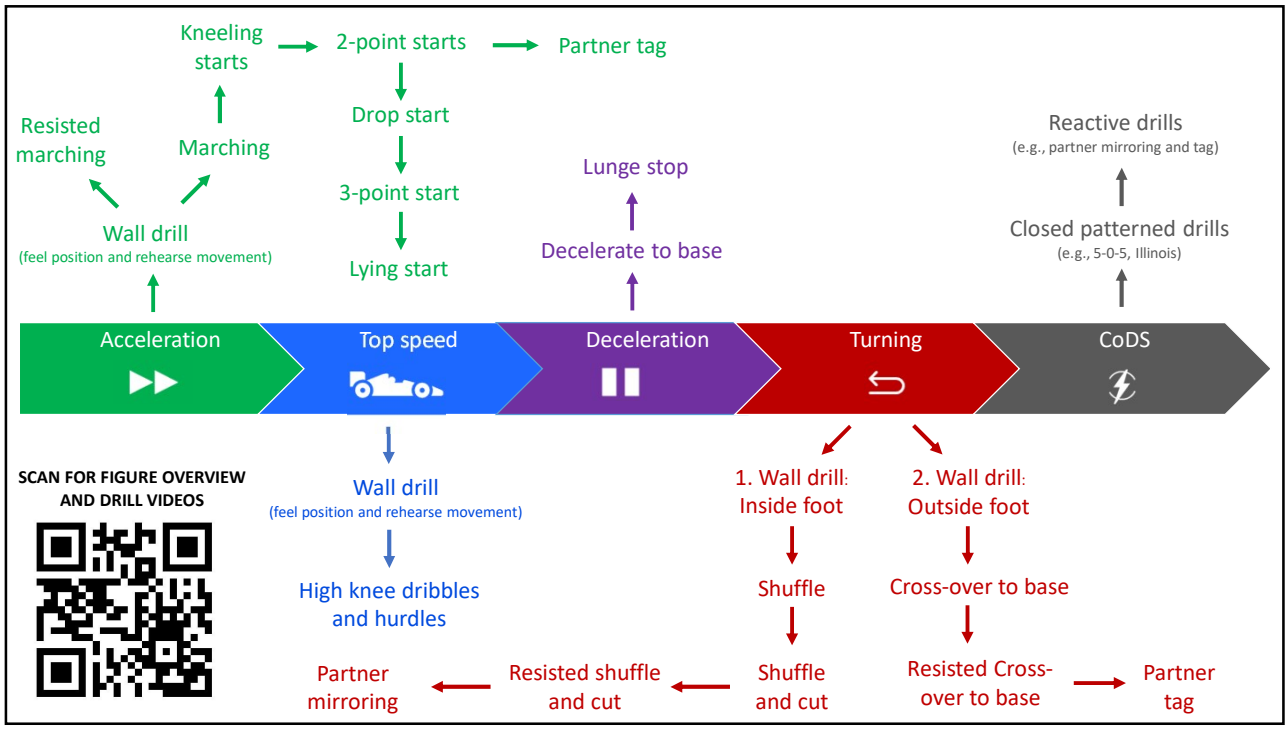


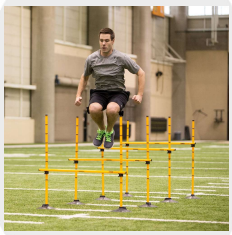


1. Closed
2. Resisted
3. Open
4. Sports context



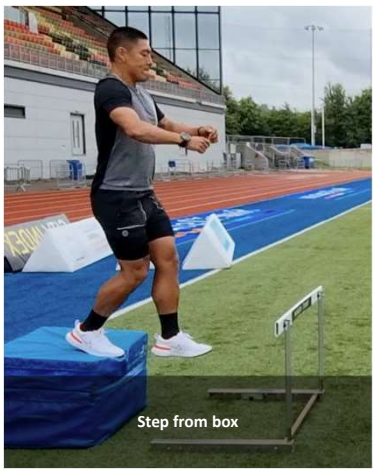


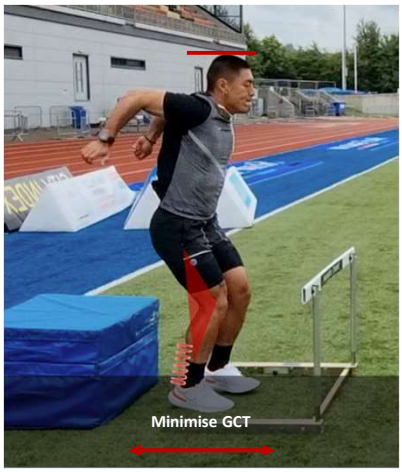

Kneeling starts
2-point starts
Partner tag
Drop start
3-point start
Lying start
Resisted marching
Marching
Wall drill
(feel position and rehearse movement)
Lunge stop
Decelerate to base
Reactive drills
(e.g., partner mirroring and tag)
Closed patterned drills
(e.g., 5-0-5, Illinois)
Acceleration
Top speed
Deceleration
Turning
CoDS
SCAN FOR FIGURE OVERVIEW AND DRILL VIDEOS
Wall drill
(feel position and rehearse movement)
High knee dribbles and hurdles
1. Wall drill: Inside foot
2. Wall drill: Outside foot
Shuffle
Cross-over to base
Partner mirroring
Resisted shuffle and cut
Shuffle and cut
Resisted Cross-over to base
Partner tag

