Performance Enhancement Training for the Post-Rehabilitated ACL Reconstructed Athlete

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CSCCa
MAXIMIZING ATHLETIC PERFORMANCE

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Thank You

- CSCCa Conference Speaker Selection Committee
- My family who support me
- My mentors who taught me
- You the attendee for your interest in my presentation this morning

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Financial Disclosures

I have no financial disclosures

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This Presentation:

- Will address the deficits found in the post-rehabilitated ACL athlete, as well as the mutual physical qualities that are essential during the ACL rehabilitation process as well as the performance enhancement training of the post-operative ACL athlete

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NFL ACL Reconstruction Surgeries 2013 - 2016

	ACL's Prior to Week 1 Schedule	ACL's Regular Season/Playoffs	Total
2016	22	24	46
2015	25	23	48
2014	22	23	45
2013	31	32	64
Total	100	102	202

Source ACL Recovery Club

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Financial Impact of NFL Knee Injuries 2016

	Non-playoff teams (20)	Playoff teams (12)	NFL (32)
Total IR Knee Injuries	78	22	100
Total CAP Hit	$132,449,374	$24,113,925	$156,563,299
% of NFL IR Knee Injuries	78%	22%	100%
% Combined Team CAP Hit	85%	15%	100%
% Team Avg. IR Knee Injuries	3.9	1.8	3.125
Team Avg. CAP Hit	$6,622,468	$1,096,087	$4,892,603

Source Andy Barr Innovate Performance

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5 Year Review NCAA ACL Football Injuries (2004 – 2009)

- 318 ACL Injuries
  - 1.42 injuries per 10,000 exposures
- Post-season 1.55 incidence vs. pre/in-season
- 10 times more likely to injure during game vs. practice
  - 8.06 injuries vs. 10,000 exposures vs. .08 injuries per 10,000 exposures
- Turf 1.3 times more injuries vs. grass
- Contact 53% vs. Non-contact 40%
- Football position of play most often injured
  - Linebackers, Running Backs, and Special Teams

Dragoo et al Amer J Sports Med 2012

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Deficits found in the ACL Reconstructed Patient

- Limb asymmetries in muscle strength and performance are consistently noted following the return to high-level activity
  - Squatting
  - Jumping
  - Landing

Risberg JOSPT 1999
Meyer JOSPT 2011
Neitzel Clin Biomech 2002
Paterno JOSPT 2011

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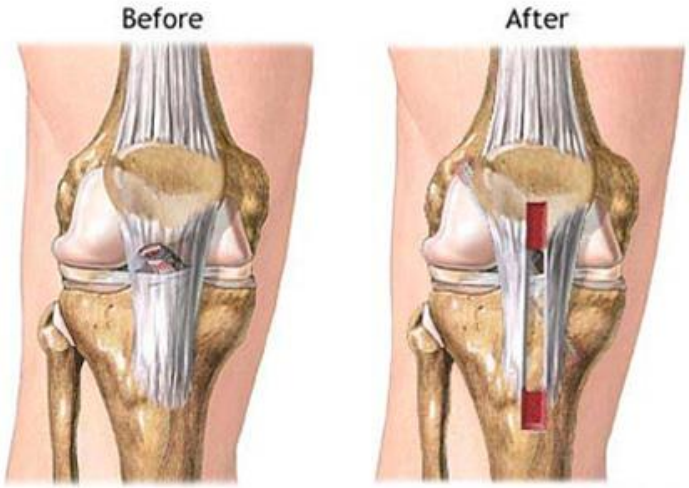
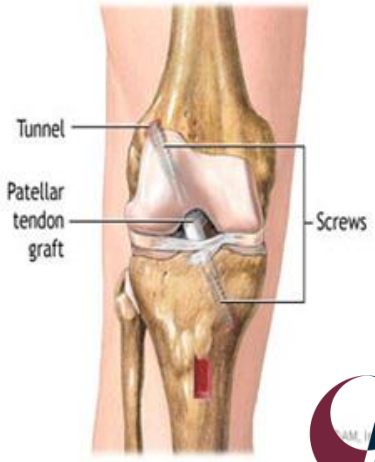
Deficits found in the ACL Reconstructed Patient

- Angelozzi *JOSPT 2012*
- 6 Months Post –op
  - MVIC (Strength) - 97% Pre-injury level
  - Rate of Force Development (RFD) – 63% pre-injury level
- 12 Months Post –op
  - Rate of Force Development (RFD) –attained or exceeded 90% Pre-injury level





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Deficits found in the ACL Reconstructed Patient

- Khayambashi et al *Am J Sports Med 2016*
  - Baseline hip strength (ABD and ER) levels were significantly lower in non-contact ACL injuries
- Ardren et al Br J Sports Med 2011
  - Meta-analysis of 48 studies (5770 participants) of ACL reconstructed athletes mean follow-up of 41 months
  - 82% returned to some type athletic activity
  - 63% returned to their preinjury level of participation
  - ***44% returned to competitive sports***
  - *Kinesiophobia was the most common reason cited for post-operative reduction in or cessation of sports participation*

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Athletic Performance

- Speed is conferred predominately by an enhanced ability to generate and transmit muscular force to the ground." Weyland J Appl Physiol 2000
- The fastest athletes spend the least amount of time on the ground (0.7 – 0.9 sec seconds at sprinting speed
  - ***The main determinant of achieving maximum sprint speed was in reducing the contact time during the stance phase!*** Mann 1998

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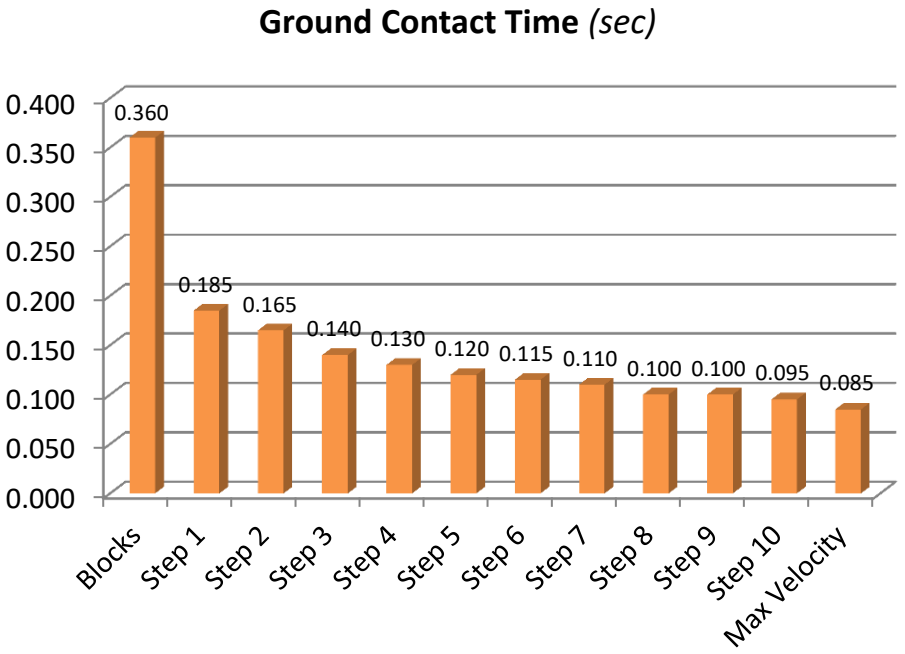
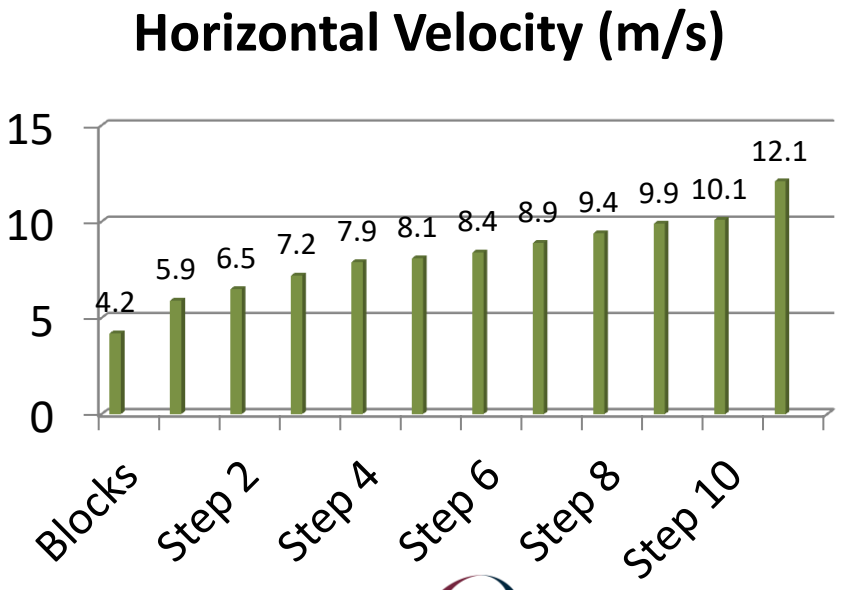
GCT and Horizontal Velocity



