Theory of Monitoring Annual Training Progression with Physical Testing to Prevent Injury and Improve Performance

By Troy Purdom, PhD & Kyle Levers, PhD CSCS

The Science of Sustained Excellence

July 22, 2017

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The Problem

- Youth sports is on the rise with estimated 30mil youth participating
- High School Sports
  - 2million injuries
  - 500k doctors visits
  - 30k hospitalizations

- Overuse/non contact injuries account for ½ of all injuries in middle school and high school sports

½ OF ALL INJURIES CAN BE PREVENTED!

-JS Powell, KD Barber Foss, 1999.
-Preserving the Future of Sport: From Prevention to Treatment of Youth Overuse Sports Injuries. AOSSM 2009 Annual Meeting

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Time Course of Testing

- When should you test?
  - **FREQUENTLY**
- When should you start testing?
  - Baseline

STUDY PROTOCOL TIMELINE OVERVIEW												
	Block 1		Block 2		Block 3		Block 4		Block 5		Block 6	
	November (Post-Season)		*January (Pre-Spring Season)*		*April (Post-Spring Season)*		*August (Pre-Season)*		*September (Mid-Season)*		*November (Post-Season)*	
Test	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
Protocol/Consent Review												
Concent/HIPPA Form	X											
Health History Form	X											
Urine Pregnancy	X		X		X		X		X		X	
Height	X		X		X		X		X		X	
Weight	X		X		X		X		X		X	
Body Composition (skinfold)	X		X		X		X		X		X	
Vertical Jump	X		X		X		X		X		X	
Aerobic Capacity ($VO_{2\ max}$)	X		X		X		X		X		X	
Deep Squat Mobility		X		X		X		X		X		X
Y-balance		X		X		X		X		X		X
T-Test Agility		X		X		X		X		X		X
40yd Sprint		X		X		X		X		X		X
RAST		X		X		X		X		X		X
Time Investment/Participant	80min	55min	65min	55min	65min	55min	65min	55min	65min	55min	65min	55min

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Data Standards

- What do you compare your measurements with?
  - Anything relevant that you can find
  - Your top/peak athletes
    - Ask yourself: what do you want your athletes to look, act, perform like- and work to replicate it.

Data Standards cont.

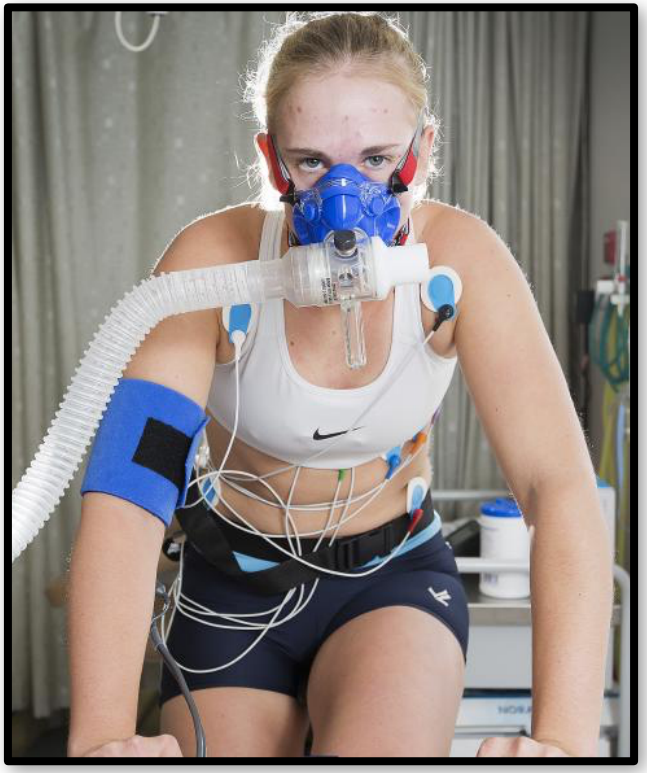
Table 1. Normative data for male and female horizontal jumpers

		Male		Female	
		Mean	SD	Mean	SD
Body Weight	(N)	766	77	612	57
Speed 0-40m	(s)	4.82	0.12	5.45	0.16
Strength (Isometric Squat)					
Peak Force	(N)	4476	803	2727	588
Peak Force / BW		5.85	0.81	4.47	0.93
RFD (150ms)	(N/s)	8852	3057	5264	2695
Power (Vertical Jump Tests)					
Squat Jump	(m)	0.44	0.10	0.36	0.04
CMJ	(m)	0.52	0.07	0.39	0.05
Drop Jump 20m	(m)	0.48	0.08	0.37	0.05
RI	RI	2.77	0.68	2.47	0.54
Contact time	(s)	0.24	0.07	0.23	0.06
Drop Jump 40 cm	(m)	0.50	0.09	0.38	0.05
RI	RI	2.71	0.69	2.56	0.58
Contact time	(s)	0.25	0.07	0.23	0.06
Horizontal Jumps					
Standing LJ	(m)	2.99	0.18	2.44	0.16
4 Bounds + Jump	(m)	16.05	1.00	12.88	0.62

The Solution

- Monitoring Athletes is indicated
  - Most sports require a multitude of skills and abilities

1. Aerobic Capacity- VO2max



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    4. Body Composition- Muscle & Fat Ratio

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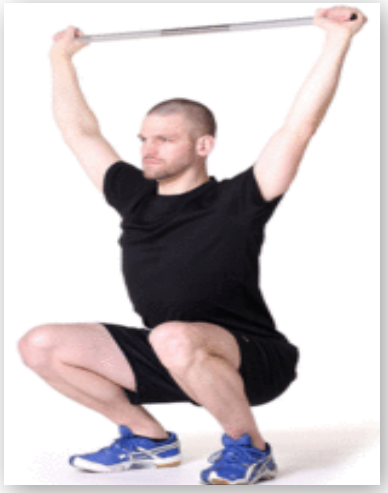
The Solution

- Monitoring Athletes is indicated
  - Most sports require a multitude of skills and abilities
    1. Aerobic Capacity- VO2max
    2. Muscle Power- Sprinting/Jumping/Agility
    3. Muscle Endurance- Resistance to Fatigue
    4. Body Composition- Muscle & Fat
    5. Flexibility/ Mobility- Range of Motion



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AND THEY NEED TO BE MONITORED FREQUENTLY!!!