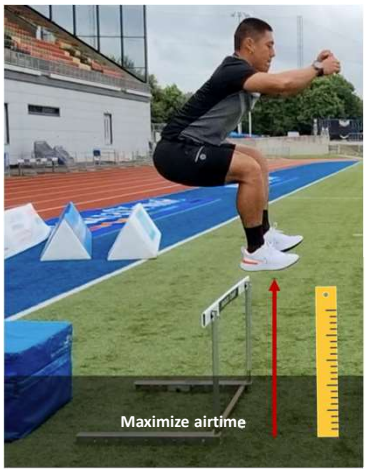


Plyometrics and the Stretch Shortening Cycle

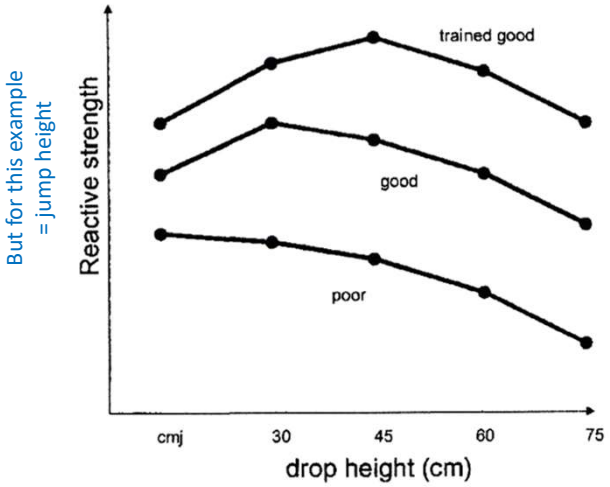
Assessing SSC ability



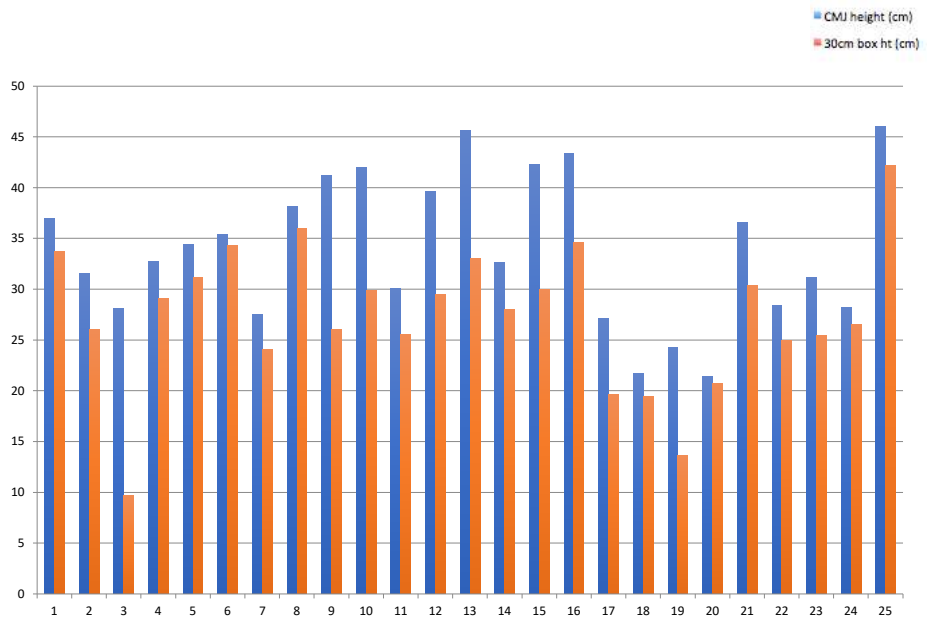


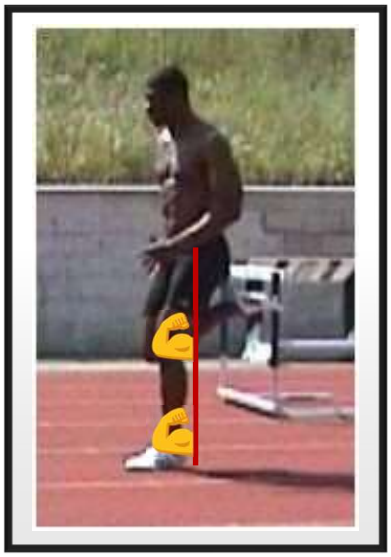


How do you know when your SSC ability is really bad!?

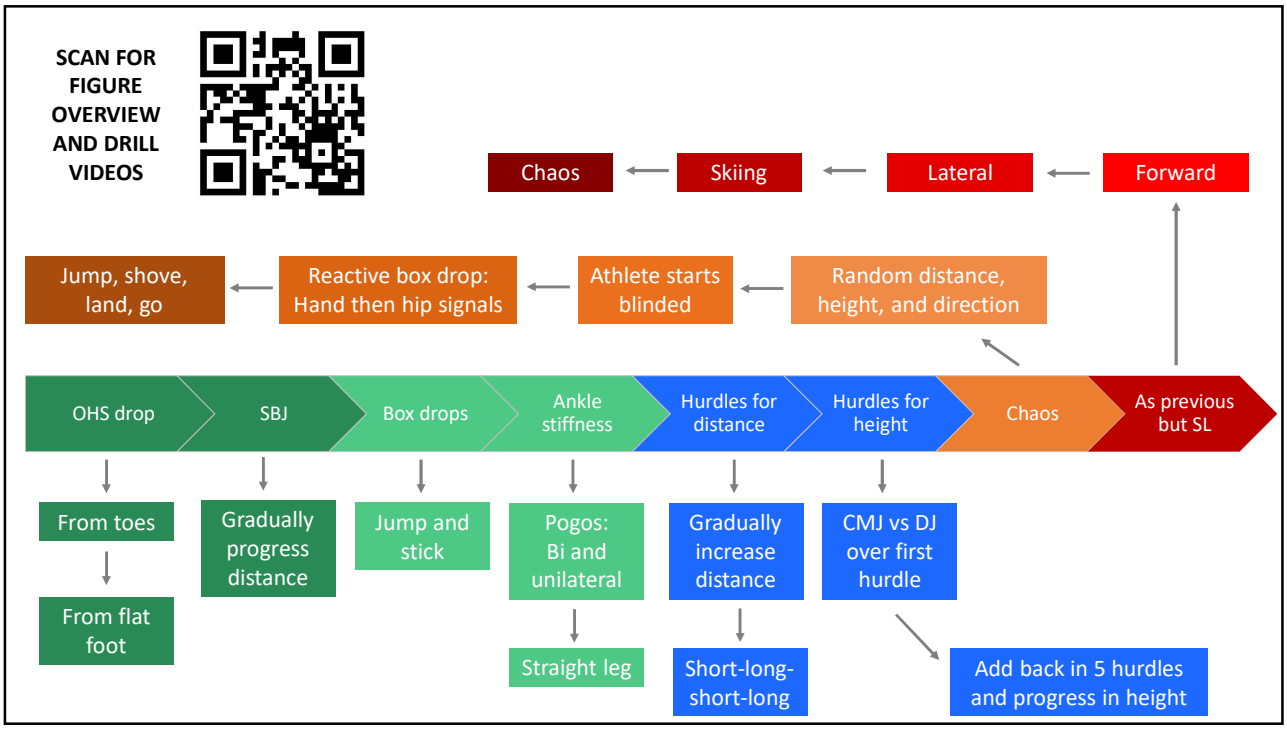


Newton & Dugan (2005)