Ralph Mann 2007



By the 8th step GCT 0.1 sec and velocity is at 9.4 m/s

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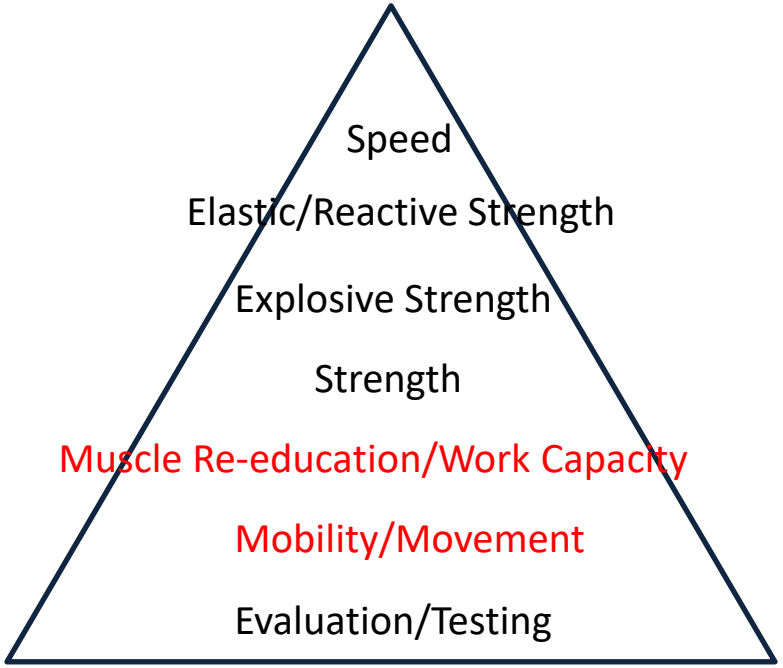
The Hierarchy of Athletic Development

- Hall of Fame S&C Coach Al Vermeil's Heirarchy of Athletic Development

Vermeil's Hierarchy of Athletic Development

Each physical quality is dependent upon it's predecessor



Rehabilitation Modified

Panariello et al Oper Tech Sports Med 2016

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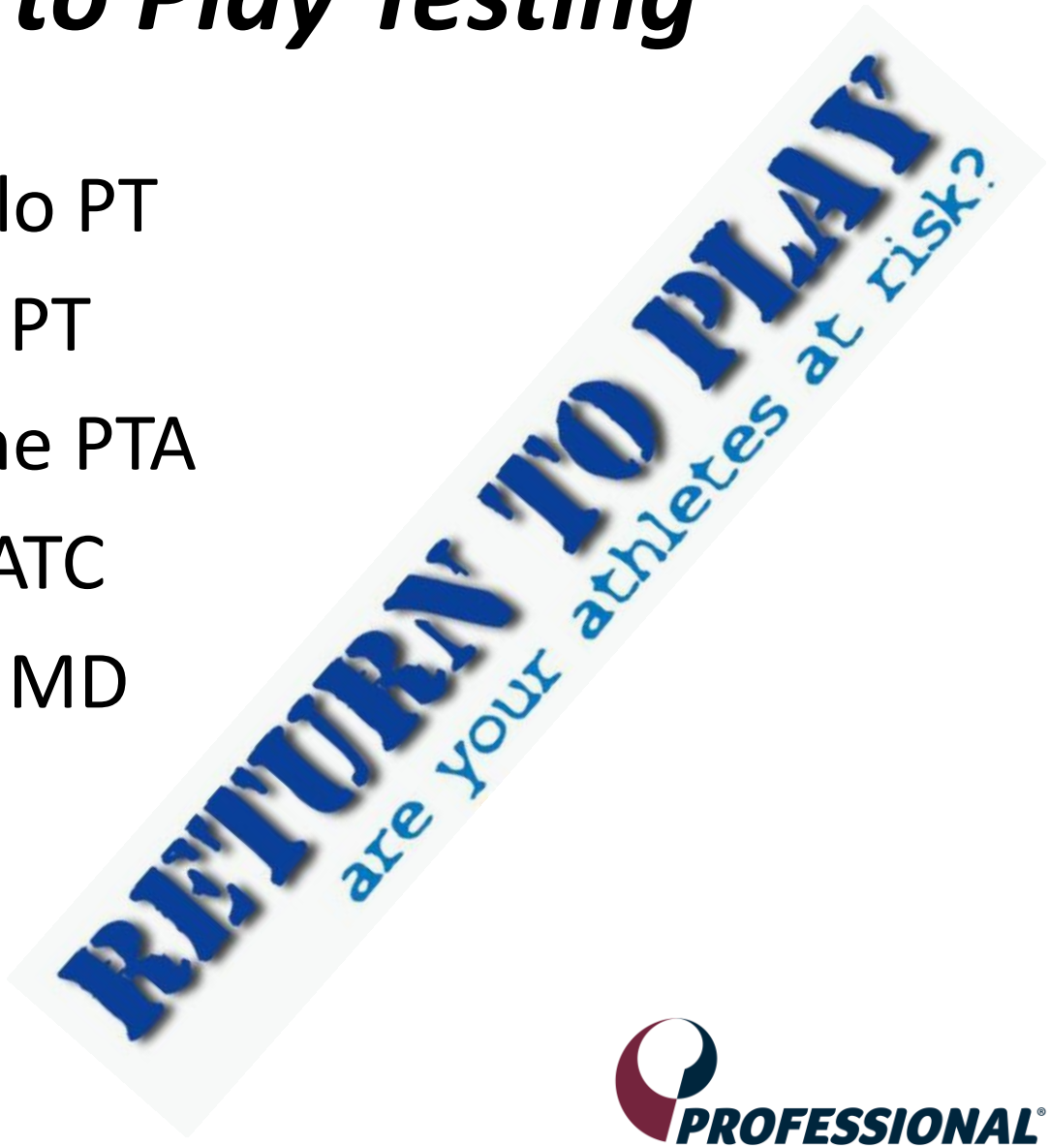
Return to Play Testing

- Robert Panariello PT
- Timothy Stump PT
- Dean Maddalone PTA
- Michael Heller ATC
- Frank Cordasco MD



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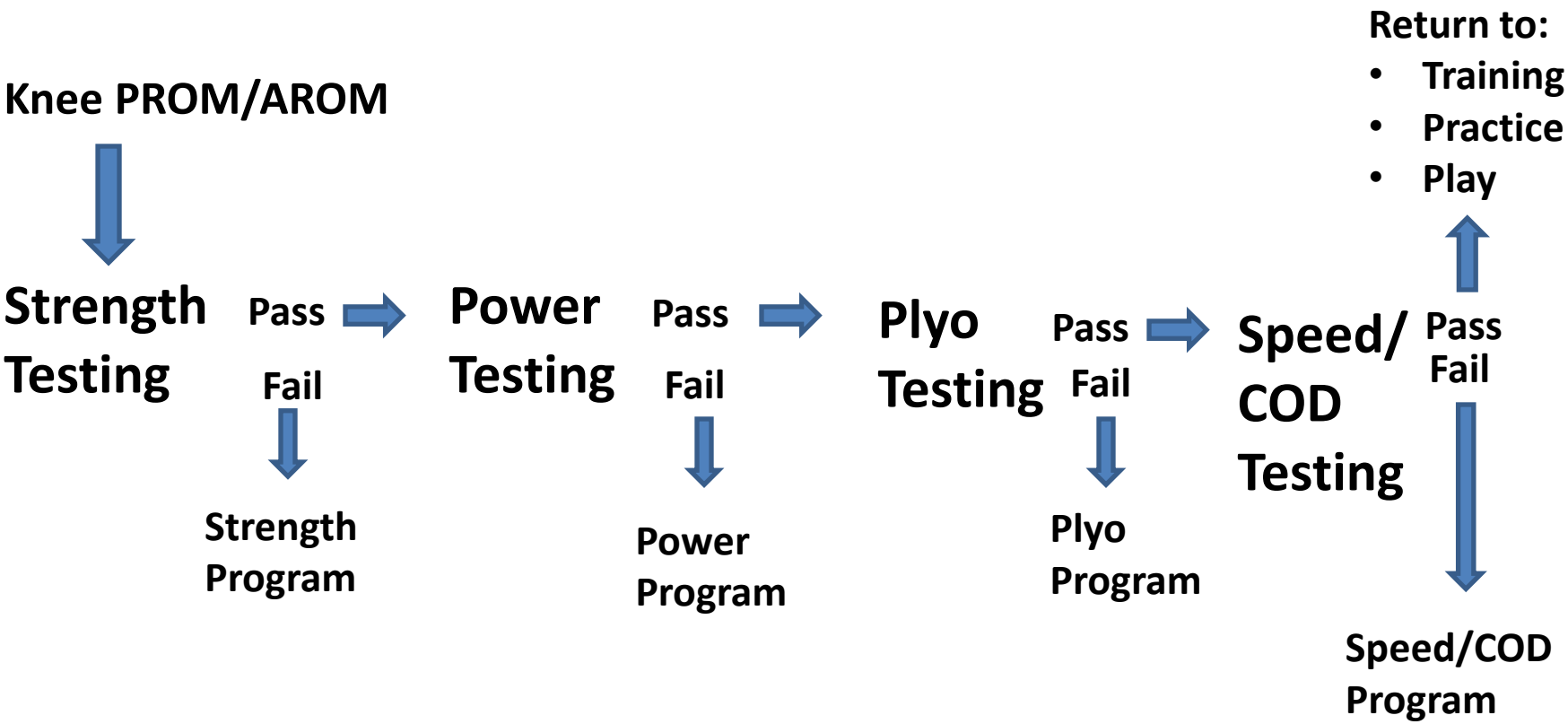
Return to Play Testing

- *Based upon Vermeil's Hierarchy of Athletic Development*



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ACL Return to Play Testing

- Deficits observed in our RTP testing

What are we missing and why can't some athletes hit the target?