Reality Check: Monitoring at the Professional Level

Wolverhamption Wanderers: English Champions League Team

Science for Sport: Wolves Testing Protocol

Testing Aerobic Capacity

- Maximum rate at which an athlete can produce energy with the availability of oxygen
- Usually referred to as aerobic power

- VO_2 Max

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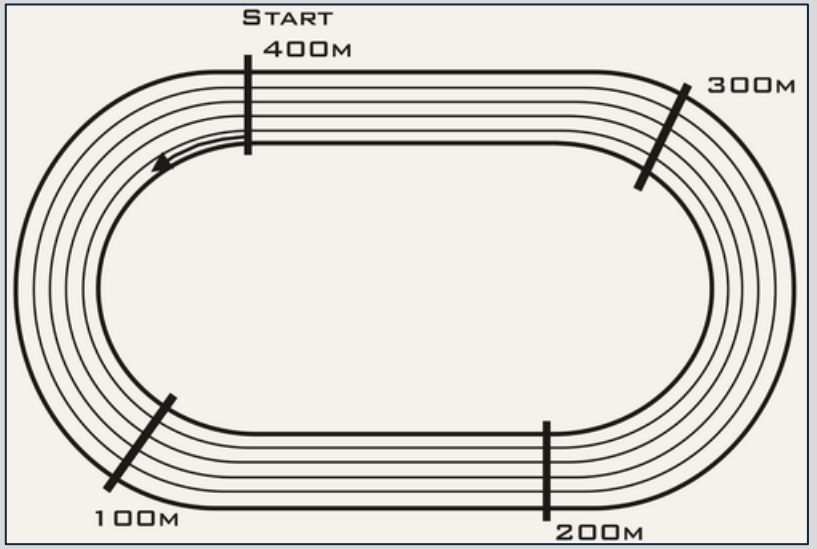
Testing Aerobic Capacity [Field-Based Testing]

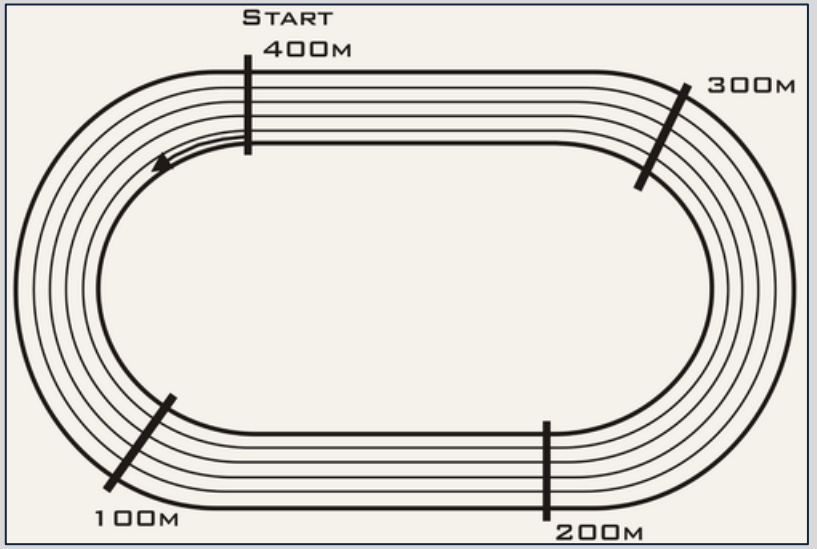
- Maximum rate at which an athlete can produce energy with the availability of oxygen



- 12-Minute Run (Cooper Test)
  - This test should be performed on a 400 meter track or flat course with markers every 100 m.
  - Athletes travel as far as possible in 12 minutes.

Testing Aerobic Capacity [Field-Based Testing]

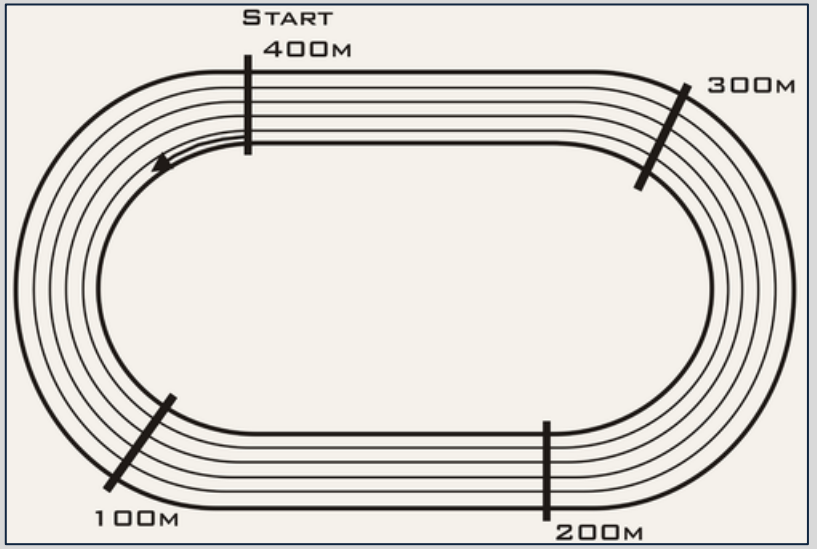
- Maximum rate at which an athlete can produce energy with the availability of oxygen



- 12-Minute Run (Cooper Test)
  - Calculation of Results: **Total Distance**
    - **Distance or # of miles completed**

Testing Aerobic Capacity [Field-Based Testing]

- Maximum rate at which an athlete can produce energy through oxidation of energy resources (carbohydrates, fats, and proteins)

