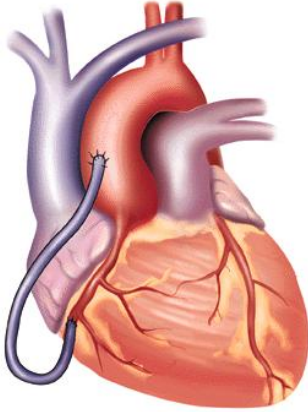
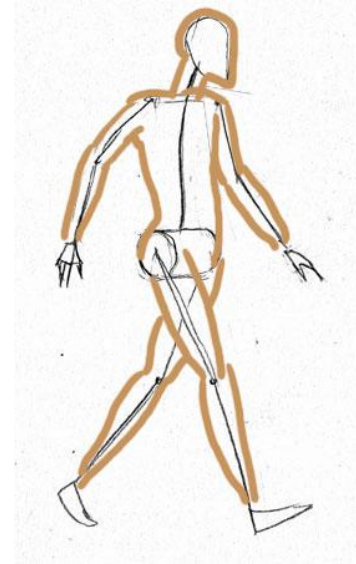


A Systematic Approach for Exercise Design

Kyle Kiesel PT PhD ATC
Lee Burton PhD ATC CSCS



Annual Cost =
444 billion USD



?

Annual Cost =
849 billion USD

Centers for Disease Control

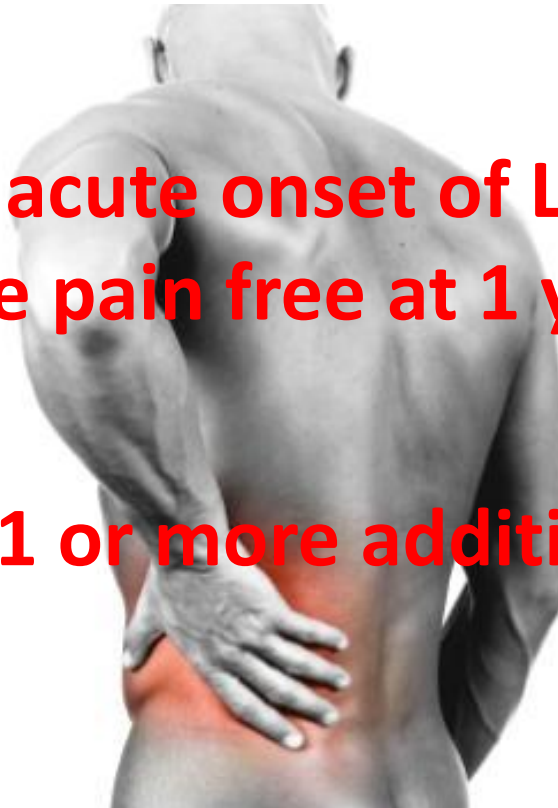
Low Back Pain

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association

J Orthop Sports Phys Ther. 2012;42(4):A1-A57. doi:10.2519/jospt.2012.0301

**Following an acute onset of LBP, only 21%
were pain free at 1 year**

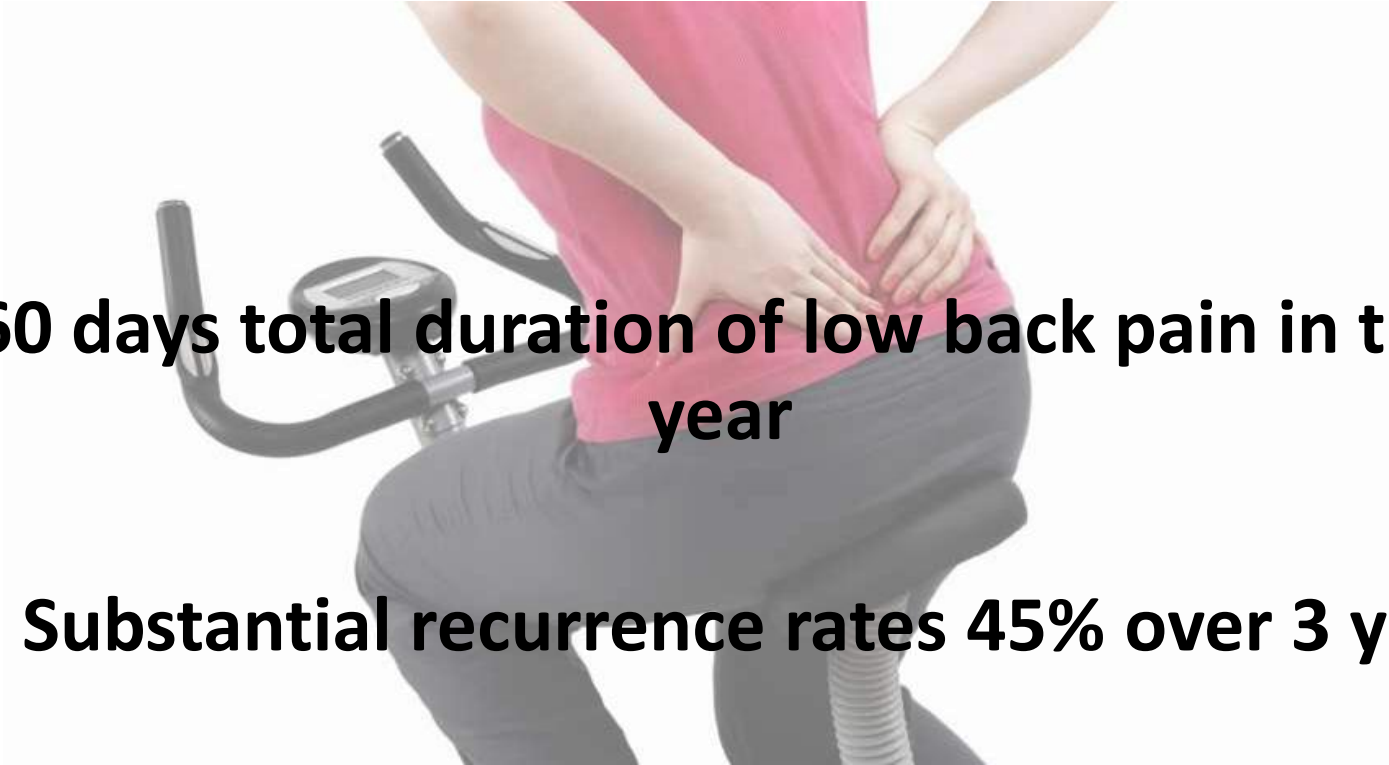
65% reported 1 or more additional episodes