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Knee AROM - The Swing Phase

- Moment arms (distance) of heel to butt

Figure 1

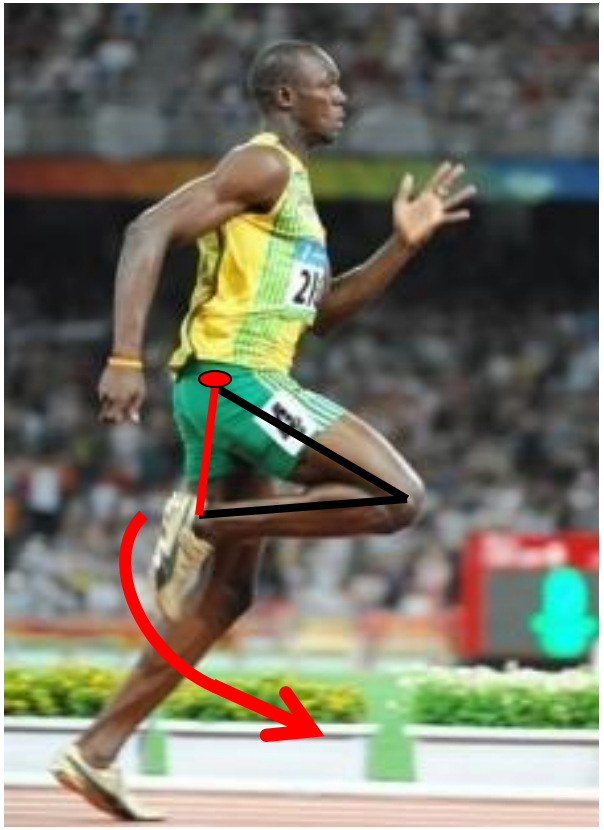

Figure 2

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Side View

Active Knee ROM

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Rearview

Active Knee ROM

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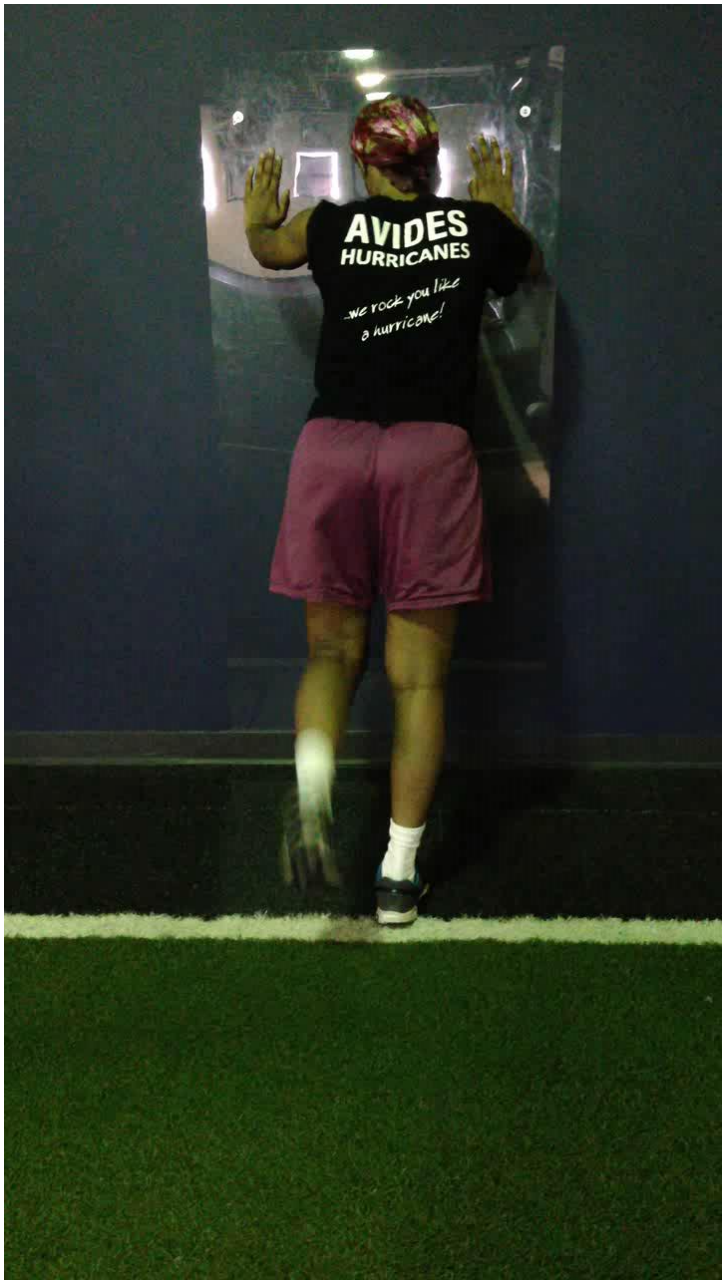
Active Knee ROM



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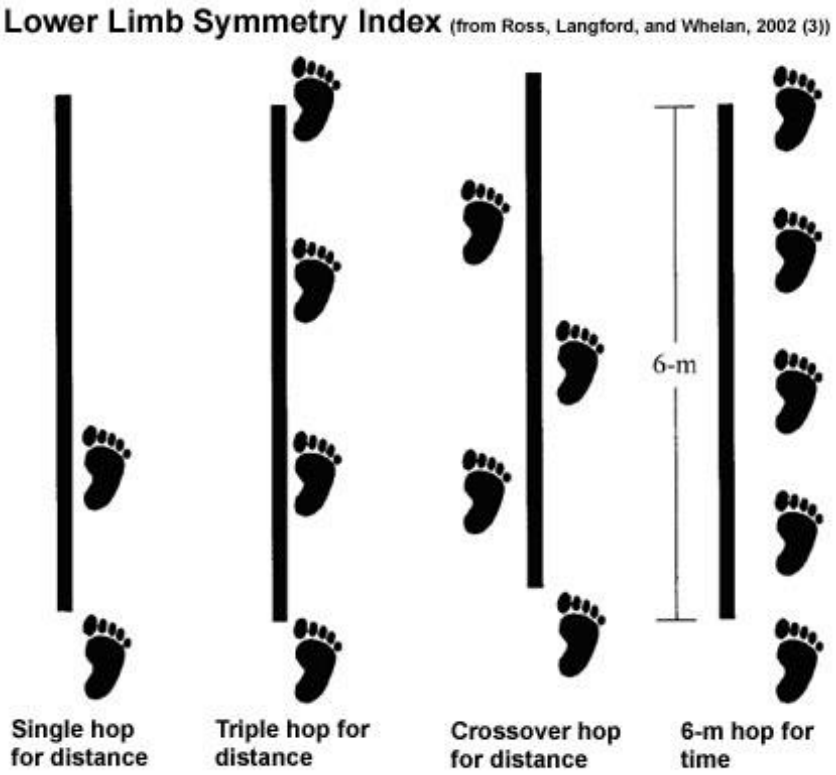
ACL Return to Play Criteria

- ACL Examination
  - Knee Ligament Integrity
- Comparison to the non-affected extremity
  - ROM
  - Strength
- "Functional" Testing
  - Hop tests
  - Running
  - Cutting



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ACL Return to Play Criteria

- In addition to the "traditional" rehabilitation standards for "return to play" why wouldn't we also consider the physical quality requirement standards of:
  - The sport of participation
  - The position of play

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ACL Return to Play Criteria

- Physical Quality Standards for Collegiate Football Players

Exercise	DI	DII	DIII
Bench Press	144.5 Kg	135.2 Kg	128.6 Kg
Back Squat	192.8 Kg	182.5 Kg	176.9 Kg
Power Clean	123 Kg	116.5 Kg	113 Kg

Figure 2 The Physical Qualities of Division I, II, and III Football Players

Fry and Kraemer *1991*

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ACL Return to Play Criteria

Physical Quality Standards for High School and College Football

	NCAA Division I			NCAA Division III		High School 16 – 18 Year Olds		
Percentile	Bench Press	Squat	Power Clean	Bench Press	Squat	Bench Press	Squat	Power Clean
90th Percentile	370 lbs.	500 lbs.	300 lbs.	365 lbs.	470 lbs.	275 lbs.	465 lbs.	250 lbs.
50th Percentile	300 lbs.	395 lbs.	252 lbs.	280 lbs.	365 lbs.	215 lbs.	335 lbs.	208 lbs.
30th Percentile	270 lbs.	355 lbs.	232 lbs.	255 lbs.	335 lbs.	195 lbs.	295 lbs.	183 lbs.
n	1,189	1,074	1,017	591	588	339	249	284

Hoffman 2006

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ACL Return to Play Criteria

40 Yard Sprint Times for High School and Collegiate Football Players

Percentile	High School (14 – 15 Year old)	High School (16 – 18 Year Old)	NCAA Division III	NCAA Division I
90th Percentile	4.86 sec	4.7 sec	4.59 sec	4.58 sec
50th Percentile	5.28 sec	5.08 sec	4.95 sec	4.87 sec
30th Percentile	5.50 sec	5.3 sec	5.12 sec	5.02 sec
n	113	205	538	757

Hoffman 2006

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ACL Return to Play Criteria

Age	Gender	Post-op Month Testing	Body Weight	Trap-bar Weight	Vertical Jump	Involve Single leg VJ	Percent vs. Non-Involved	Position Related VJ
21	Male (OL)	8	275	275X10	27.5”	15.5”	98%	40%
20	Male (RB)	11	185	185X10	30.0”	13.5.”	90%	10%
21	Male (LB)	7	220	220X10	18.0”	10.5”	110%	0%

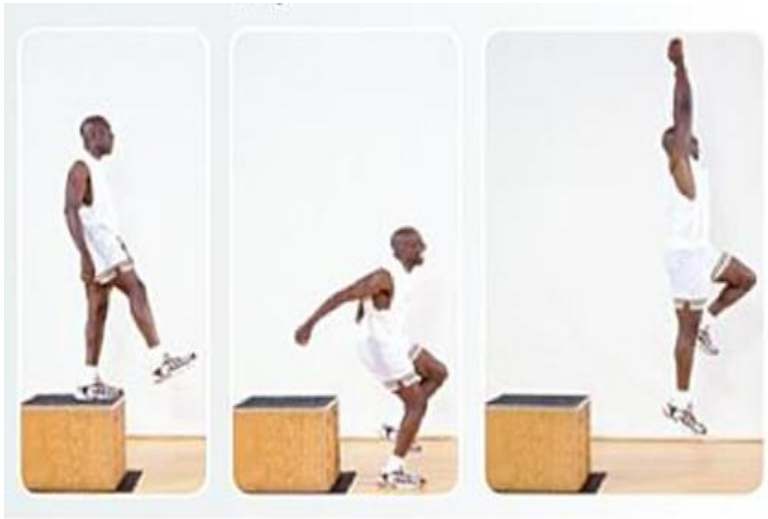
Vertical Jump Heights for College Football Players Participating in the NFL Combine