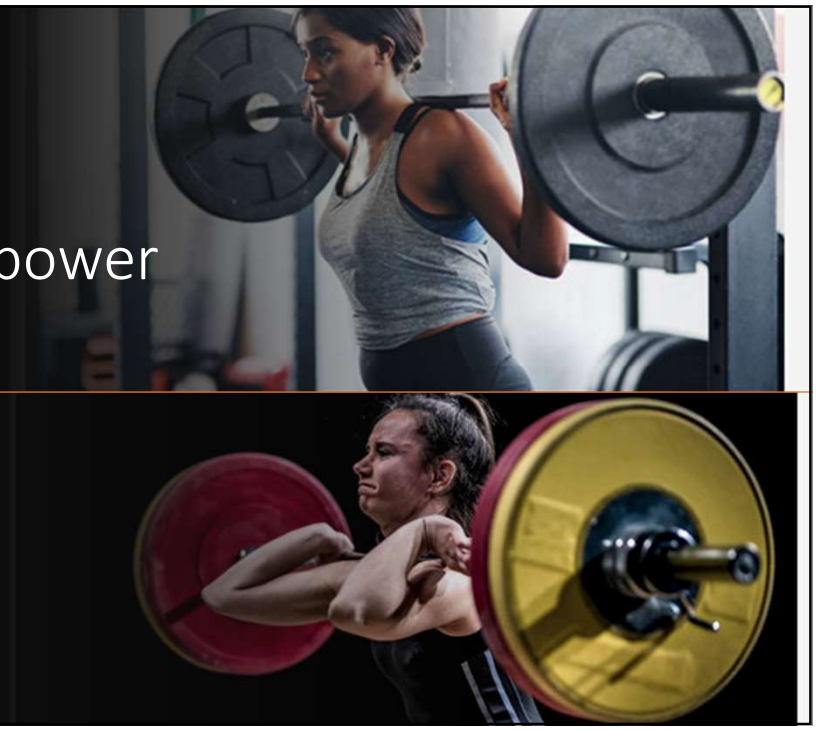




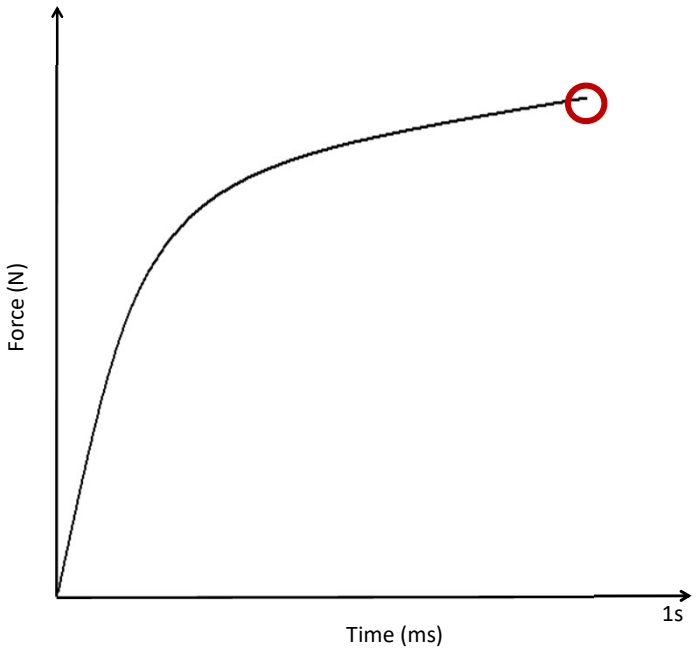

QUICK
SAND


SCAN FOR FIGURE OVERVIEW AND DRILL VIDEOS
Chaos
Skiing
Lateral
Forward
Jump, shove, land, go
Reactive box drop: Hand then hip signals
Athlete starts blinded
Random distance, height, and direction
OHS drop
SBJ
Box drops
Ankle stiffness
Hurdles for distance
Hurdles for height
Chaos
As previous but SL
From toes
From flat foot
Gradually progress distance
Jump and stick
Pogos: Bi and unilateral
Straight leg
Gradually increase distance
Short-long-short-long
CMJ vs DJ over first hurdle
Add back in 5 hurdles and progress in height

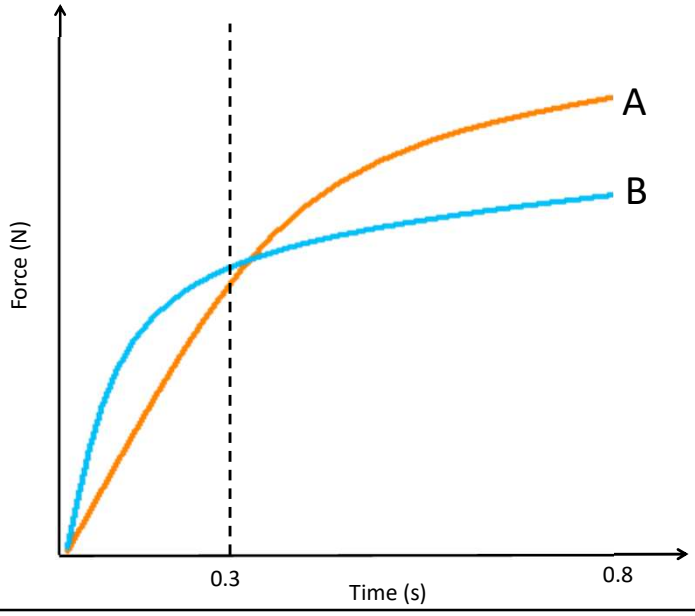
Strength and power training



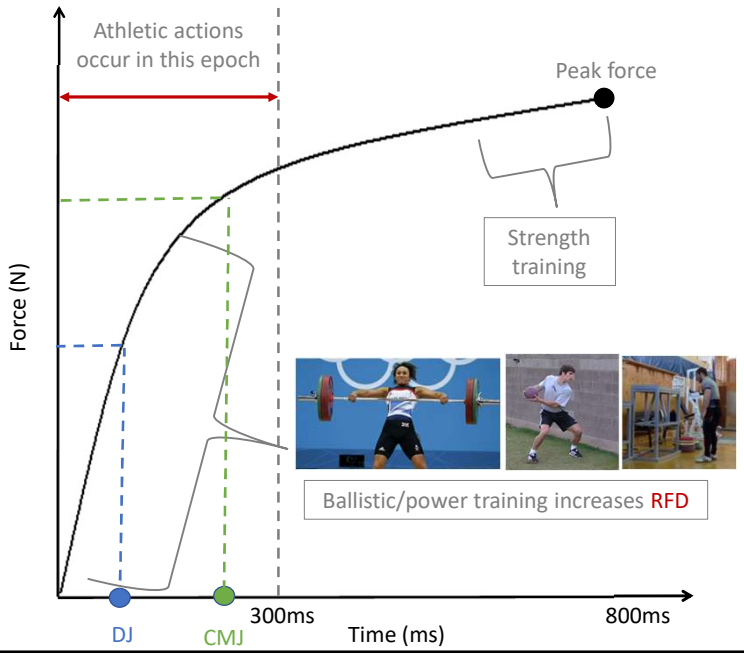
Force – time curve



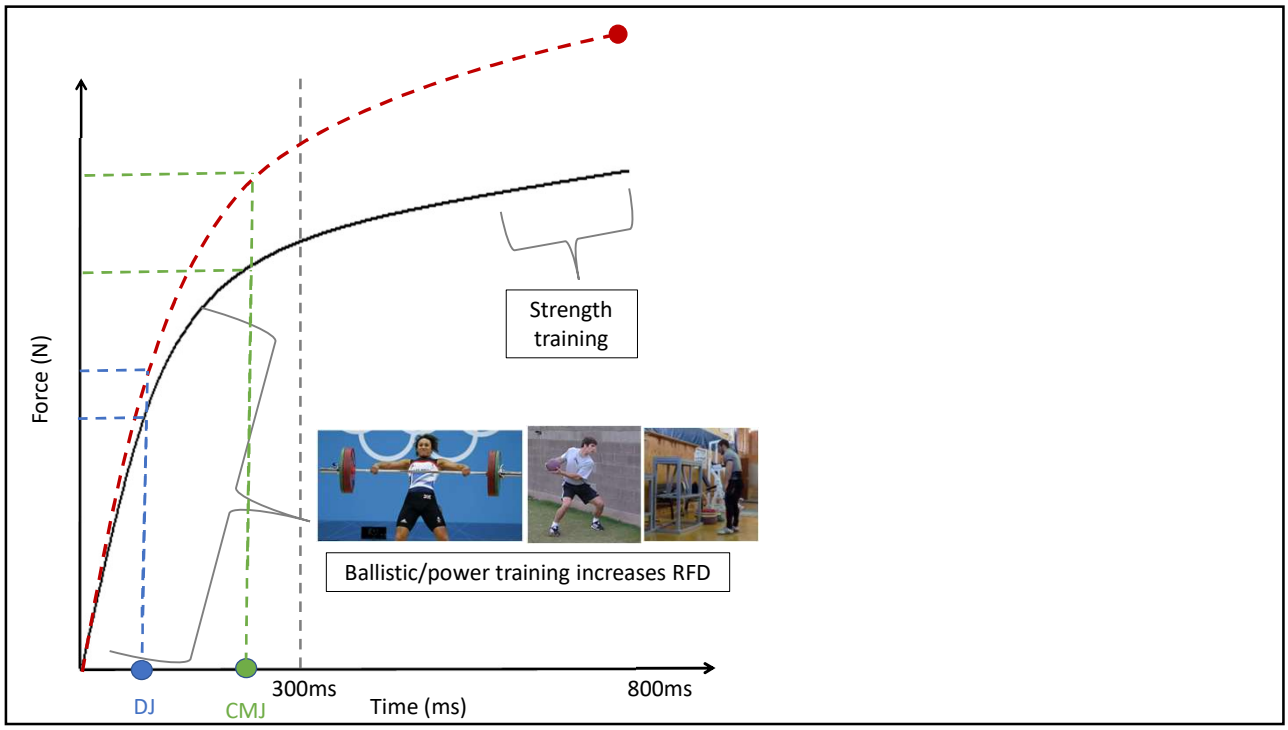
Who would you rather be?