Low Back Pain

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association

J Orthop Sports Phys Ther. 2012;42(4):A1-A57. doi:10.2519/jospt.2012.0301



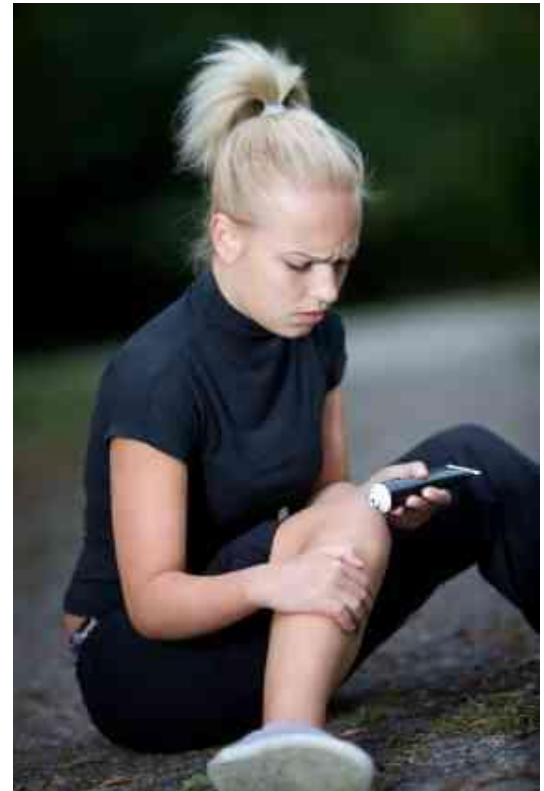
60 days total duration of low back pain in the year

Substantial recurrence rates 45% over 3 years

Return to sport following anterior cruciate ligament reconstruction surgery: a systematic review and meta-analysis of the state of play

Clare L Arden,¹ Kate E Webster,¹ Nicholas F Taylor,^{1,2} Julian A Feller¹

48 studies evaluating 5770
participants at a mean follow-up
of 41.5 months



Ardern et al *BJSM* 2011

63% returned to their pre-injury level of participation

Ardern et al *BJSM* 2011

63% returned to their pre-injury level of participation

44% had returned to competitive sport at final follow-up”

Ardern et al *BJSM* 2011

63% returned to their pre-injury level of participation

44% had returned to competitive sport at final follow-up

20-30% re-tear rate

A person is sitting on a yellow examination table. A healthcare professional, wearing a grey shirt, is examining the person's right knee. The person is wearing a white t-shirt, black shorts, and white socks. The background shows a clinical setting with a red table and a white wall.

**~90% achieved normal knee
function based on traditional
impairment measures**

Previous Injury



Looking at 70 teams, in 18 countries,
over 8 seasons (9,000 injuries), we
have found that **previous injury** is by
far the greatest predictor of future
injury in football.

Jan Eckstrand

Soccer Industry Medical Symposium 2009



Delayed
Gluteal
Firing

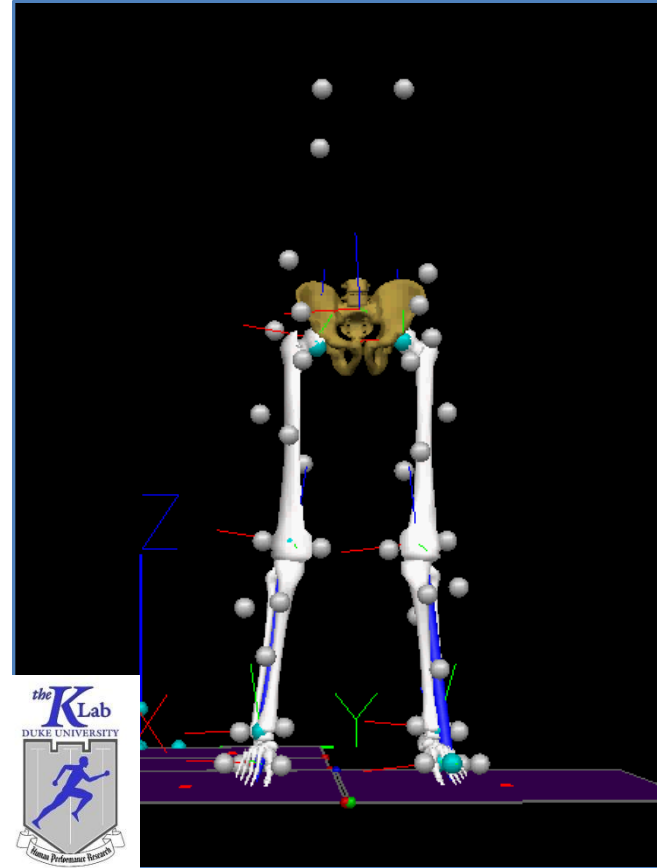
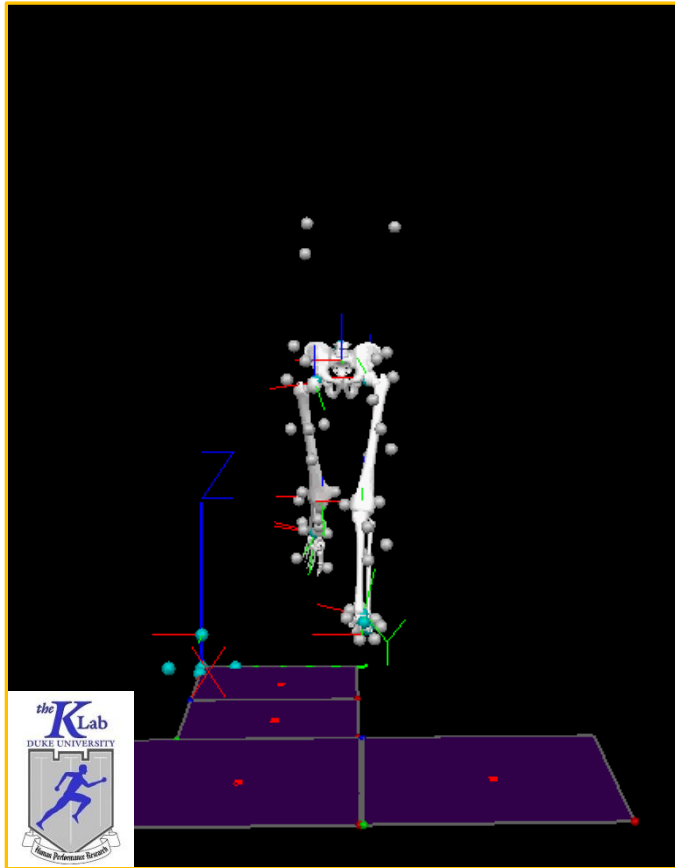
Excessive
Core
Activation

Decreased hip &
knee control

Is there a need for a Standard
Operating Procedure related to the
Musculoskeletal System?

Where should we the start ?

~ 4 BW ← → ~ 1 BW



What if.....

Motor Control of 1x BW



SOP for Musculoskeletal System

Screen – Generalized Grouping of Dysfunction

- Asymptomatic (no pain with movement) **Check Risk**

Test – **Specific Measurement** of Dysfunction

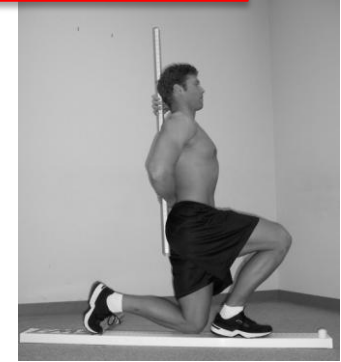
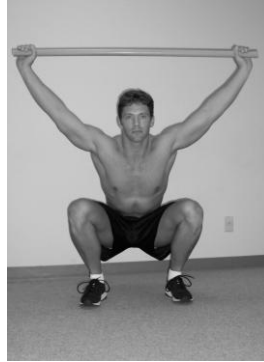
- Asymptomatic (no pain with movement)