Percentile	DI VJ Football (DB’s)	DI VJ Football (DL)	DI VJ Football (LB)	DI VJ Football (OL)	DI VJ Football (QB)	DI VJ Football (RB)	DI VJ Football (TE)	DI VJ Football (WR)
90	40.0”	36.8”	37.0”	33.0”	35.5”	38.5”	37.9”	39.5”
50	36.0”	32.0”	33.5”	28.5”	31.8”	33.5”	34.0”	36.0”
30	34.5”	30.5”	32.4”	27.0”	30.0”	32.0”	31.0”	34.0”

Single Leg Elastic Strength Testing Results

Gender	Age	Post-op Knee	Post-Op Month Testing	Ht.	Weight LBS.	GCT R SEC.	GCT L SEC.	SLJ R Inches	SLJ L Inches
Male	16	Right	11	68”	158	.42	.47	8.8”	11”
Male	17	Right	9	67”	173	.49	.54	11.9”	14.3”
Male	17	Left	8	73”	195	.53	.47	13.6”	10.6”

Single leg in-depth jump from an 8” box



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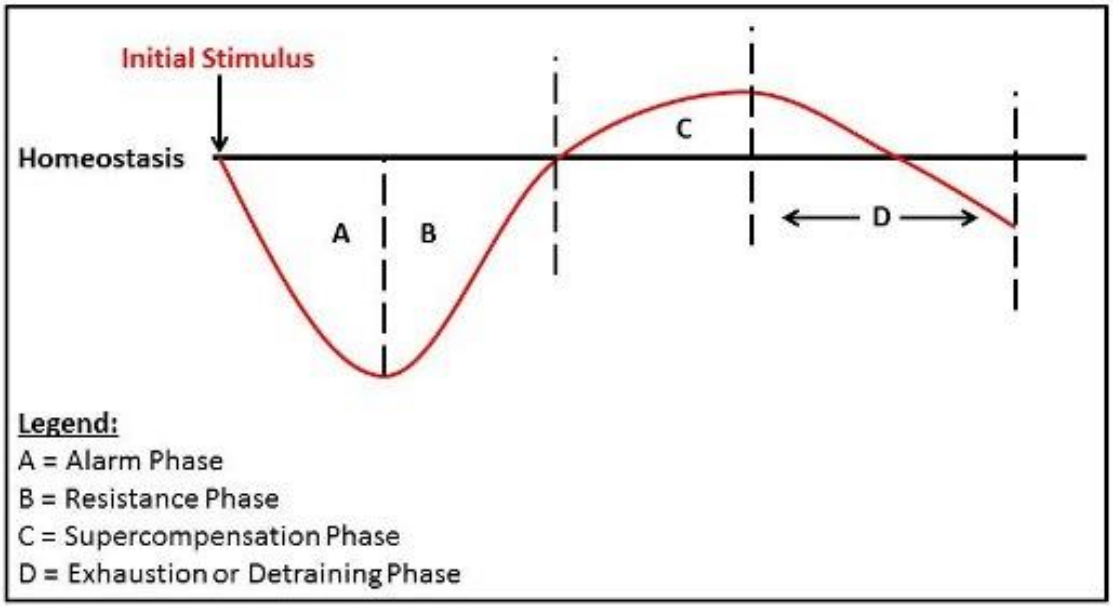
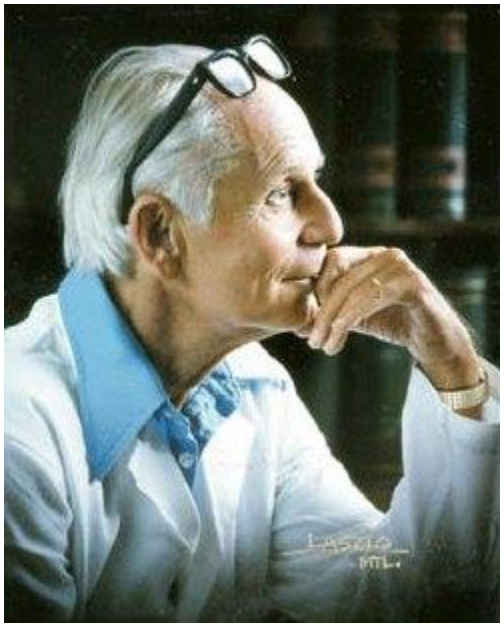
Developing the Physical Qualities of Rehabilitation & Athletic Performance

- Selye's General Adaptation Syndrome
  - The need for the application of *unaccustomed* stress





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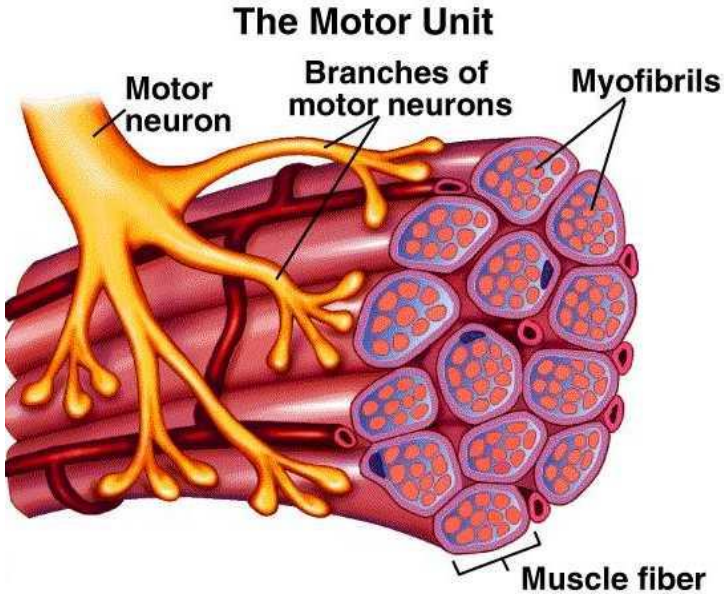
Motor Unit Recruitment

- Motor Unit
  - Single motor neuron and all of the muscle cells it stimulates
- Recruitment
  - When more motor units need to be stimulated for increased strength
- Size Principle
  - In any muscle contraction, smaller motor units (MU) are recruited first. Larger and more powerful MU are recruited last.
  - Type I MU are recruited first while type IIb/IIx are recruited last.



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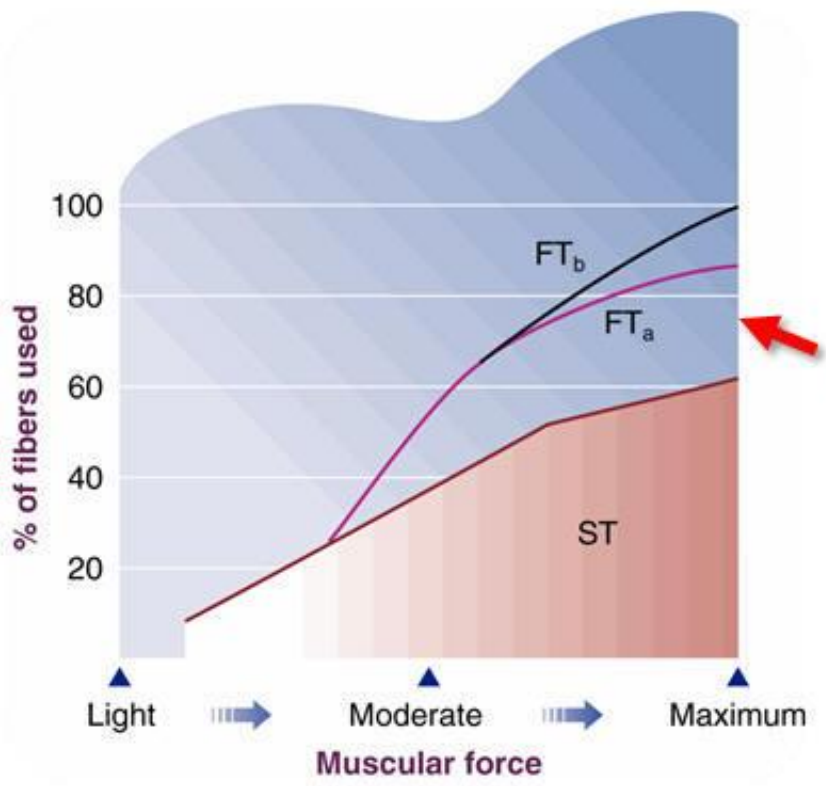
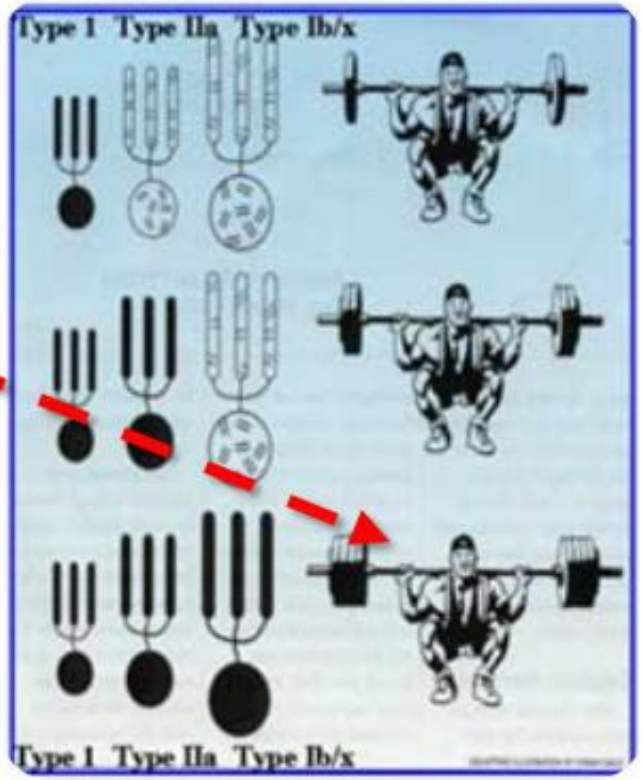
Motor Unit Recruitment (Need to Apply Intensity)