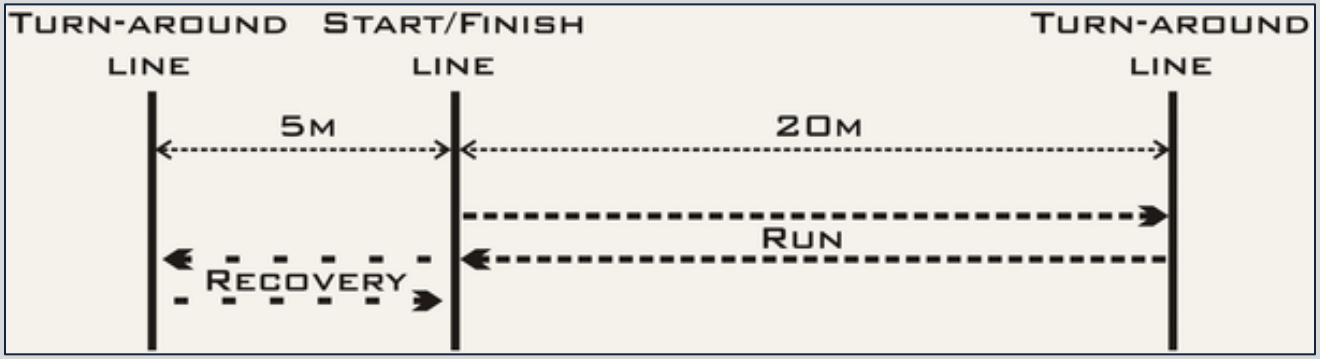


- 12-Minute Run (Cooper Test)
  - Calculation of Results: **Total Distance**
    - Distance completed (e.g., 5.25 laps × 400 m = 2,100 m)
    - Remember: 1 meter = 0.000621 miles
  - Calculation of Results: **VO_2 max (ml/kg/min)**
    - (# of miles completed x 35.97) – 11.29

Testing Aerobic Capacity [Field-Based Testing]

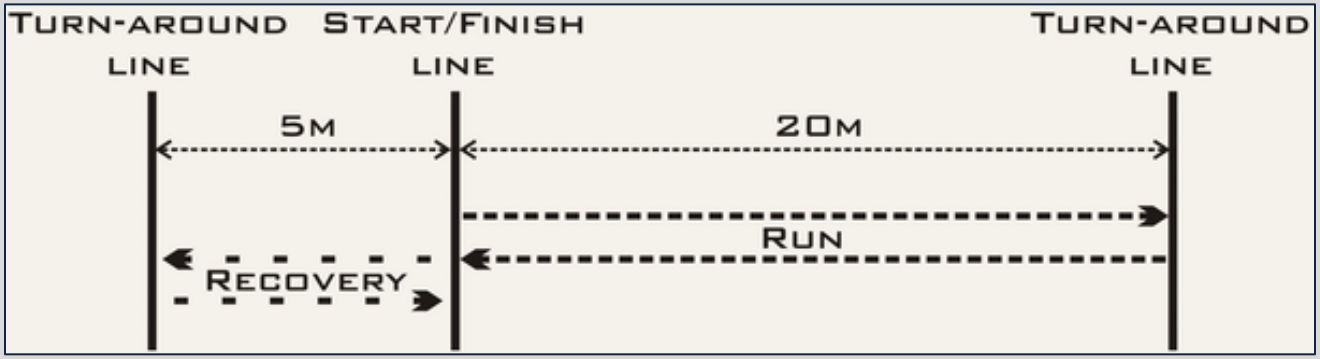
- Maximum rate at which an athlete can produce energy with the availability of oxygen

- Yo-Yo Intermittent Recovery Test



Testing Aerobic Capacity [Field-Based Testing]

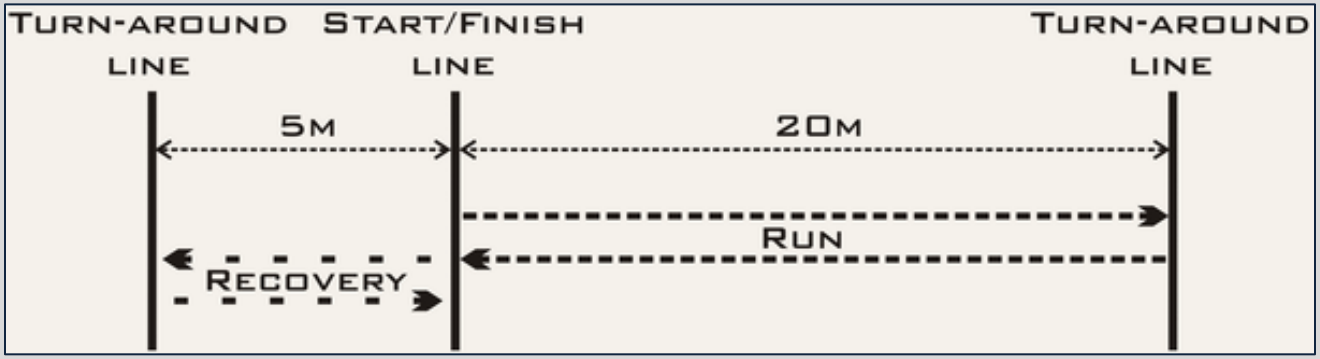
- Maximum rate at which an athlete can produce energy through oxidation of energy resources (carbohydrates, fats, and proteins)
- Yo-Yo Intermittent Recovery Test
  - Calculation of Results: **Total Distance**
    - # of shuttles completed x 40 meters



Testing Aerobic Capacity [Field-Based Testing]

- Maximum rate at which an athlete can produce energy through oxidation of energy resources (carbohydrates, fats, and proteins)

- Yo-Yo Intermittent Recovery Test
  - Calculation of Results: **Total Distance**
    - # of shuttles completed x 40 meters
  - Calculation of Results: **VO_2 max (ml/kg/min)**
    - Distance (m) x 0.0084 + 36.4



Testing Anaerobic or Max Muscular Power

- High-speed strength
- Related to the ability of muscle to exert high force while contracting at a high speed
  - Also called maximal anaerobic muscular power or anaerobic power