Assess – **Judgment** of Dysfunction / Diagnosis

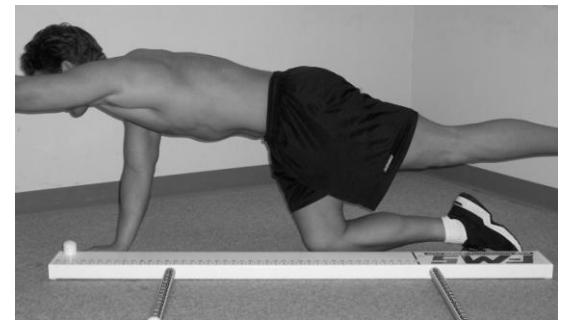
- Symptomatic (pain associated with movement)

THE FUNCTIONAL MOVEMENT

SCREEN

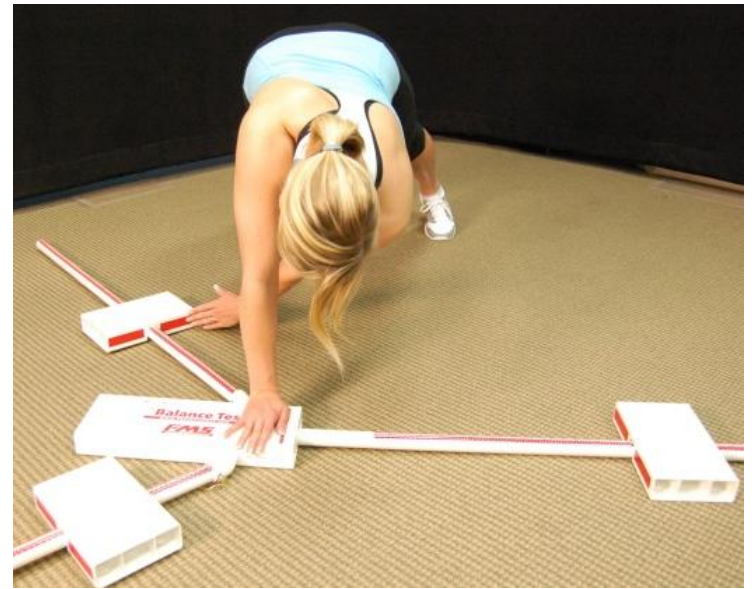
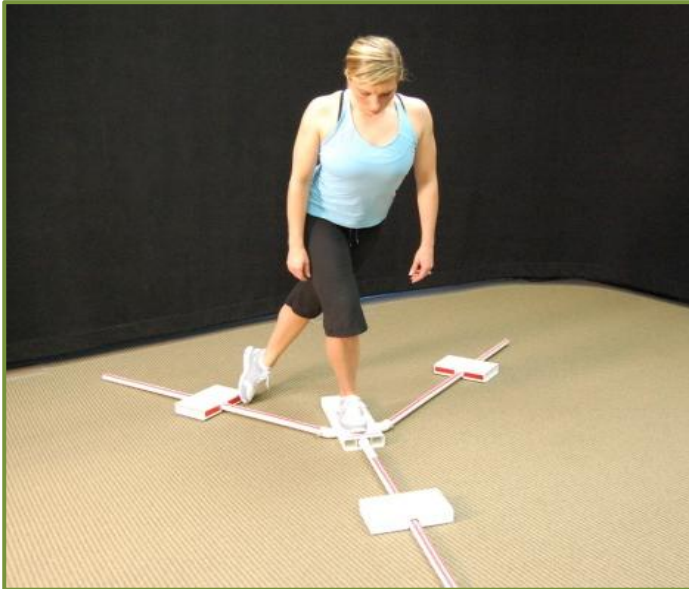


- 1.Squatting
- 2.Stepping
- 3.Lunging
- 4.Reaching
- 5.Leg raising
- 6.Push-up
- 7.Rotary Stability



Y – BALANCE

TEST



Y Balance Test™

Cervical Patterns



Upper Ext. Patterns



Multi-Segmental Flexion

Multi-Segmental Extension

Multi-Segmental Rotation

Single Leg Stance

Squatting Pattern



FMS Research Overview

Reliable across trained raters (Minick et al., 2010, Butler et al., 2011, Frohm et al., 2011, Schneiders et al., 2011 Teyhen et al 2012)

Injury Prediction with Composite Score (≤ 14)

- Firefighters (Butler et al., 2012)
- NFL Football (Kiesel et al. 2013 in press)
- NFL Football (Kiesel et al., 2007)
- Collegiate athletes (Chorba et al., 2010)
- Marines (O'Connor et al., 2011)
- Marines (Lisman et al., 2012)

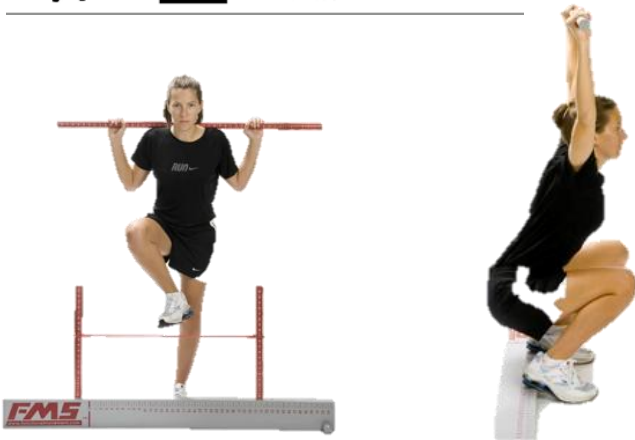
Injury Prediction with FMS test Asymmetry

- NFL Football (Kiesel et al. 2013 in press)

FMS Composite score is **modifiable** with *some* training programs

- Corrective Exercises (Kiesel et al., 2010)
- Yoga (Cowen et al., 2007)
- Functional training program (Goss et al., 2009)

Motor Control of 1x BW



+



Y Balance Test - LQ



- **Reliable** (Plisky et al 2009, Shaffer et al 2010)
- **Predictive of injury** (Plisky 2006, Lehr 2011, de Noronah 2012)
- **Can differentiate between athletes based on age, sport, gender** (Plisky 2009, Thorpe & Ebersole 2008, Bressel et al 2007)
- **Improves after training**
(Filipa 2010, Fitzgerald 2010, Leavy 2010, Eisen 2010, McKeon 2008, Hale 2007, English 2007, Bouillon 2009, Kahle & Gribble 2009, Rasool & George 2007)
- **Reduces injury risk after training**

$$\frac{1}{2} \rho (\omega r)^2 dV = \frac{1}{2} \omega^2 \rho (x^2 + y^2) dV \quad v(\varphi)$$



$$U = Mgh = Mg \rho \sin \theta \frac{dr}{d\varphi} = -\frac{1}{r^2} \frac{dr}{d\varphi}$$

$$K = \frac{1}{2} M v^2 + \frac{1}{2} I \omega^2$$

$$\frac{1}{2} M v^2 + \frac{1}{2} I \left(\frac{v}{R} \right)^2 = \frac{1}{2} M v^2 + \frac{1}{2} \frac{I}{R^2} v^2$$

$$S = N \Rightarrow \left(\frac{dS}{dt} \right) = \frac{dS}{dt} \vec{\omega} \wedge \vec{S}$$

$$\vec{S} + \omega \wedge \vec{S} = \vec{N} \quad \alpha = \frac{I_2 - I_1}{I_1} \omega_1$$