90% - 95% Intensity is still sub-maximal Intensity may be load and/or velocity

Graph source JMU strength and Conditioning

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The Physical Quality of Strength

- Foundation of Athletic Performance
  - Application of force into the ground surface area
  - Maintenance of proper postural position during athletic performance
  - Muscle and Joint Stiffness (requirement for SSC)
  - Joint Stability
  - *The physical quality from where all other physical qualities evolve*

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Vertical Hip Height in Sprinting and Running

- *Proper Vertical hip height*
  - Increases both flight time and a greater distance covered due to the “toe off” occurring closer to the body’s center of mass

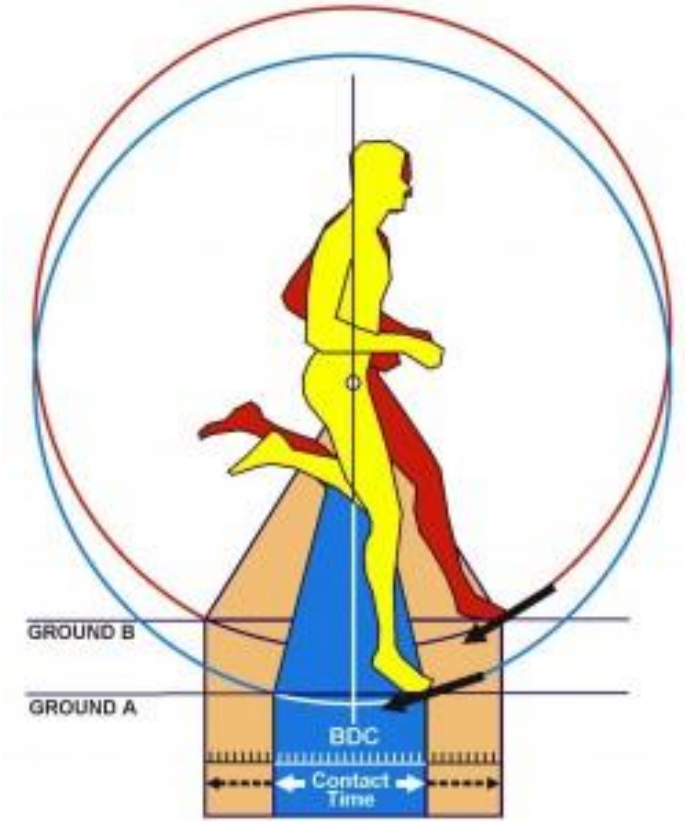

Figure Courtesy of Derek Hansen

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The Physical Quality of Strength

- The Squat Exercise
  - Decrease in 10 and 40 yard dash times
  - Increase in vertical jump McBride et al J Strength Cond Res 2009
  - No adverse affect in "normal" ACL's in NFL Football Players Panariello et al AJSM 1994
    - 21 Weeks of training
    - 2440 Knee ligament arthrometer test measurements
- The Squat Exercise
  - Relative Muscular Effort (RME)
  - Squat Exercise Depth
    - How deep should I squat?

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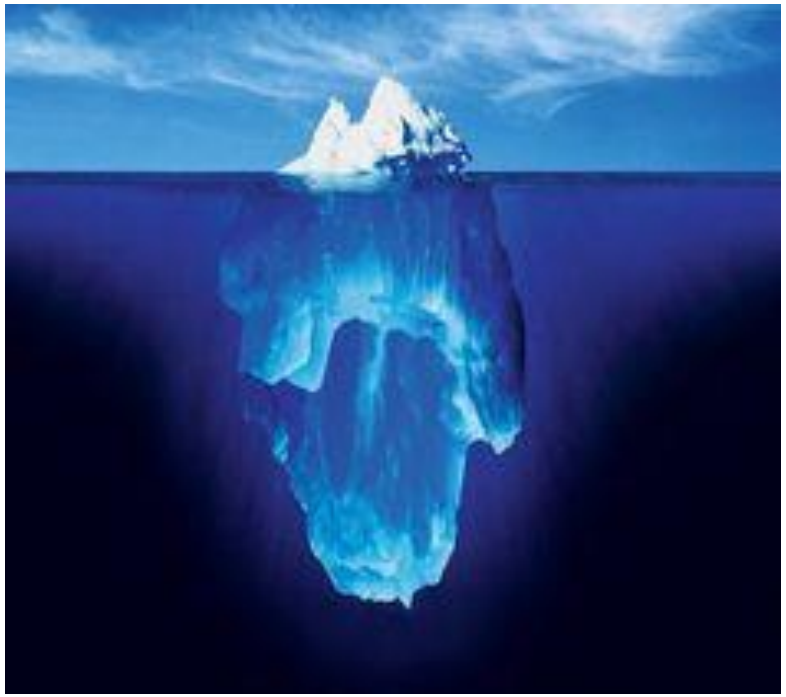
Relative Muscular Effort (RME)

- Relative Muscular Effort (RME) is defined as:

"The muscle force required to perform a task relative to the maximum force a muscle can produce."



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Squat Exercise Relative Muscular Effort (RME)

Muscle Group	Effect of Depth	Effect of Load
Knee Extensor RME	Yes	No
Ankle Plantar RME	No	Yes
Hip Extensor RME	Yes	Yes

Bryanton, MA et al JSCR 2012

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The Physical Quality of Power

- Maximal Strength must be combined with either explosive strength (power) and/or elastic strength to enhance optimal athletic performance

Harris et al J Strength Cond Res 2000
Tricoli J Strength Cond Res 2005

- P = F X D/T ⇨ Velocity Component
  - Acceleration
  - Rate of Force Development (RFD)
    - Many ACL athletes are unable to apply adequate force at higher velocities

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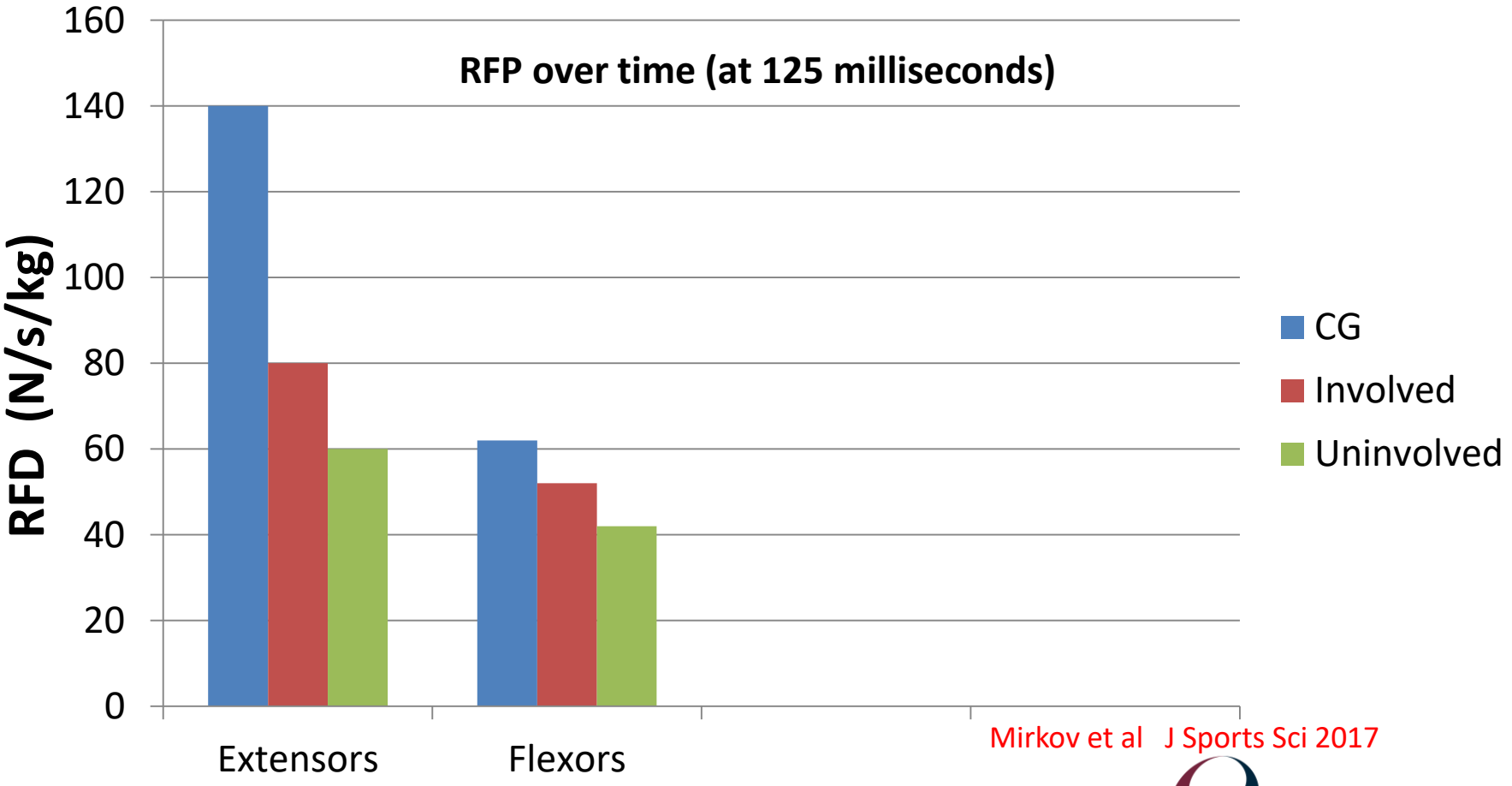
RFD of Knee Extensor and Knee Flexor Muscle Groups at 4 Months Post-Operative ACLR