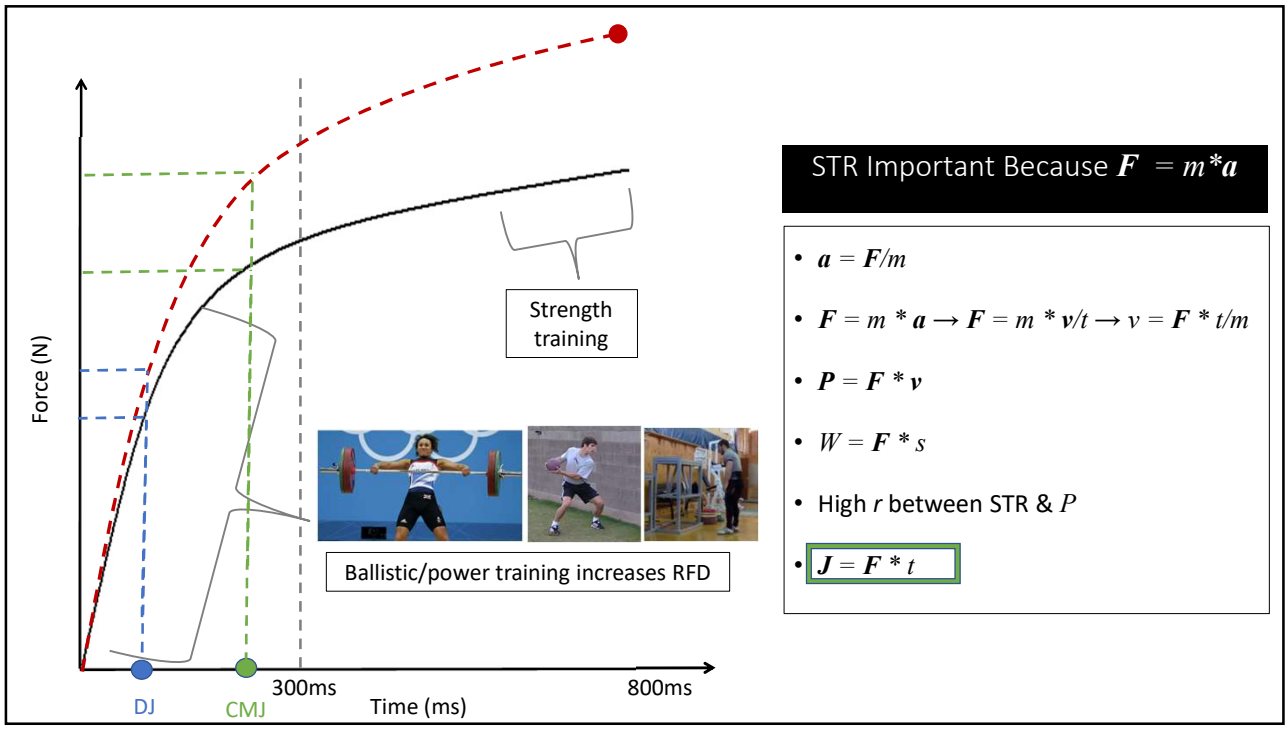


Force – time curve



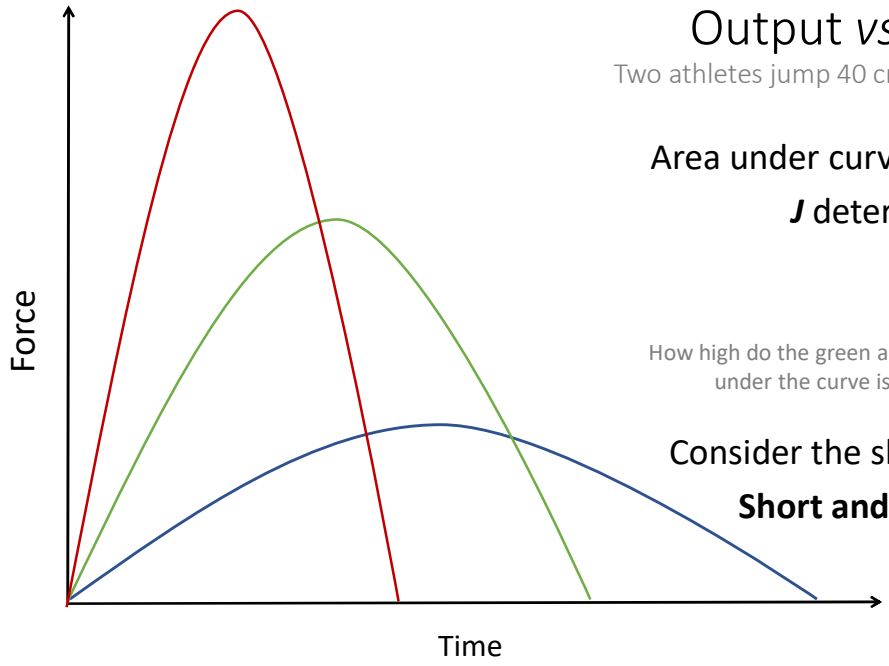
Ballistic/power training increases RFD





STR Important Because $F = m*a$

- $a = F/m$
- $F = m * a \rightarrow F = m * v/t \rightarrow v = F * t/m$
- $P = F * v$
- $W = F * s$
- High *r* between STR & P
- $J = F * t$