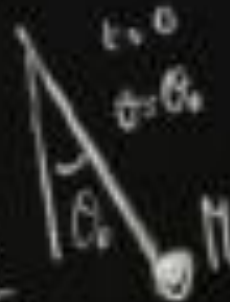
$$\vec{F} = \frac{c}{r^2} \vec{r} \quad F = -\frac{\partial U}{\partial r} = \frac{c}{r^2}$$

$$U(r) = \frac{c}{r} \quad \frac{\partial U}{\partial r} = -\frac{c}{r^2}$$

$$= \frac{d}{d\varphi} \left(\frac{3}{4} \right) - \frac{2}{r^2} \cdot \frac{3}{4} \left(\frac{dr}{d\varphi} \right) = \frac{3}{4} \frac{1}{r^2} \frac{dr}{d\varphi}$$

$$\frac{d^2 \omega}{d\varphi^2} = \frac{1}{r^2} \frac{d^2 r}{d\varphi^2} + \frac{2}{r^3} \left(\frac{dr}{d\varphi} \right)^2$$

$$\frac{d^2 v}{dt^2} = -\frac{1}{r^2} \left(\frac{3}{4} \right) \frac{d^2 \omega}{d\varphi^2} \Rightarrow \frac{d^2 \omega}{d\varphi^2} + \omega = \frac{\mu G M m_1}{3^2}$$



$$K = \frac{1}{2} M \dot{x}^2 = \frac{1}{2} M \left[\omega_0 l \cos(\omega_0 t + \varphi) \right]^2$$

$$\langle K \rangle = \frac{\int_0^T K dt}{T} = \frac{1}{4} M \omega_0^2 l^2$$

$$\frac{\omega_0}{2\pi} \int_0^{2\pi} \cos^2 \omega_0 t dt = \frac{1}{2\pi} \int_0^{2\pi} \cos^2 \varphi d\varphi = \frac{1}{2} \quad \langle K \rangle = \frac{1}{4} M \omega_0^2 l^2$$

$$U = \frac{1}{2} c x^2 = \frac{1}{2} c A^2 \cos^2 \omega_0 t$$

$$\langle U \rangle = \frac{1}{4} c A^2$$

Validation Study

183
Collegiate
Athletes



Lehr et al 2013

Algorithm Components

The following components with various weightings and interactions are included in the algorithm

- ✓ Previous Injury
- ✓ Y Balance Test Composite risk cut score **based on gender, sport, and competition level**
- ✓ Y Balance Test Asymmetry
- ✓ Functional Movement Screen Total Score
- ✓ Functional Movement Screen Asymmetry
- ✓ Pain with testing

Based on the algorithm, athletes were categorized according to risk level

-  **Substantially Increased Risk**
-  **Moderately Increased Risk**
-  **Slightly Increased Risk**
-  **Normal Risk**



Category Distribution

Risk Level	N
Substantial	26
Moderate	37
Slight	93
Normal	27

Results for Individual Categories

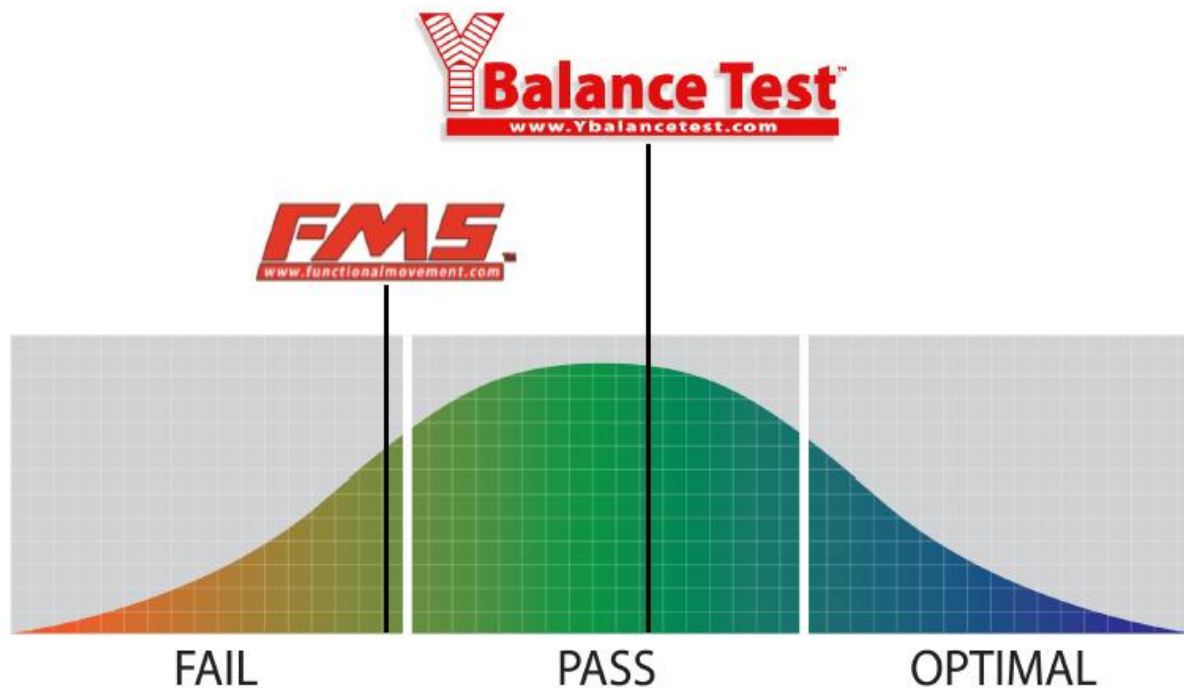
Risk Level	Percent	
	N	Injured
Substantial	26	61%*
Moderate	37	30%*
Slight	93	16%
Normal	27	0%

**Non-contact
time loss &
medical
attention
injury
definition**

Results for Moderate and Substantial Combined

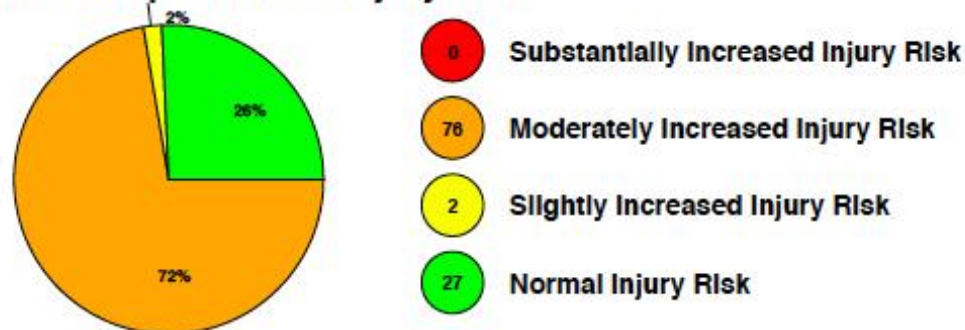
Risk Level	N	Injured	%	RR	RR _{95% CI}
Moderate & Substantial Combined (High Risk)	63	27	43%	3.4*	2.0-6.0

Here are your results compared to other College Football (American) athletes.



Move2Perform is a musculoskeletal screening process designed to help determine your group's injury risk. Injuries are difficult to predict and current research suggests injury risk is multifactorial. The software synthesizes a variety of evidence-based factors to categorize each person's individual risk. Here is the breakdown of the four risk level categories.