Mirkov et al J Sports Sci 2017

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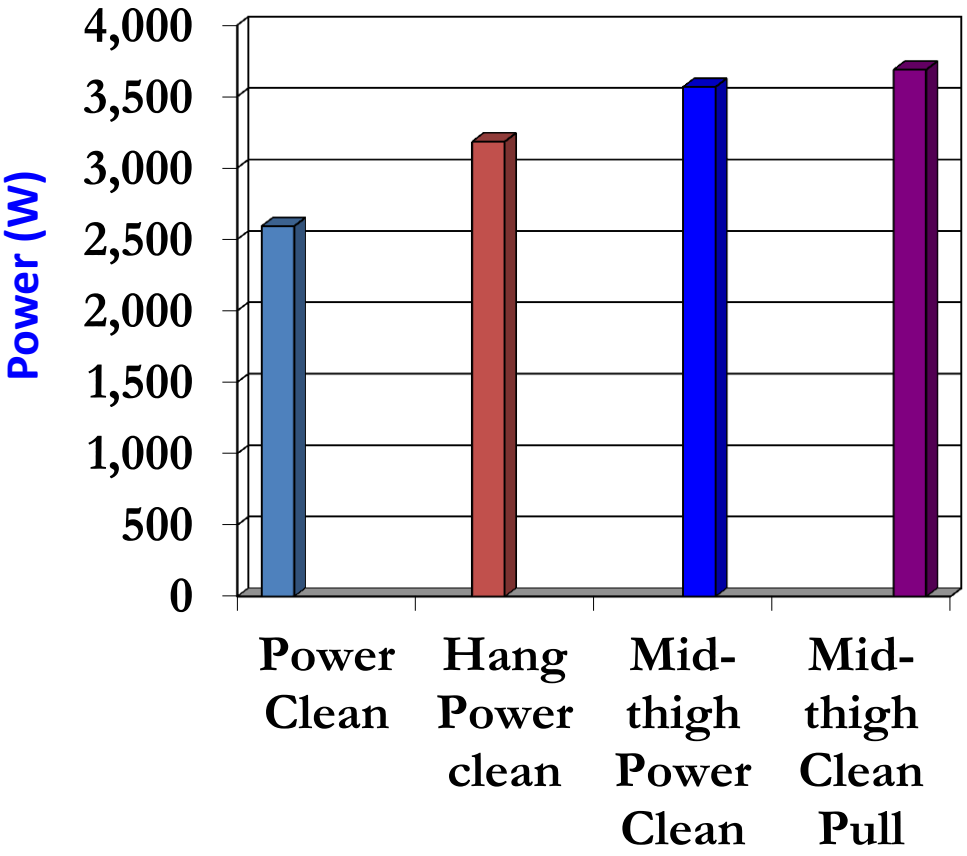
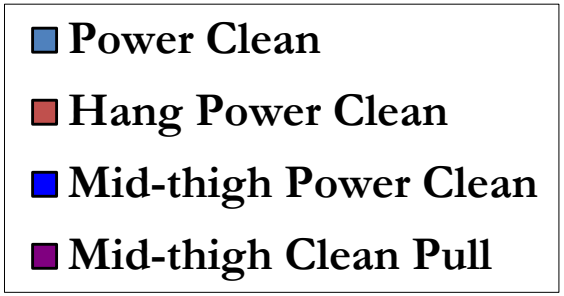
Peak Power Output





Comfort JSCR 2011

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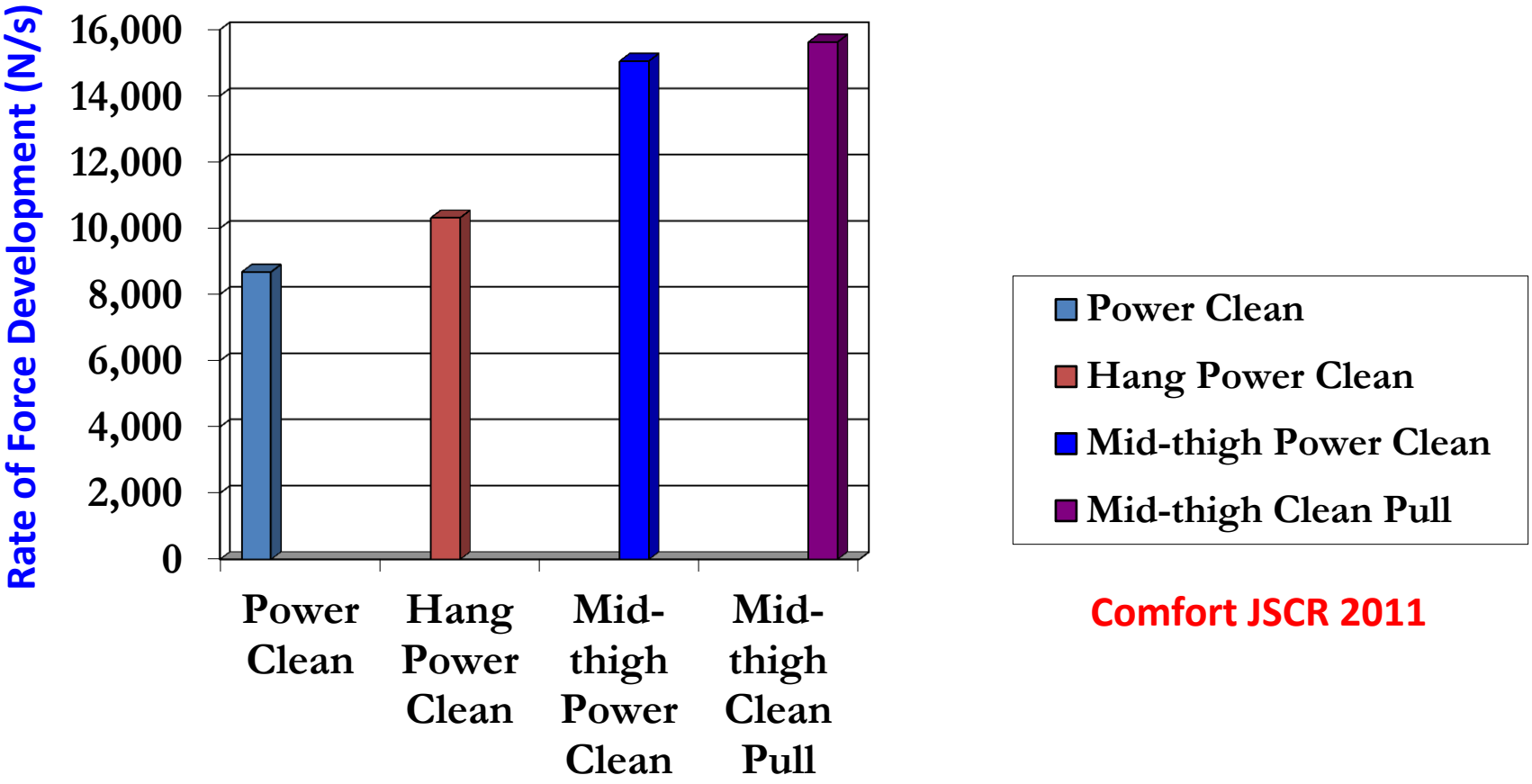
Comparison of Peak Rate of Force Development (RFD)