Testing Anaerobic or Max Muscular Power

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- Related to the ability of muscle to exert high force while contracting at a high speed
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- Broad Jump or Vertical Jump

Testing Anaerobic or Max Muscular Power

- High-speed strength
- Related to the ability of muscle to exert high force while contracting at a high speed
  - Also called maximal anaerobic muscular power or anaerobic power
- Vertical Jump using wall

Testing Anaerobic or Max Muscular Power

- Countermovement Vertical Jump (Harman Formula):
  - Calculation of Results: **Average Jump Height (cm)**
    - (jump #1 ht + jump #2 ht + jump #3 ht) ÷ total # of jumps
  - Calculation of Results: **Peak Power (Watts)**
    - (61.9 * avg jump height (cm)) + (36.0 * body mass (kg)) + 1,822
  - Calculation of Results: **Average Power (Watts)**
    - (21.2 * avg jump height (cm)) + (23.0 * body mass (kg)) – 1,393

Testing Linear Acceleration and Power

- How is linear acceleration and power tested?
  - 10 Yard Sprint
  - 20 Yard Sprint
  - 40 Yard Sprint

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Testing Linear Acceleration and Power

- 10, 20, & 40-Yard Sprint:
- Calculation of Results: **Average Sprint Time**
  - (sprint #1 sec + sprint #2 sec) ÷ total # of sprints

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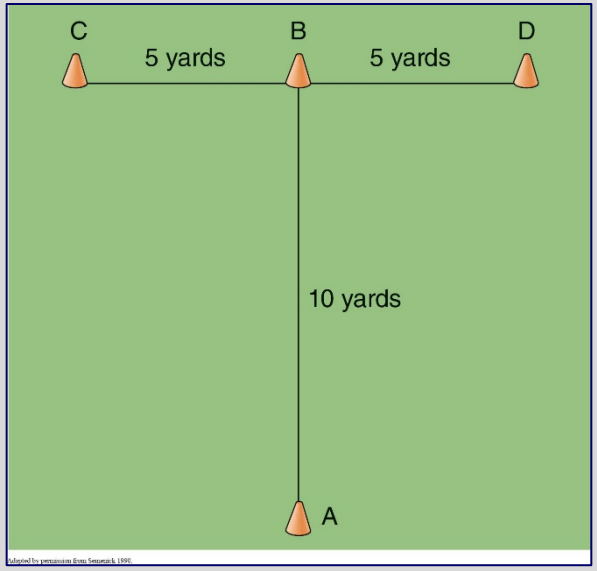
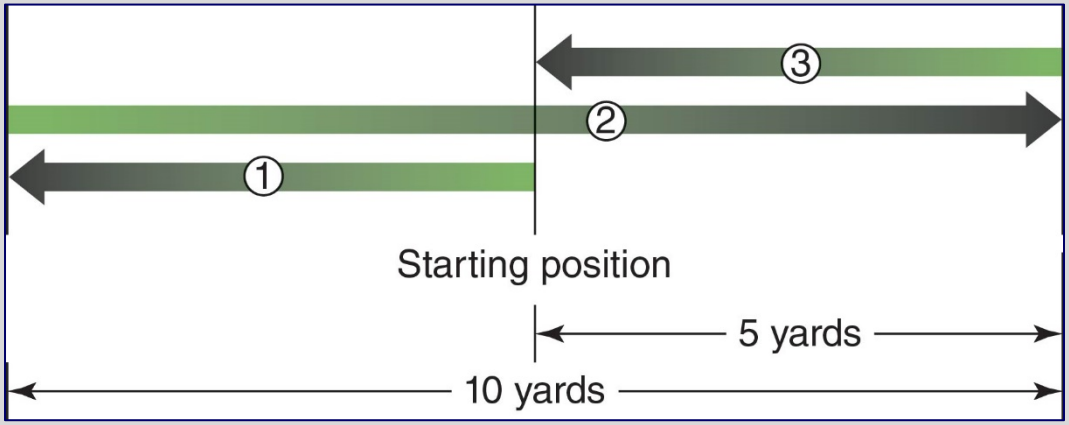
Testing Agility (Multidirectional COG Power)

- AGILITY = The ability to change direction or speed of the whole body in response to a sport-specific stimulus