Output *vs.* strategy

Two athletes jump 40 cm, who is the best!? 😐

Area under curve = impulse (***J***) = ***F****t*

J determines jump height

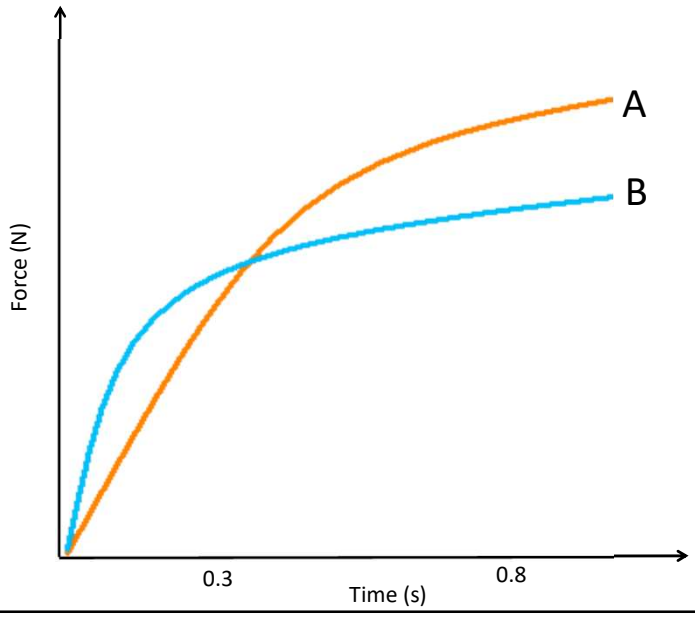
F*t* = 40 cm

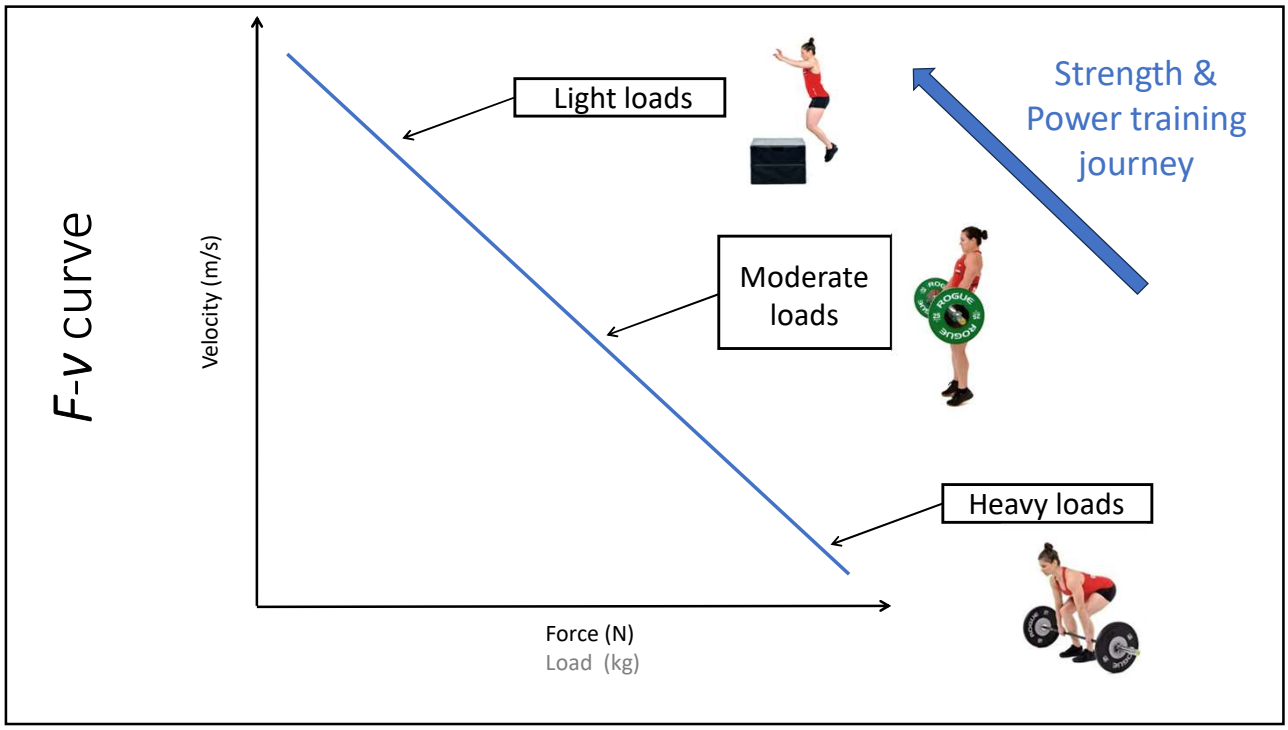
How high do the green and red athlete jump if the area under the curve is the same as the blue athlete's

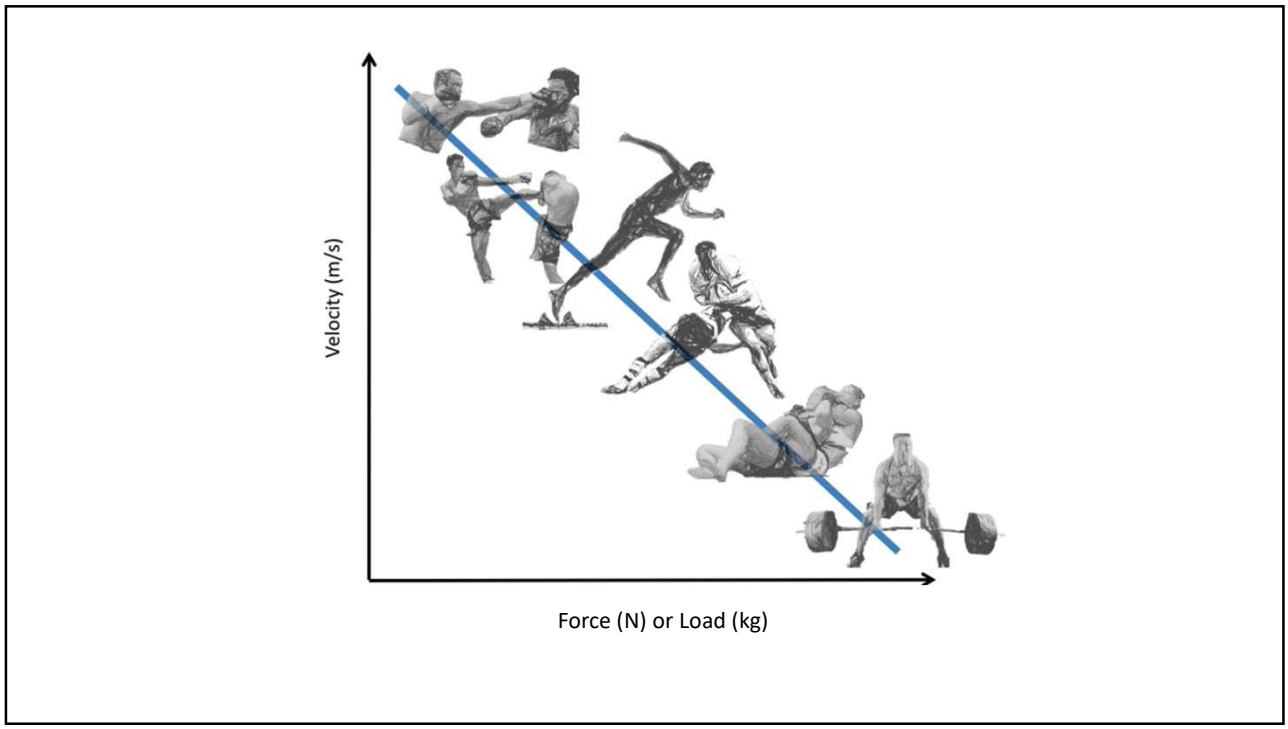
Consider the shape of the impulse

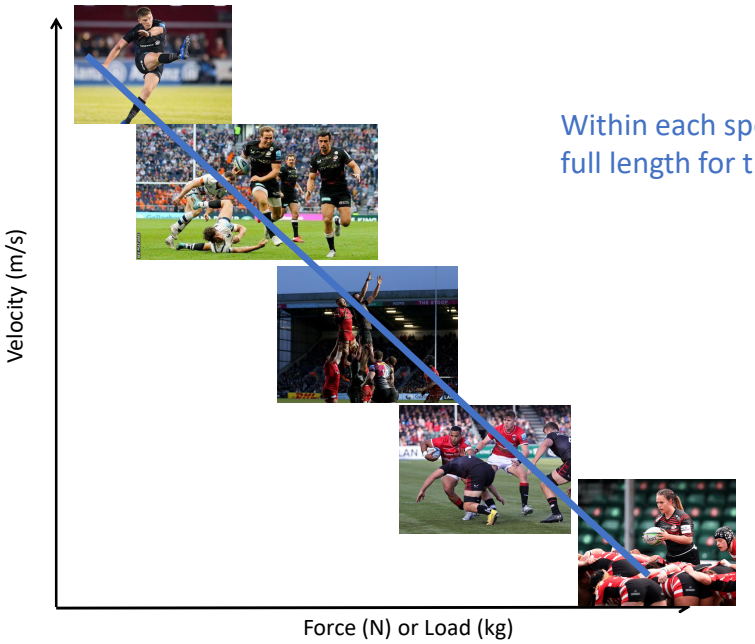
Short and fat *vs.* tall and thin

Should they train strength or P ?