Comfort JSCR 2011

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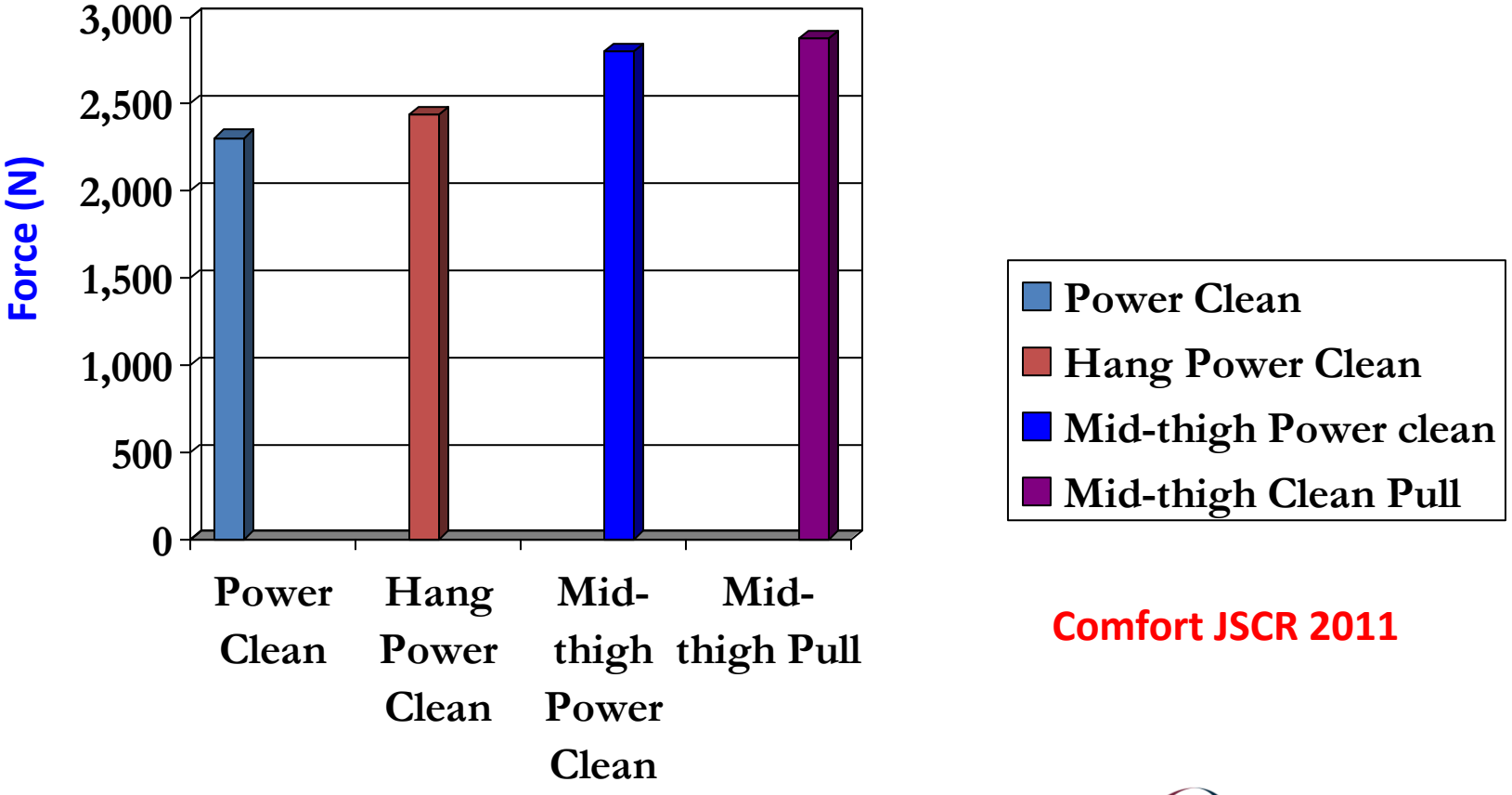
Comparison of Peak Ground Reaction Forces



Comfort JSCR 2011

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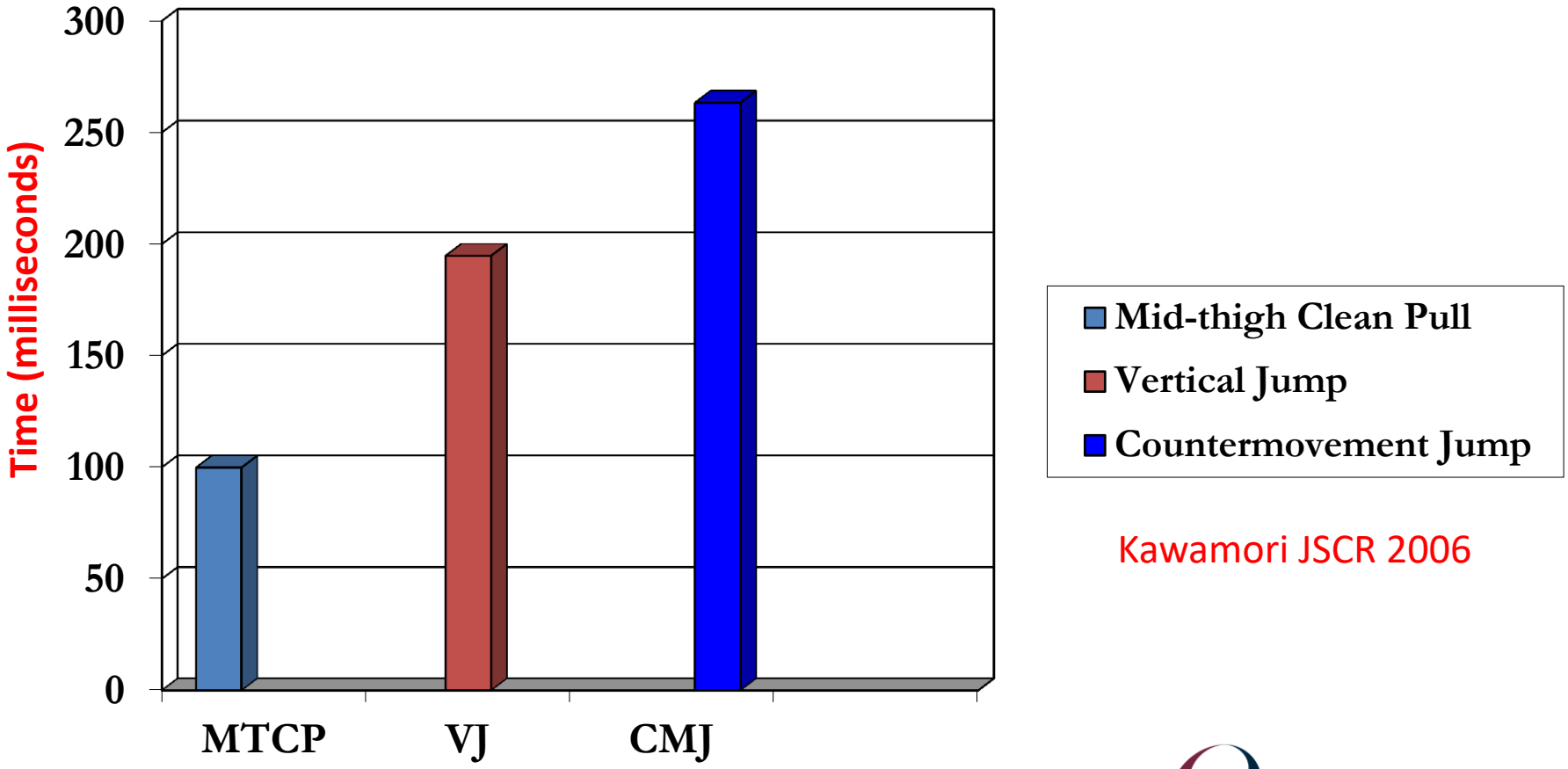
Peak Rate of Force Development (RFD) for Different Activities



Kawamori JSCR 2006

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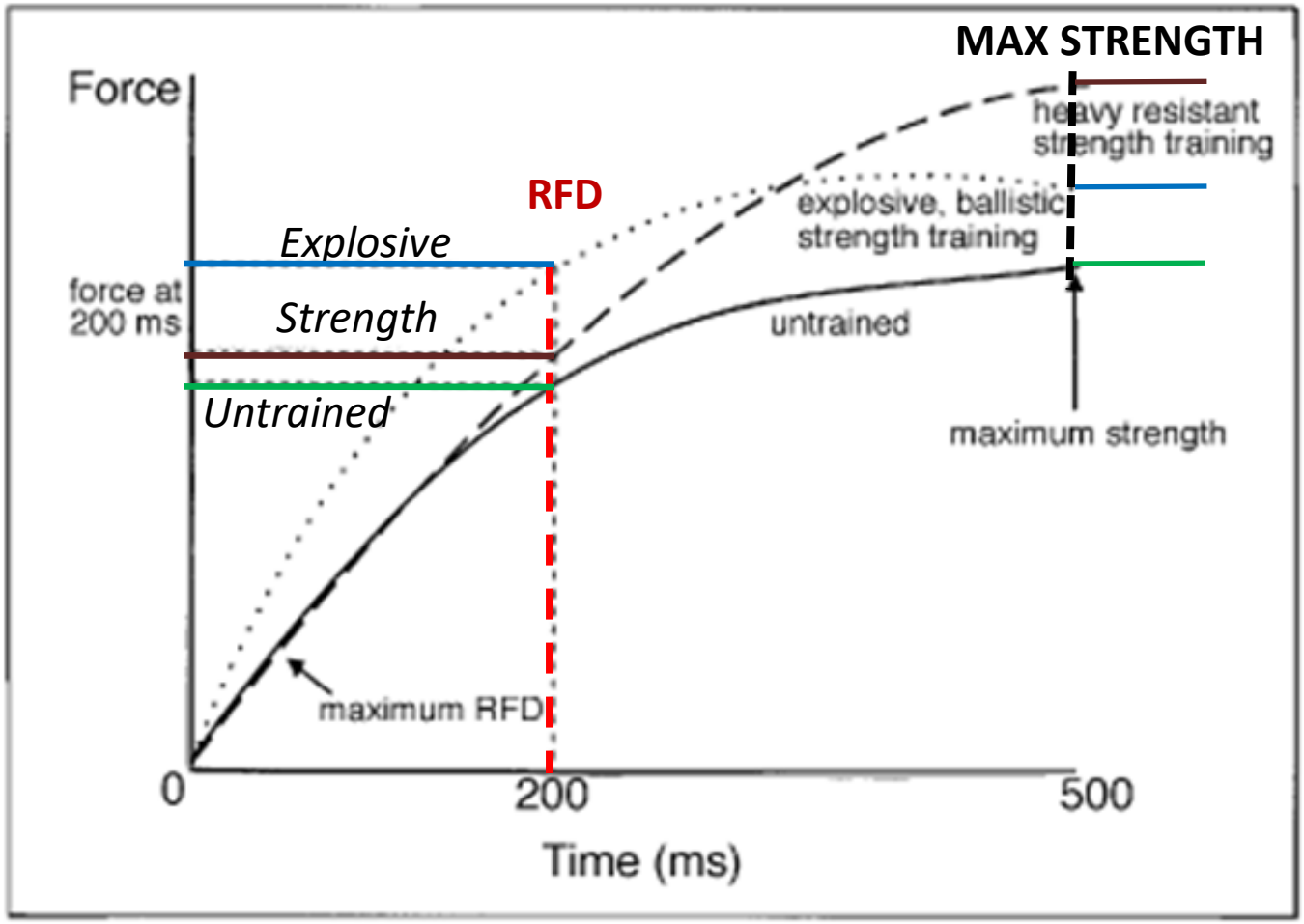
The Rate of Force Development in Athletics