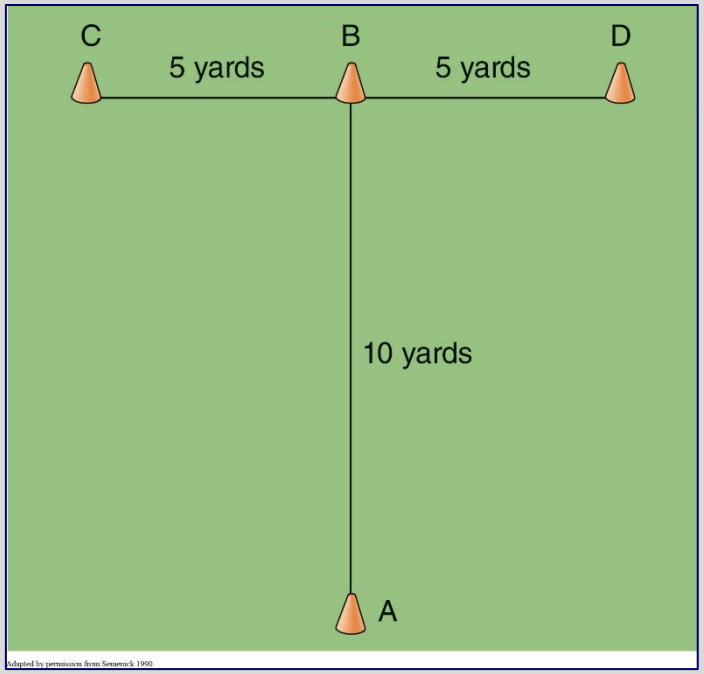
T-Test Multidirectional COG



5-10-5 Lateral COG

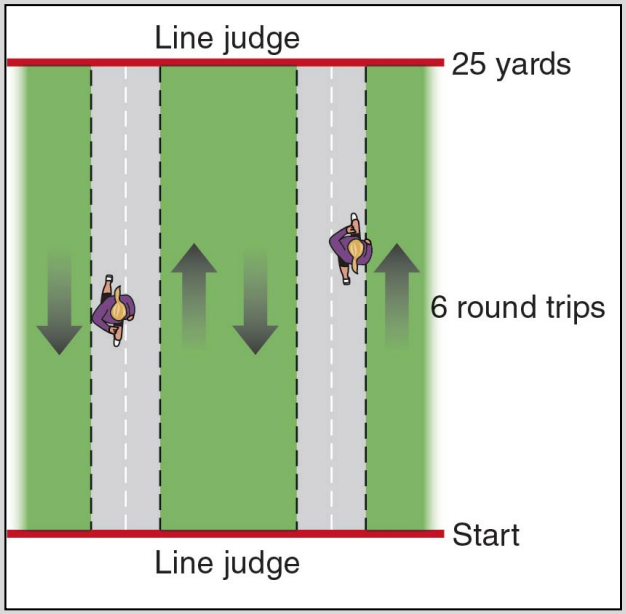
Testing Agility (Multidirectional COG Power)

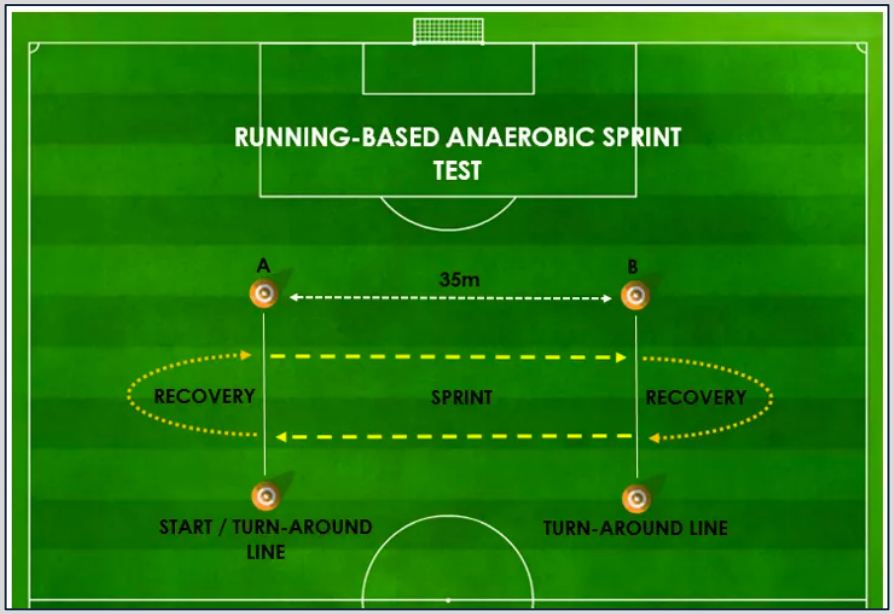
- T-Test Agility:
- Calculation of Results: **Average Agility Time**
  - (trial #1 sec + trial #2 sec) ÷ total # of trials



Testing Anaerobic Power and Capacity

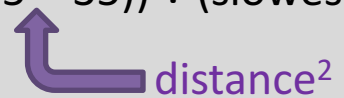
- How is anaerobic power and capacity tested?
  - 300-Yard Shuttle
  - 35-Meter Running Anaerobic Sprint Test (RAST)





Testing Anaerobic Power and Capacity

- 35-Meter RAST:
  - Calculation of Results: **Minimum Power (Watts)**
    - (body wt (kg) * (35 * 35)) ÷ (slowest time (sec))^3



  - Calculation of Results: **Maximum Power (Watts)**
    - (body wt (kg) * 1225) ÷ (fastest time (sec))^3
  - Calculation of Results: **Average Power (Watts)**
    - (body wt (kg) * 1225) ÷ (average time (sec))^3
  - Calculation of Results: **Fatigue Index (%)**
    - (fastest time (sec)—slowest time (sec)) ÷ (fastest time (sec))

Examining Balance, Stability, and Mobility

- How is balance, stability, & mobility tested?
  - Star Excursion Balance Test (SEBT)
  - Balance Error Scoring System (BESS)
  - FMS Y-Balance Test
  - FMS Functional Movement Screen
    - Overhead Deep Squat

Examining Balance, Stability, and Mobility

- FMS Y-Balance:
  - Calculation of Results: **Leg Length Difference (cm)**
    - Leg length LEFT (cm)—Leg length RIGHT (cm)
  - Calculation of Results: **Normalized (Relative) Reach Distance (%)**
    - (Reach distance (cm) ÷ Limb length (cm)) * 100
    - NOTE: Can be calculated for all directions on both stance legs
  - Calculation of Results: **Composite Reach Distance (%)**
    - (Sum of 3 reach directions (cm) ÷ 3x Limb length (cm)) * 100

Examining Balance, Stability, and Mobility

- FMS Overhead Deep Squat

Scoring of the FMS

3	-Perform pattern as directed
2	-Perform pattern with compensation/imperfection
1	-Unable to perform pattern
0	-Pain with pattern regardless of quality