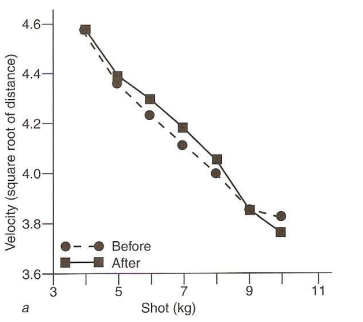


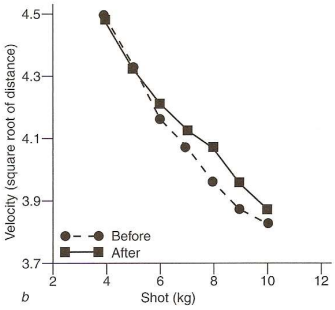

F-v curve
Velocity (m/s)
Force (N)
Load (kg)
Light loads
Moderate loads
Heavy loads
Strength & Power training journey

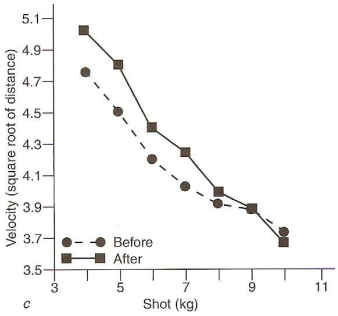

Velocity (m/s)
Force (N) or Load (kg)



Within each sport we travel the full length for the **F**-*v* curve

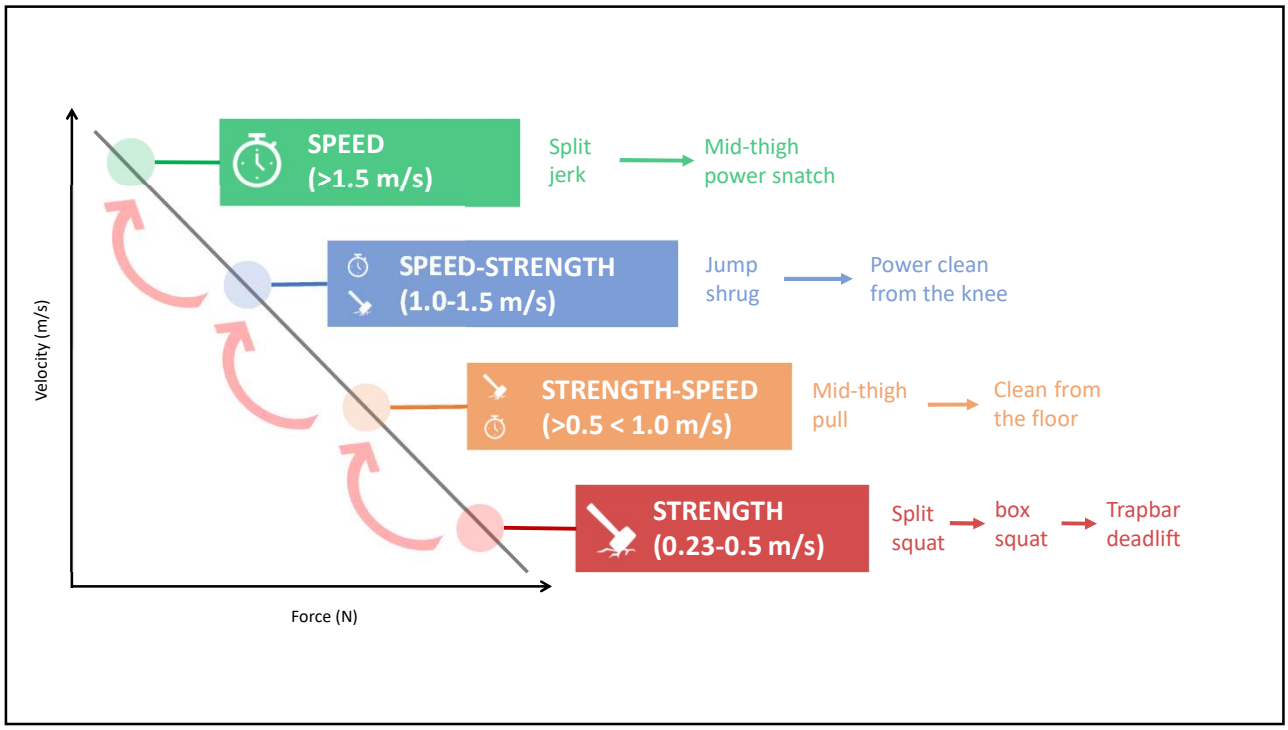


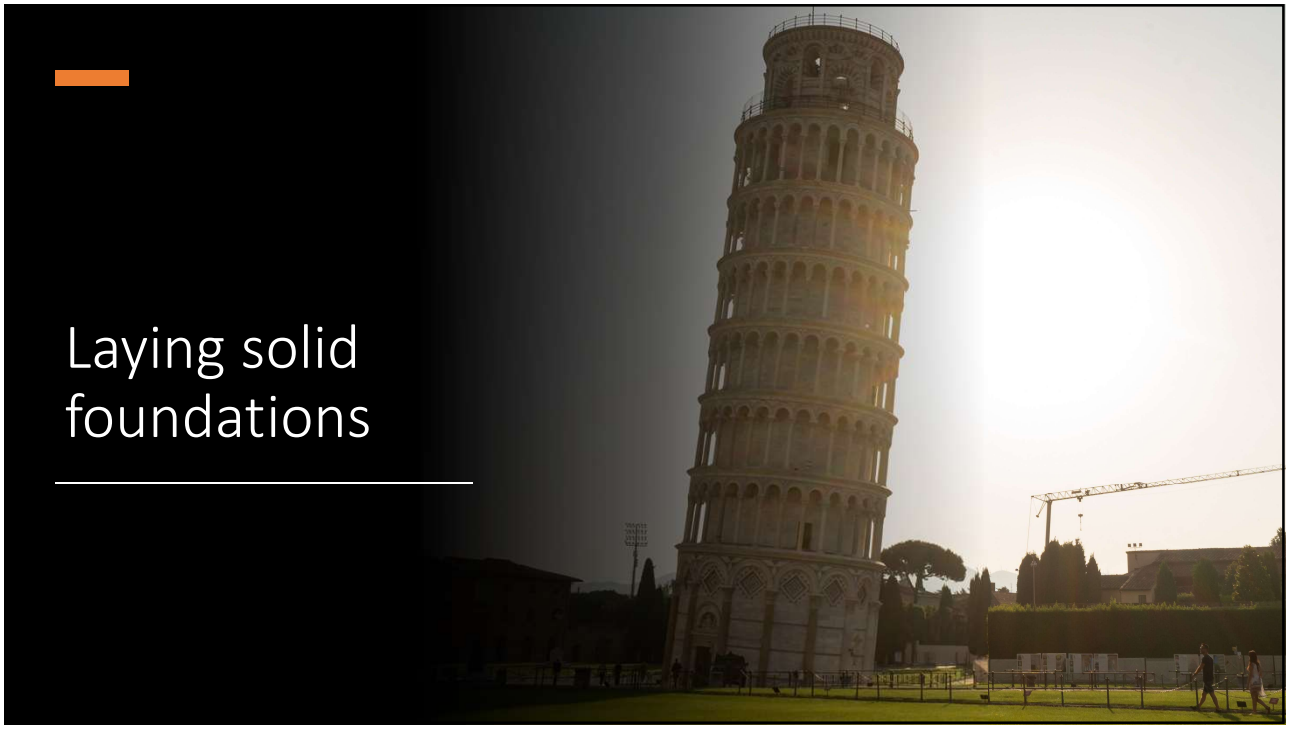




Shot-putting

Which graph is which?
Heavy, light or standard?