Your Group's Overall Injury Risk



Recommended Action Items:

Multiple published studies* indicate that individuals who are in the Substantially and Moderately Increased Injury Risk categories are 3-6 times more likely to get injured. They should contact your Move2Perform provider to set up a comprehensive evaluation and remain under care until re-testing demonstrates they are in a lower risk category.

Individuals in the Slightly and Normal Increased Injury Risk categories should perform the personalized exercises provided to correct the any risk factors found in their testing. For additional personalized exercise progressions, they should contact your Move2Perform provider.

Expected Outcomes:

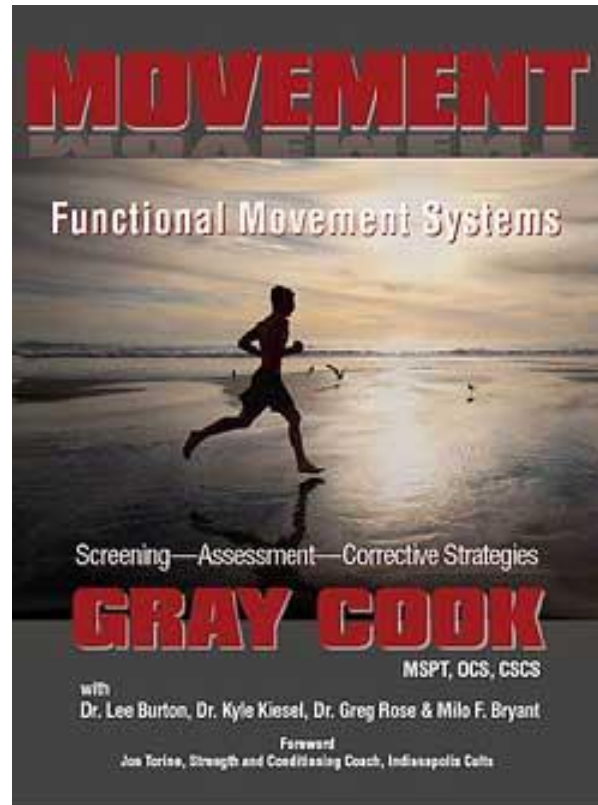
With implementation of the suggested strategies, we would expect those in the substantial and moderate categories to move to a lower risk category.

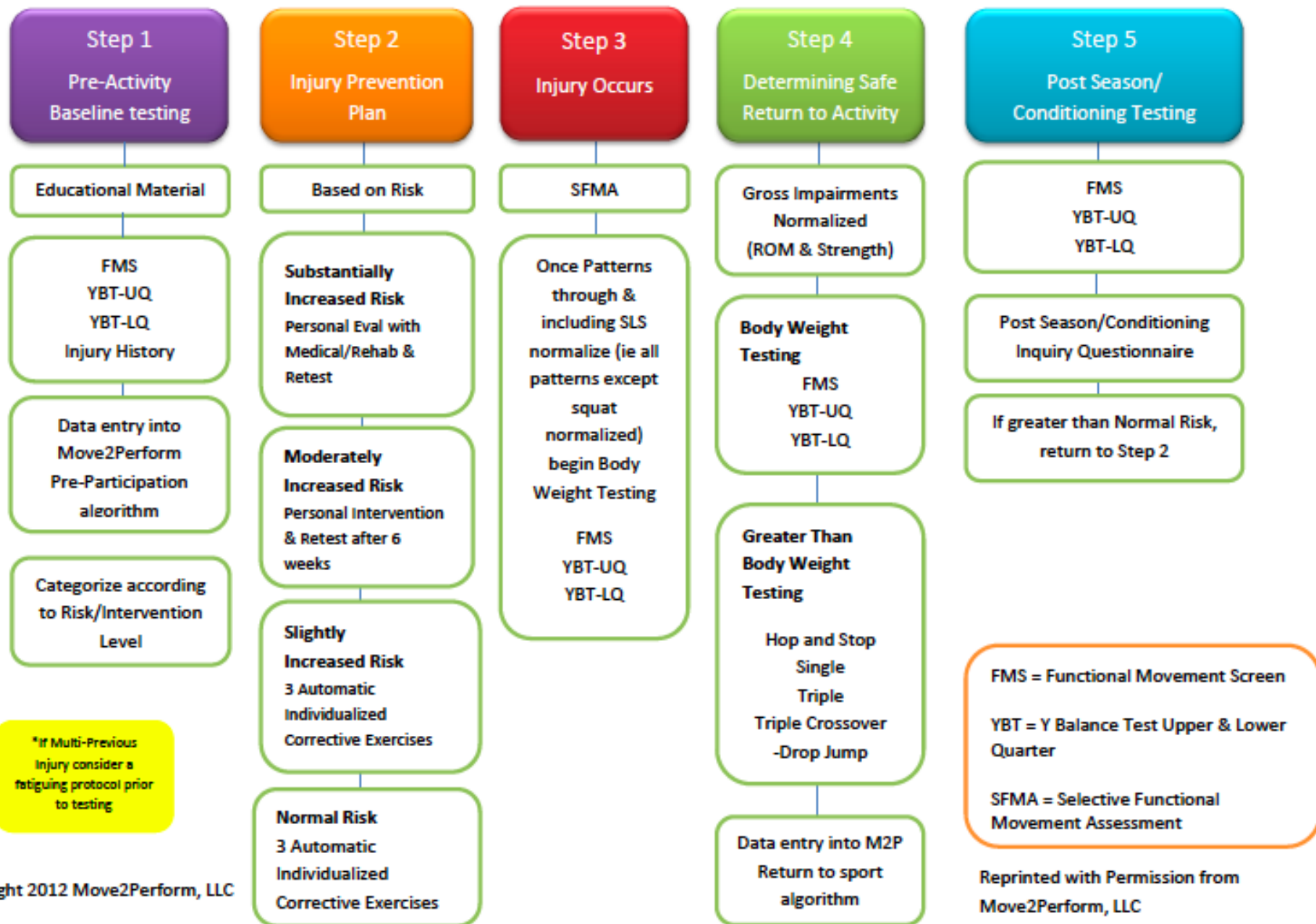
* IJSPT 2007 & 2010, JOMT 2007, JOSPT 2006 www.move2perform.com/evidence

Functional Movement Testing

Test		Raw Score Ave	Final Score Ave	# Asym	# of 0's	# of 1's	# of 2's	# of 3's
Deep Squat:		2.1	2.1		0	8	81	16
Hurdle Step:	L	2.2	2.2	13	0	2	84	19
	R	2.3						
Inline Lunge:	L	2.3	2.2	13	0	3	75	27
	R	2.3						
Shoulder Mobility:	L	2.3	2.2	41	0	12	63	30
	R	2.5						
Impingement Clearing Test:	L	0						
	R	0						
Active Straight-Leg Raise:	L	2.3	2.3	14	0	12	49	44
	R	2.4						
Trunk Stability Pushup:		2.5	2.5		0	0	51	54
Press-Up Clearing Test:		0						
Rotary Stability:	L	2.1	2	8	0	0	101	4
	R	2						
Posterior Rocking Clearing Test:		0						
Total:			15.5	89	0	37	504	194

Functional Movement Systems



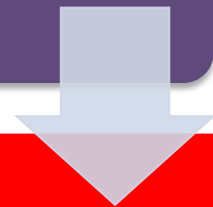


Summary

Suboptimal Outcomes



Standardized Movement
Appraisal (SOP)



Movement Characteristics
are modifiable Risk Factors

Personalized Program Checklist

☒ What do they not need?