Functional Movement Systems — FMS — FunctionalMovement.com

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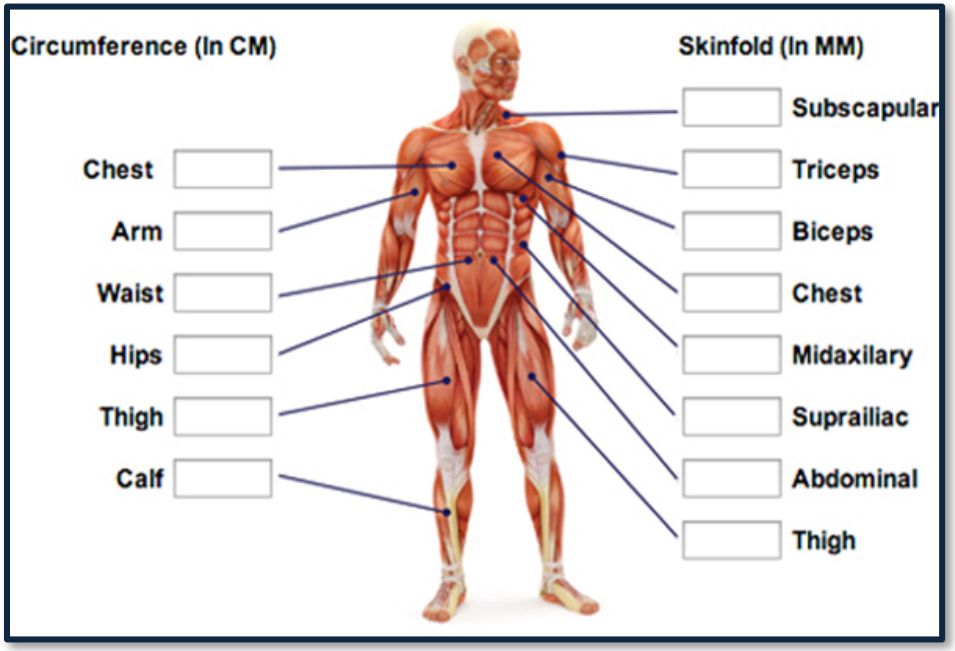
Examining Balance, Stability, and Mobility

- Scoring the FMS Overhead Deep Squat

Without Heel Lift	With Heel Lift	**PLACE A CHECK MARK IN THE APPROPRIATE BOX IF THE LISTED MOVEMENT MODIFICATION IS PRESENT. CIRCLE DEFINING CHARACTERISTIC IN THE DESCRIPTION IF NECESSARY.**
		Arms falling forward and do not stay in line with the ears
		Excessive forward lean of the torso
		Excessive spinal flexion or extension
		Feet turn out
		Feet turn in
		Heels come off the floor
		Unable to make parallel with upper thighs
		Knees cave in
		Knees cave out
		Knees go out over the toes
		Asymmetric weight shift (dipping of shoulder or hip)
Comments:		

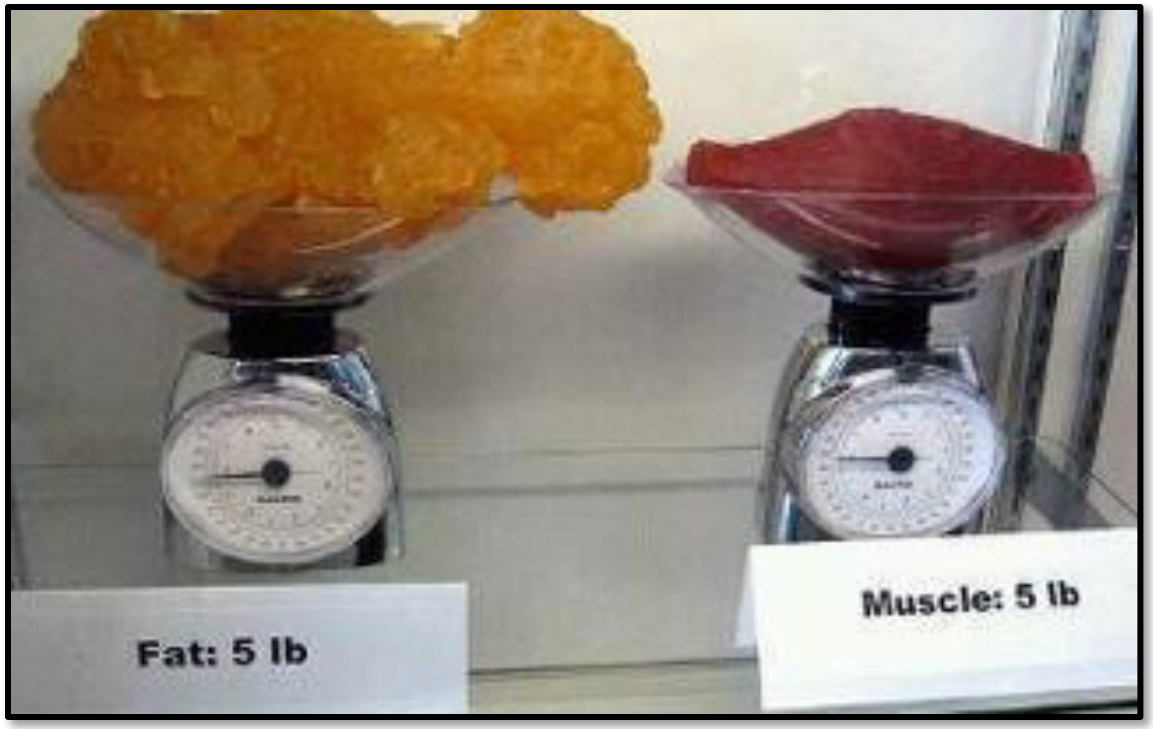
Body Composition Measurement

- Types of Body composition measurement
  - Bioelectric Impedance Analysis
  - Skinfold
  - Circumferences/Girth



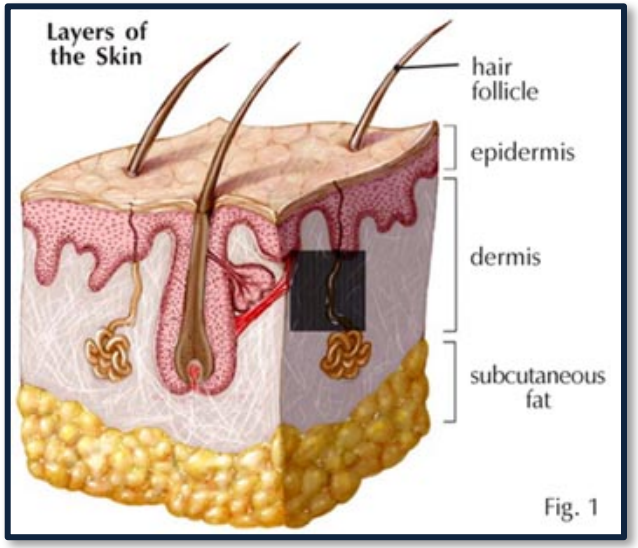
Measuring Body Composition cont.