Kraermer and Newton Gatorade Sport Sci Exchange 1994

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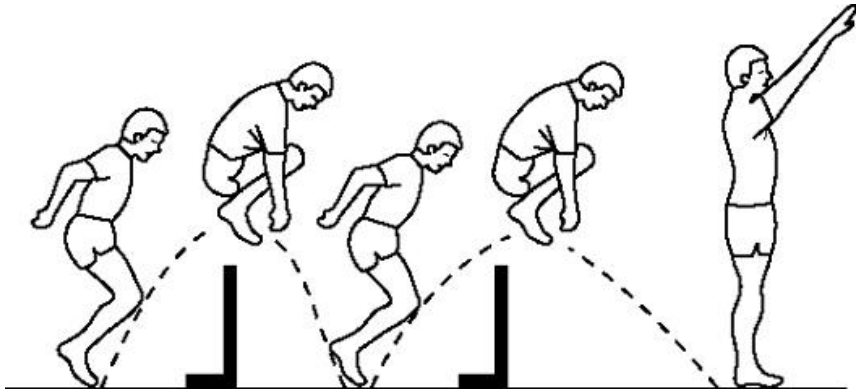
The Physical Quality of Elastic/Reactive Strength

- Elastic/Reactive Strength incorporates the Stretch Shortening Cycle (SSC)
- Accomplished by “shock” or “Plyometric” type training
- Short Amortization Phase
  - Ground contact time (GTC)
  - Requires muscle and joint “stiffness”
- Ground Contact Time (GCT)
  - Improves but without adequate force production
  - Kinesiophobia



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The Physical Quality of Speed

- Optimal development of the physical quality hierarchy
- Must be technically proficient in sprinting mechanics
- Athletes must pick their parents well

SPEED

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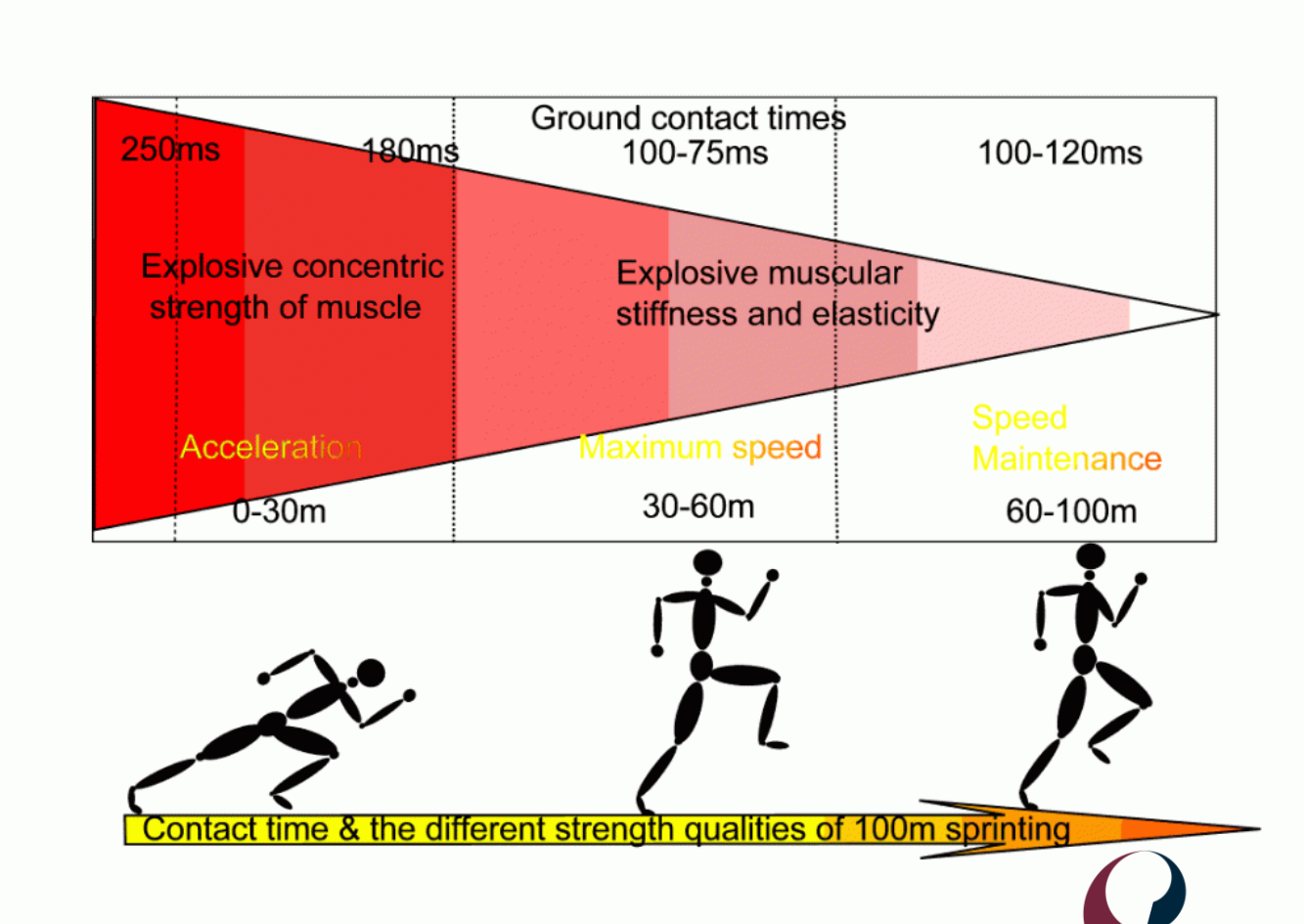
The Contribution of Different Strength Qualities to 100m Sprinting



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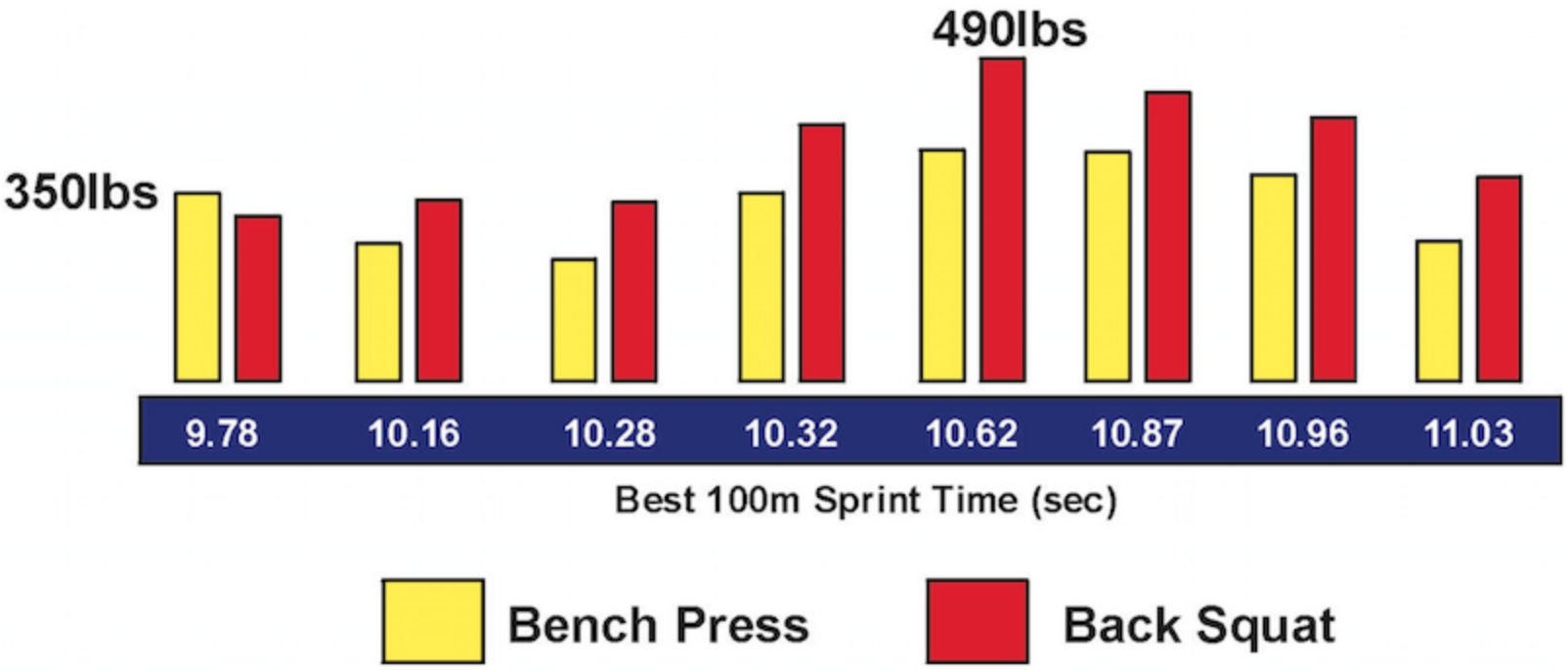
Critical Thinking



Courtesy Derek Hansen

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Summary

- The Post-rehabilitated ACL athlete likely has some of the following deficits when returning to athletic performance enhancement training:
  - Lack of knee AROM
  - Physical Quality of Strength
  - The Physical Quality of Explosive Strength (Power)
  - The Physical Quality of Elastic/Reactive Strength ******
  - The Physical Quality of Speed
  - Kinesiophobia (fear to use the affected extremity)
  - It likely will be a year or more for the ACL athlete to return to their previous level of athletic performance

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