- Corrective:
- Conditioning:

☒ What do they need?

- Corrective:
- Conditioning:

☒ What do they not want?

☒ What do they want?

Case Study

Personal History: 17 year-old male, D1 football prospect, lineman



Medical History/Health:

- Shoulder surgery, heel contusion
- Other findings normal: Vitals, HR, etc.



Movement Health:

- FMS screen (17)

FMS Score Sheet

<u>SCREEN</u>	<u>RAW</u> <u>SCORE</u> R/L	<u>FINAL</u> <u>SCORE</u>
Deep Squat	<u>2</u>	<u>2</u>
Hurdle Step	<u>2 / 2</u>	<u>2</u>
In-line Lunge	<u>3 / 3</u>	<u>3</u>
Shoulder Mobility	<u>3 / 3</u>	<u>3</u>
Active Straight Leg Raise	<u>3 / 3</u>	<u>3</u>
Trunk Stability Push-up	<u>2</u>	<u>2</u>
Rotary Stability	<u>2 / 2</u>	<u>2</u>
	TOTAL	17



Training History:

- Traditional strength training at high school



Additional Testing:

- Lower Quarter Y-Balance Test

Lower Qtr Y-Balance Test		
	Left	Right
Anterior	73	72
Posteromedial	111	112
Posterolateral	101	111
Composite	90.5	93.7



Additional Testing:

- Ankle mobility (41 deg. symmetrical)
- Grip (Symmetrical within 10%)



Specific Interests and Targets:

- Body Comp. Goal: 13
- D1 football ready

Personalized Checklist



What does he not need?

- Corrective: Mobility (ASLR,SM)
- Conditioning: Generalized aerobic



What does he need?

- Corrective: Rotary Stability and TSPU
- Conditioning: Sport specific



What does he not want?

- Conditioning

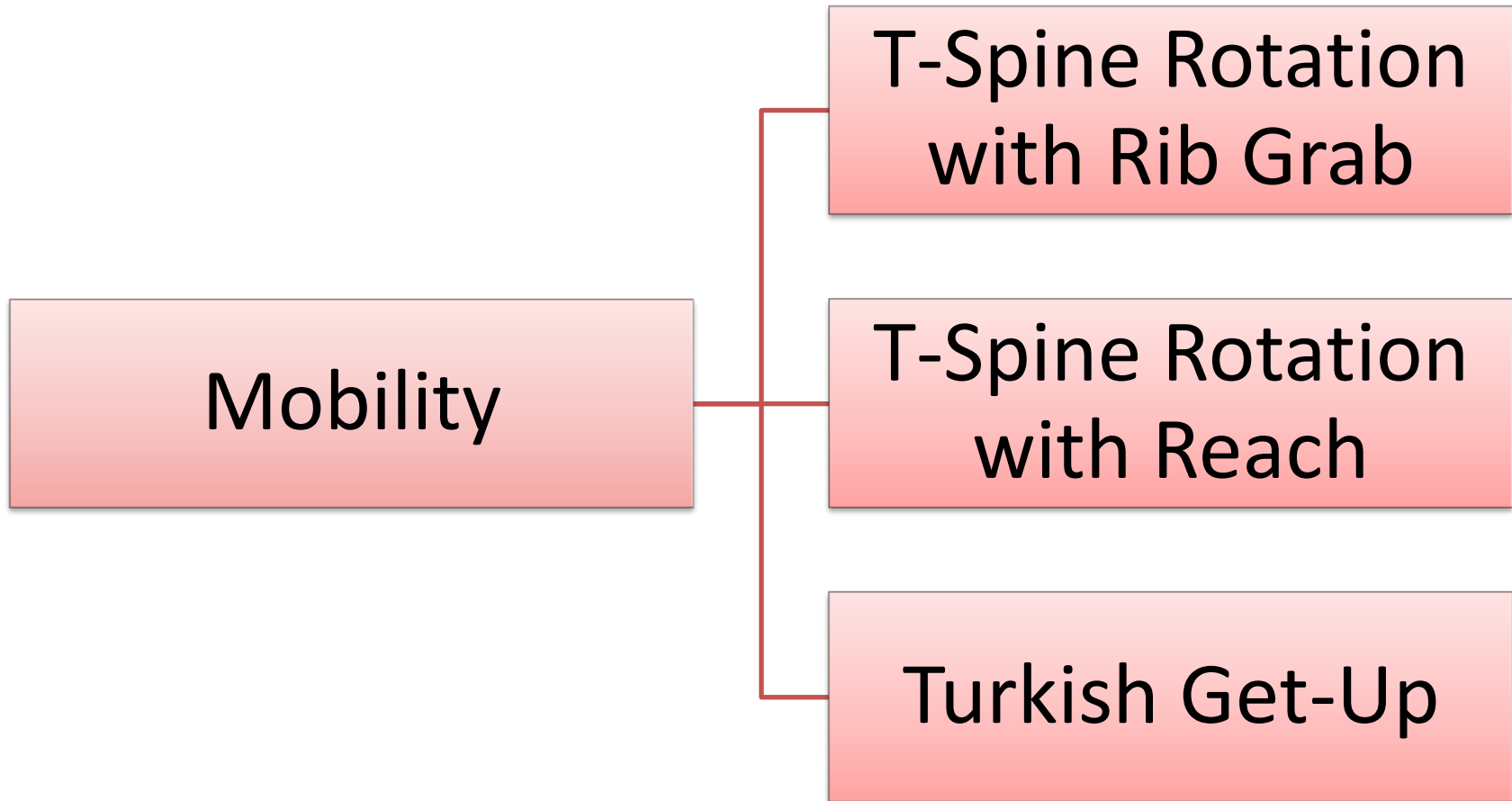


What does he want?