- 3-Site Skinfold Technique Calculations:
  - Total width of the 3 sites are used to calculate:
    - Body fat %
    - Fat-free mass



Measuring Body Composition

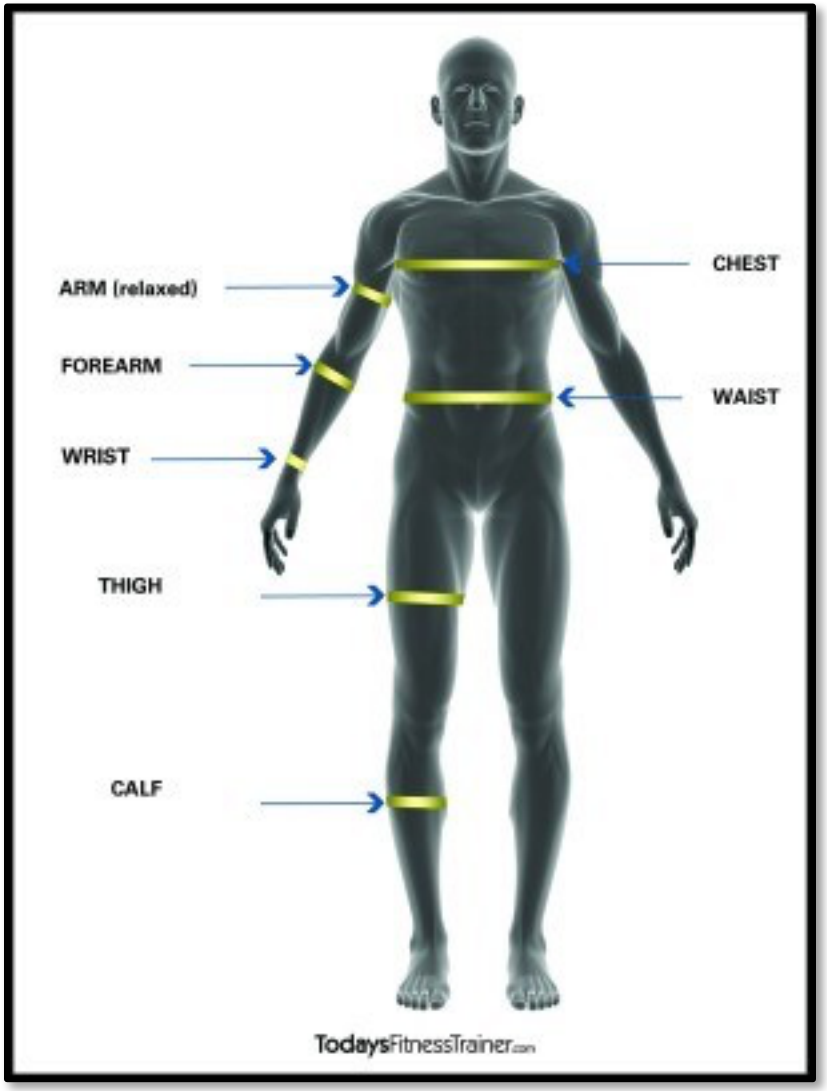
- 3-Site Skinfold Technique:
  - Skinfold technique: measures width of fat lying directly below skin
  - Largest source of error = Test administrator inconsistency



  - Three-sites utilized in WOMEN:
    - Middle of the triceps (Back of the upper arm)
    - Inguinal Fold (Above the hip bone)
    - Mid-thigh (1/2 between hip bone and knee cap)
  - Three-sites utilized in MEN:
    - Chest (mid point between acromion & nipple)
    - Abdomen (2cm to the left of naval)
    - Mid-thigh (1/2 between hip bone and knee cap)

Measuring Body Composition

- Circumference/Girth Measurements:
  - Specified circumference measures of particular body regions.
  - **Please be aware that you are entering someone else's personal space!!!**



Measuring Body Composition

- Circumference/Girth Measurements for Body Fat Percentage
  - Younger WOMEN (17-26 years) body fat %:

(abdominal (in) * 1.34) + (thigh (in) * 2.08) + (forearm (in) * 4.31)—19.6

  - Older WOMEN (26+ years) body fat %:
    - (abdominal (in) * 1.19) + (thigh (in) * 1.24) + (calf (in) * 1.45)—18.4
  - Younger MEN (17-26 years) body fat %:
    - (upper arm (in) * 3.70) + (abdominal (in) * 1.31) + (forearm (in) * 5.43)—10.2
  - Older MEN (26+ years) body fat %:
    - (buttock (in) * 1.05) + (abdominal (in) * 0.90) + (forearm (in) * 3.00)—15.0

Presenting Results of Test Performance

- Individuals compared to benchmarks and team average:

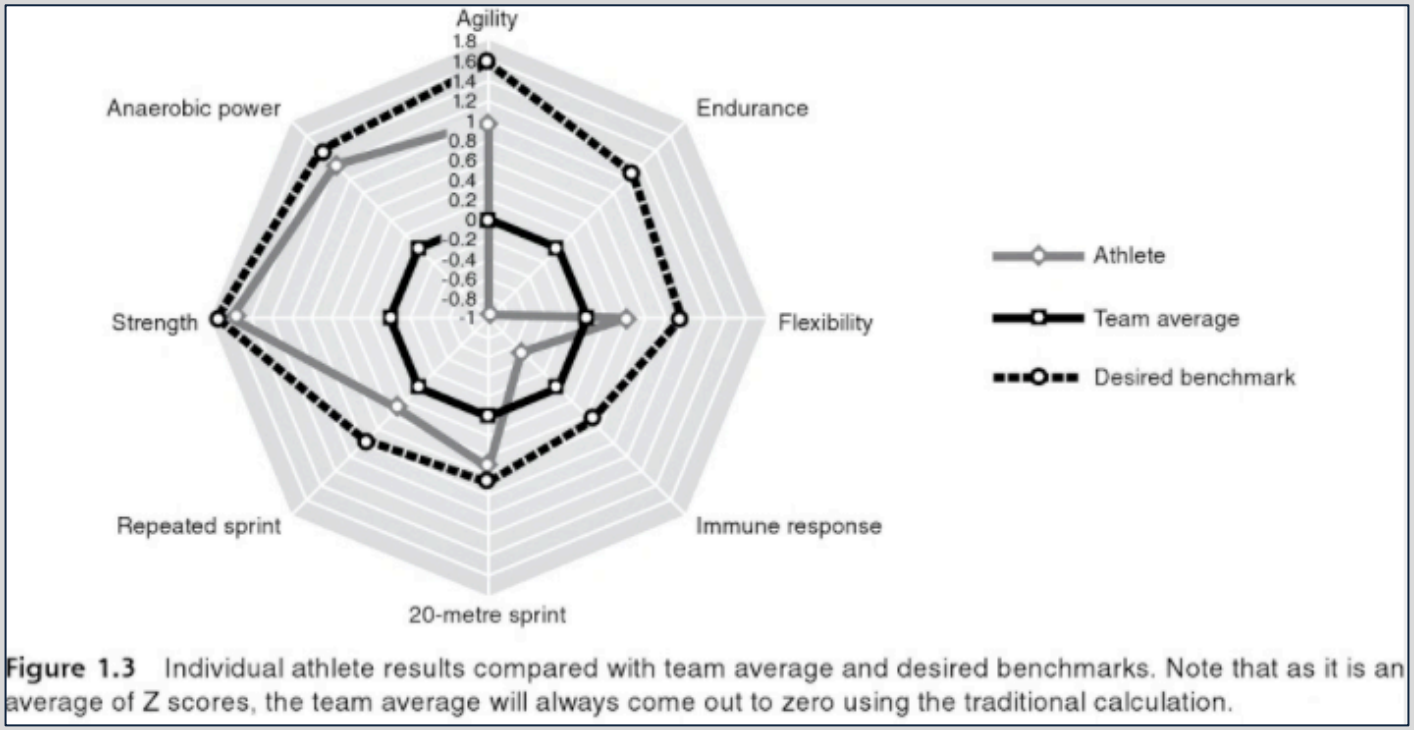


Figure 1.3 Individual athlete results compared with team average and desired benchmarks. Note that as it is an average of Z scores, the team average will always come out to zero using the traditional calculation.

Presenting Results of Test Performance

- Individuals compared to themselves:

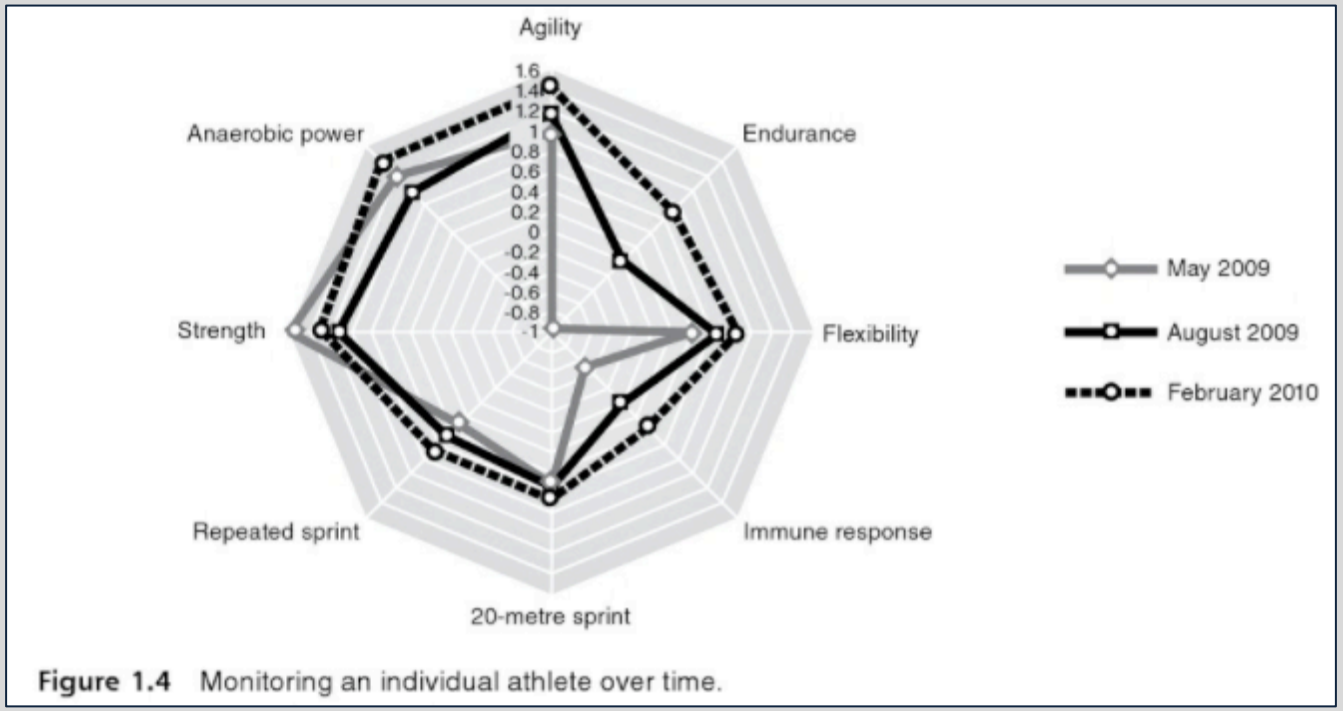


Figure 1.4 Monitoring an individual athlete over time.


Questions?

Theory of Monitoring Annual Training Progression with Physical Testing to Prevent Injury and Improve Performance

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