SPEED
(>1.5 m/s)
Split jerk
Mid-thigh power snatch
SPEED-STRENGTH
(1.0-1.5 m/s)
Jump shrug
Power clean from the knee
STRENGTH-SPEED
(>0.5 < 1.0 m/s)
Mid-thigh pull
Clean from the floor
STRENGTH
(0.23-0.5 m/s)
Split squat
box squat
Trapbar deadlift
Velocity (m/s)
Force (N)



Laying solid foundations

What's the best squat!?

Mobility, stability, and form

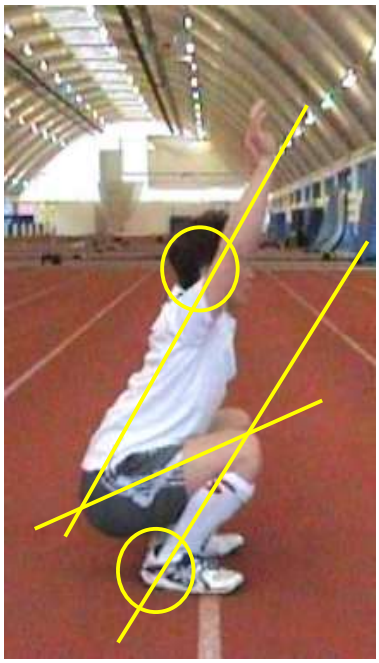
OVERHEAD SQUAT FOR MOVEMENT SCREENING ISSUE 12 / SEPTEMBER 2014

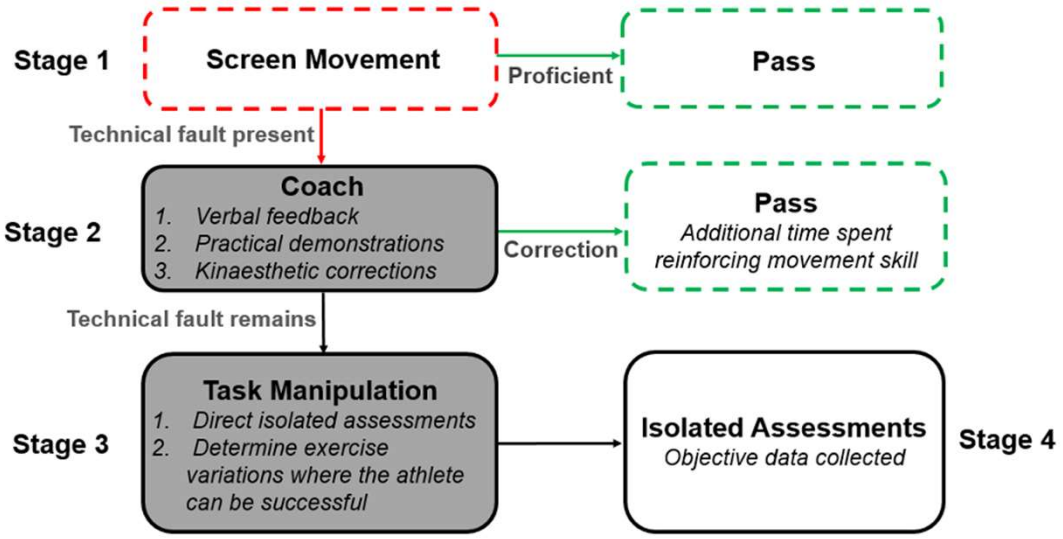
Screening movement dysfunctions using the overhead squat

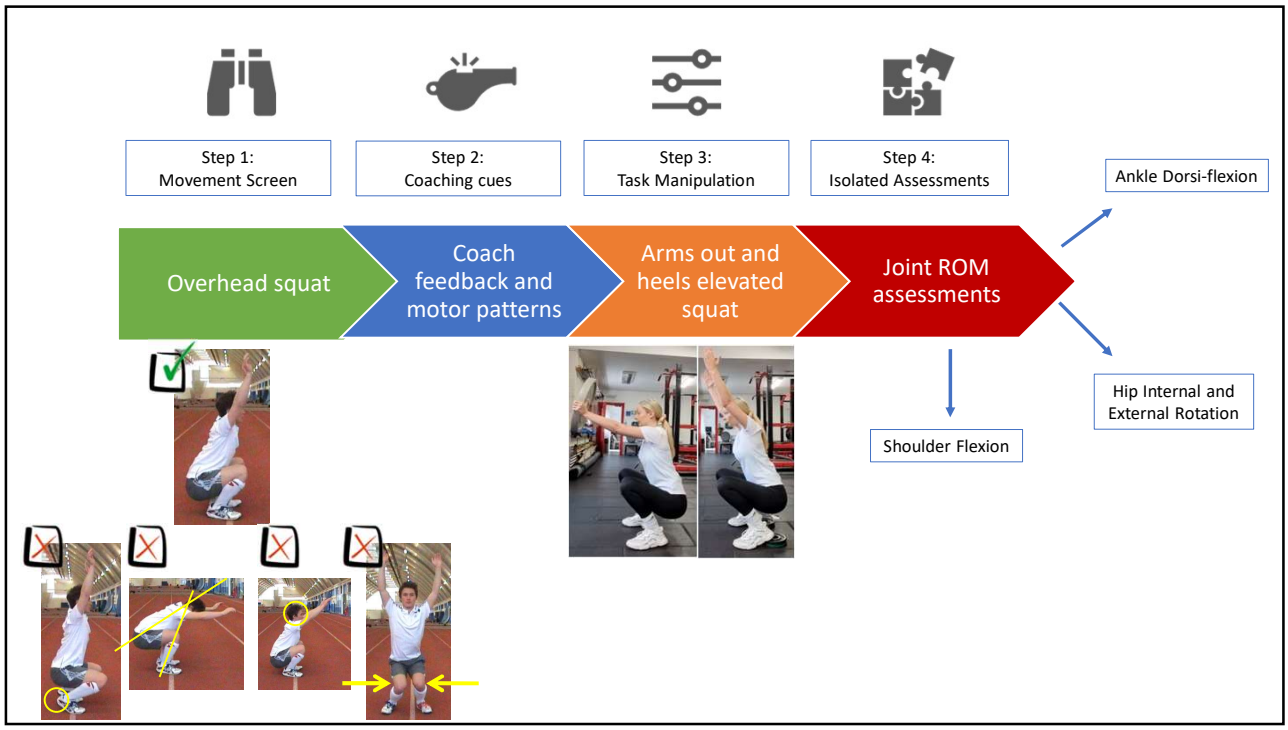
By Chris Bishop, MSc, PGCHE, ASCC, Mike Edwards MSc, ASCC, and Anthony Turner, PhD, MSc, ASCC, CSCS*D,
London Sport Institute, Middlesex University

Table 3. Proposed grading criteria for the overhead squat assessment (guided by suggestions from the NASM) [9,10]

JOINT	COMPENSATION	LEFT	RIGHT	NOTES
Foot/ankle	External rotation	○	○	
	Feet flatten	○	○	
	Heel raise	○	○	
Knee	Valgus	○	○	
	Varus	○	○	
LPHC	Forward lean	○		
	Lumbar arching	○		
	Lumbar rounding	○		
Shoulder	Arms fall forward	○	○	
	Elbows flex	○	○	
Head	Protruding	○		
Score: Left/Right				
Total score:				