- Strength training

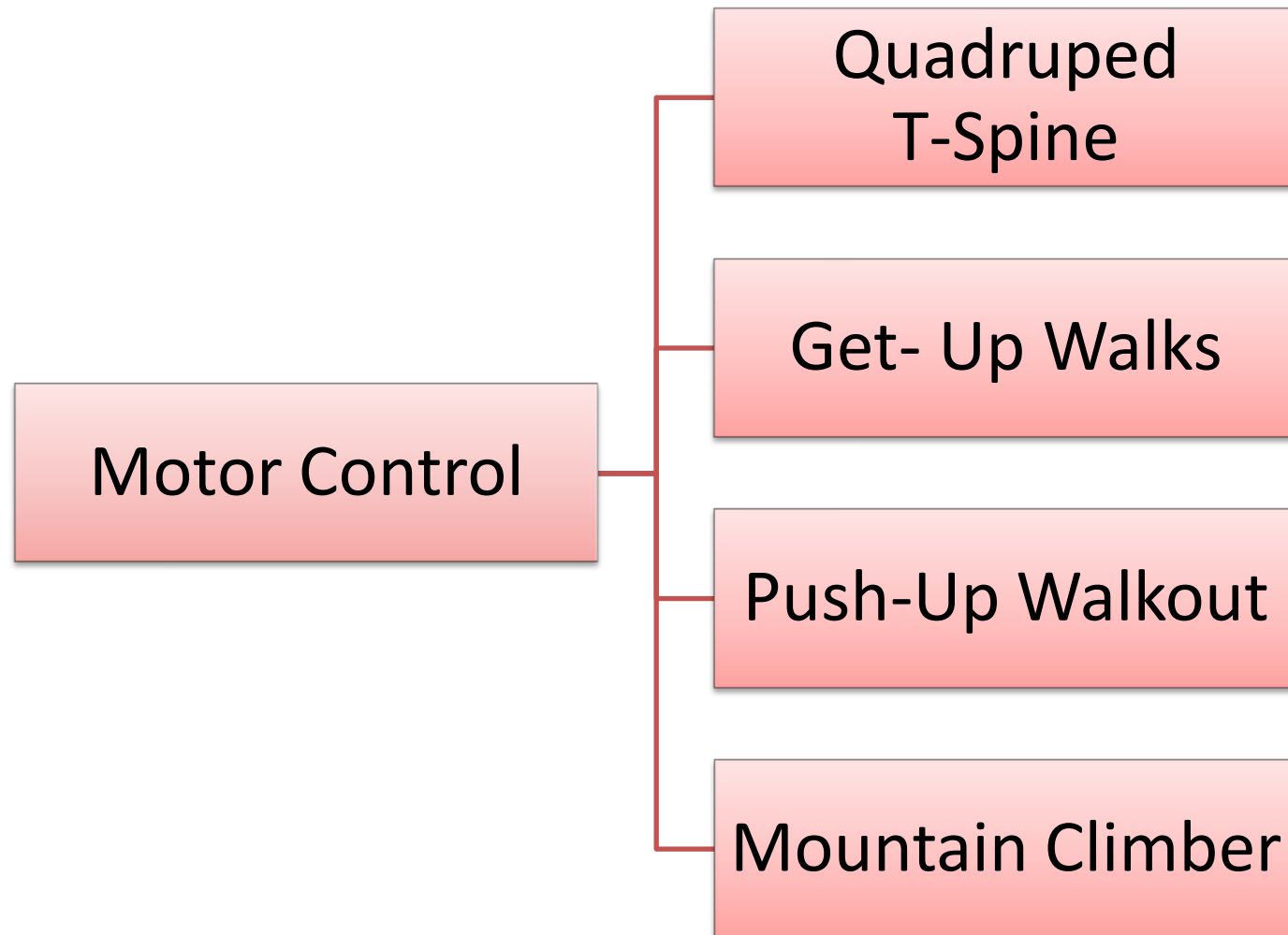
Programming

Goal: Rotary Stability and Trunk Stability Push-Up



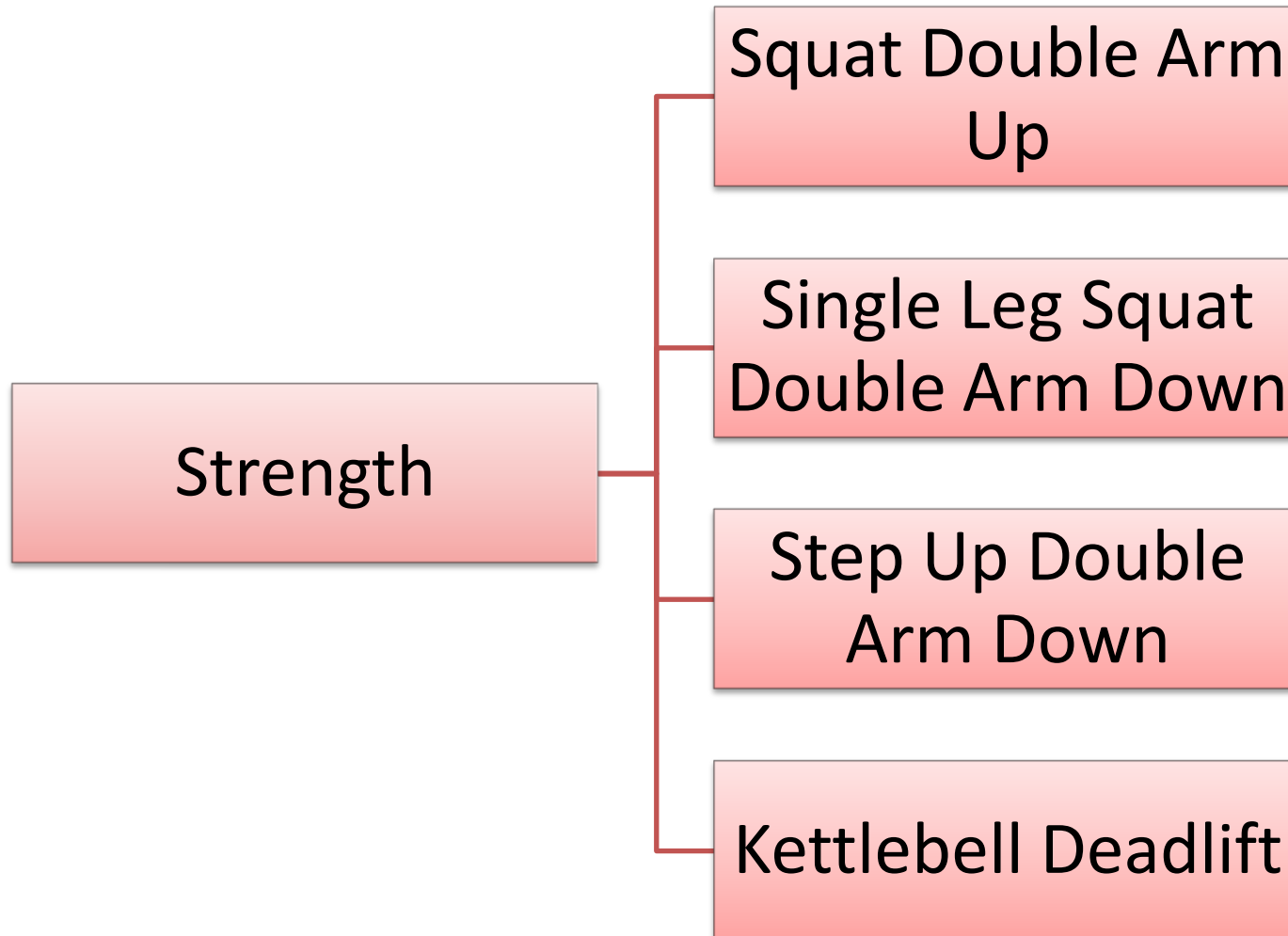
Programming

Goal: Rotary Stability and Trunk Stability Push-Up



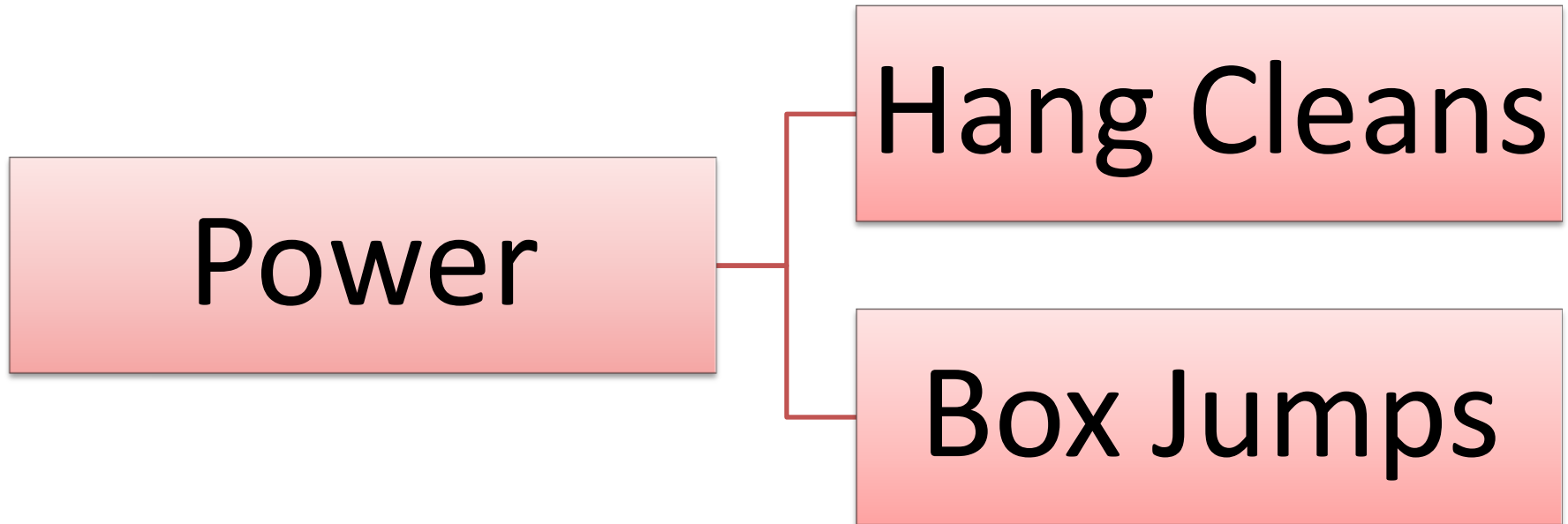
Programming

Goal: Rotary Stability and Trunk Stability Push-Up



Programming

Goal: Rotary Stability and Trunk Stability Push-Up



SOP for Musculoskeletal System

Screen – Generalized Grouping of Dysfunction

- Asymptomatic (no pain with movement) Check Risk

Test – Specific Measurement of Dysfunction

- Asymptomatic (no pain with movement)

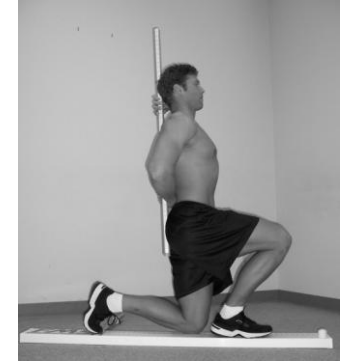