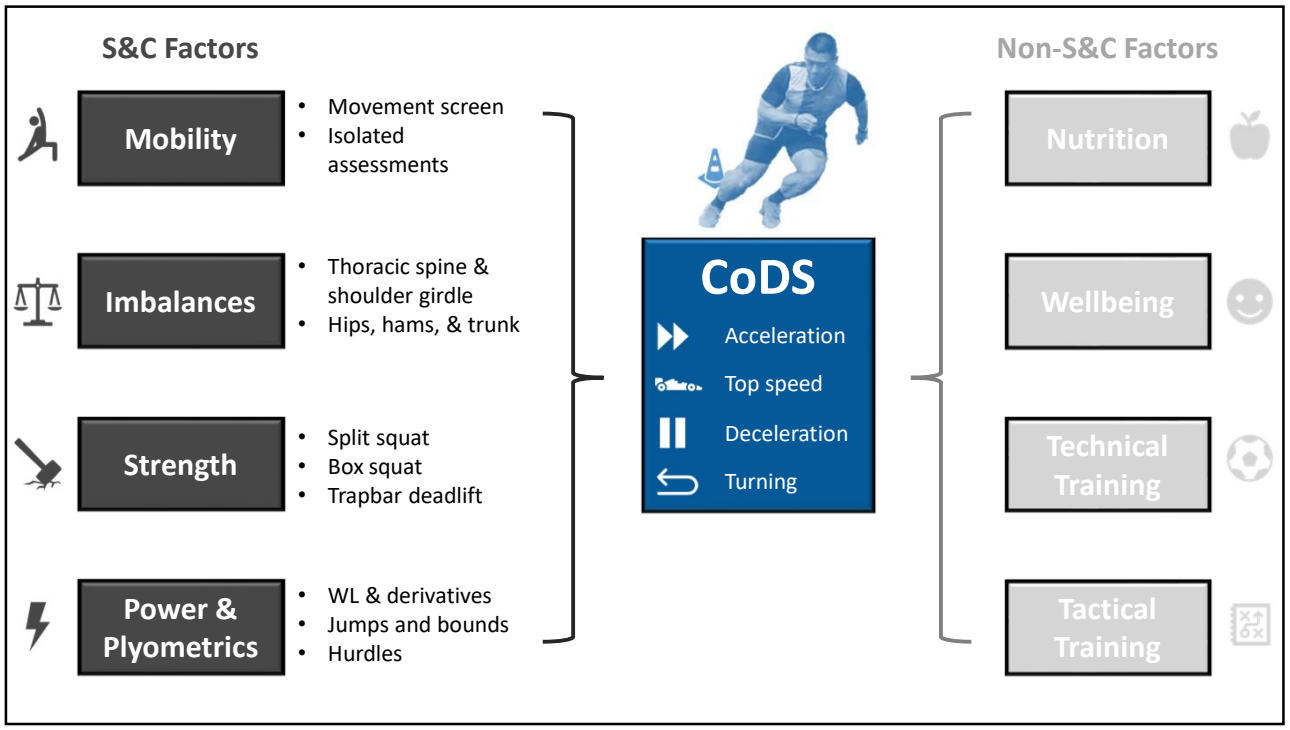


In Conclusion…

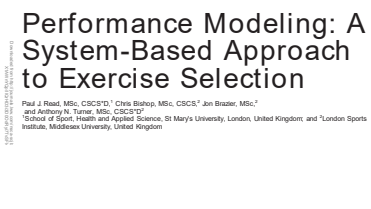
The theoretical or biological basis for how we move and respond to exercise stimuli, coupled with an understanding of how these are best sequenced such that one stimuli and subsequent adaptation can potentiate the next, is a means of devising effective and efficient training plans

Such an approach likely gives our athletes the best chance of attaining their goal

So, consider reverse engineering your performance outcomes



Recommended Reading ☺


Performance Modeling: A System-Based Approach to Exercise Selection

Paul J. Read, MSc, CSCS*D,[1] Chris Bishop, MSc, CSCS,[2] Jon Brazier, MSc,[2] and Anthony N. Turner, MSc, CSCS*D[1]
[1]School of Sport, Health and Applied Science, St Mary's University, London, United Kingdom; and [2]London Sports Institute, Middlesex University, United Kingdom


Building a High-Performance Model for Sport: A Human Development-Centered Approach

Anthony N. Turner, PhD,[1] Chris Bishop, MSc,[1] Jon Crew, MSc,[1] Paul Cain,[2] Andy McCann,[3] Brett Bartholomew, MSEd, CSCS*D, RSCC*D,[4] and Laurence Halsted[5]
[1]Faculty of Science and Technology, London Sports Institute, Middlesex University, London, United Kingdom; [2]Human Performance Lead, UK Military; [3]Department of Psychology, Faculty of Health, Psychology and Social Care, Manchester Metropolitan University, Manchester, United Kingdom; [4]The Bridge Human Performance and The Art of Coaching; and [5]Danish Fencing Federation, Copenhagen, Denmark


Reverse Engineering in Strength and Conditioning: Applications to Agility Training

Anthony N. Turner, PhD,[1] Paul Read, PhD,[2] Luca Manolron, MSc,[1] Shyam Chavda, MSc,[1] Xiang Yao, MSc,[1] Kostas Papadopoulos, PhD,[1] Adam Virgin, MSc,[1] Alrow Spiegelhalter, MSc, and Chris Bishop, PhD[1]
[1]London Sports Institute, Middlesex University, London, United Kingdom; [2]Institute of Sport, Exercise and Health (ISEH), London, United Kingdom; and [3]College of Nursing and Health Sciences, University of Vermont, Burlington, Vermont

Recommended Reading:

Power and underpinning mechanics

Developing Powerful Athletes, Part 1: Mechanical Underpinnings

Anthony N. Turner, PhD,[1] Paul Comfort, PhD,[2] John McMahon, PhD,[2] Chris Bishop, MSc,[1] Shyam Chavda, MSc,[1] Paul Read, PhD,[3,4] Peter Mundy, PhD,[5] and Jason Lake, PhD[6]
[1]London Sports Institute, Middlesex University, Greenlands Lane, United Kingdom; [2]University of Salford, School of Health and Society, Salford, United Kingdom; [3]Aspetar Aspetar Orthopaedic and Sports Medicine Hospital, Doha, Qatar; [4]Centre for Exercise and Sports Science Research, Edith Cowan University, Joondalup, Australia; [5]Coventry University, Coventry, United Kingdom; and [6]Chichester Institute of Sport, University of Chichester, Chichester, United Kingdom

Developing Powerful Athletes Part 2: Practical Applications

Anthony N. Turner, PhD,[1] Paul Comfort, PhD,[2,3] John McMahon, PhD,[2] Chris Bishop, MSc,[1] Shyam Chavda, MSc,[1] Paul Read, PhD,[4] Peter Mundy, PhD,[5] and Jason Lake, PhD[6]
[1]London Sports Institute, Middlesex University, London, United Kingdom; [2]School of Health and Society, University of Salford, Salford, United Kingdom; [3]Centre for Exercise and Sports Science Research, Edith Cowan University, Joondalup, Australia; [4]Aspetar Aspetar Orthopaedic and Sports Medicine Hospital, Doha, Qatar; [5]Coventry University, Priory Street, Coventry, United Kingdom; and [6]Chichester Institute of Sport, University of Chichester, Chichester, United Kingdom

Q's?