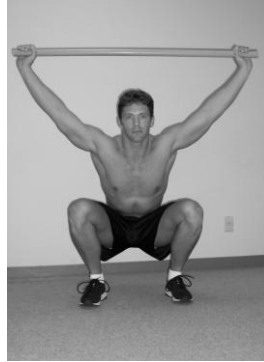
Assess – Judgment of Dysfunction / Diagnosis

- Symptomatic (pain associated with movement)

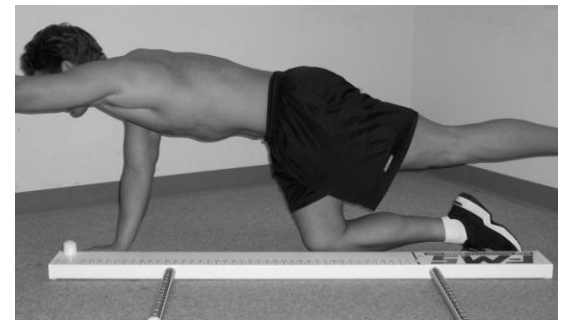
Demonstration

THE FUNCTIONAL MOVEMENT

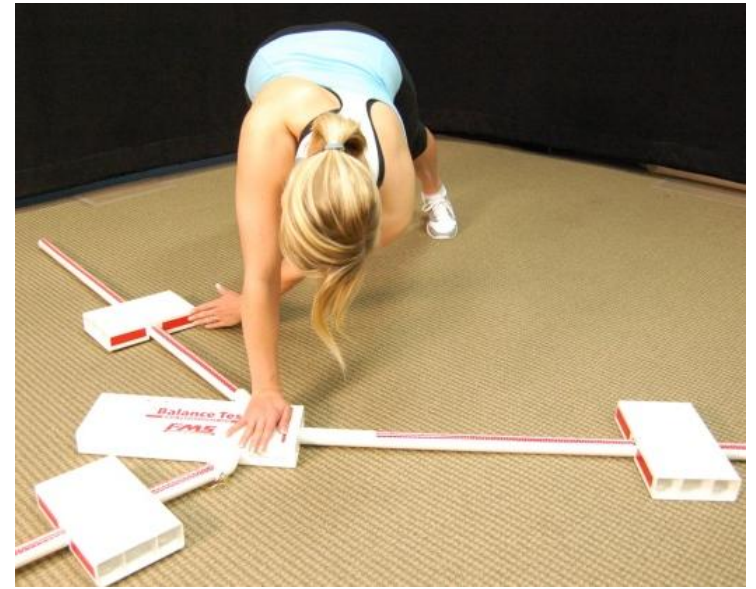
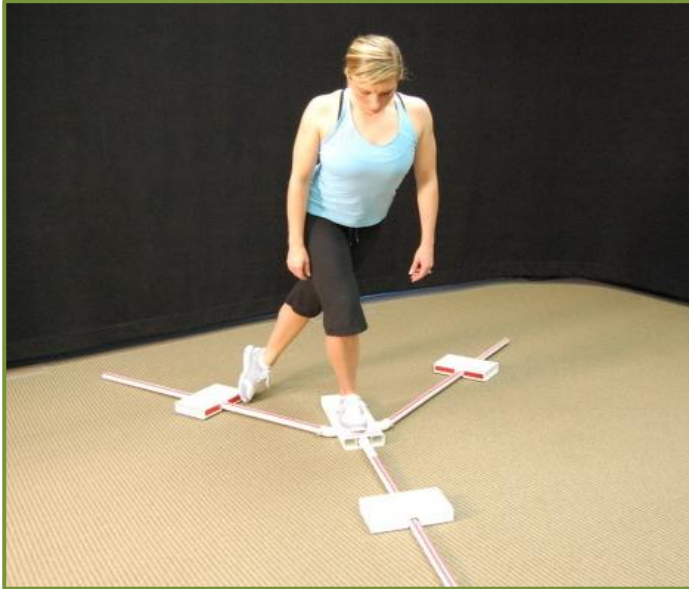
SCREEN



- 1.Squatting
- 2.Stepping
- 3.Lunging
- 4.Reaching
- 5.Leg raising
- 6.Push-up
- 7.Rotary Stability



Y – BALANCE TEST



Y Balance Test™

ASSESSMENT

Cervical Patterns



Upper Ext. Patterns



Multi-Segmental Flexion



Multi-Segmental Extension



Multi-Segmental Rotation



Single Leg Stance



Squatting Pattern

