Physiological and metabolic background of Strength Training

Practical consequences for Science based Strength Training

Shaun Pickering

3rd IAAF World Coaches Conference

London: 7-10th August, 2017

About Me

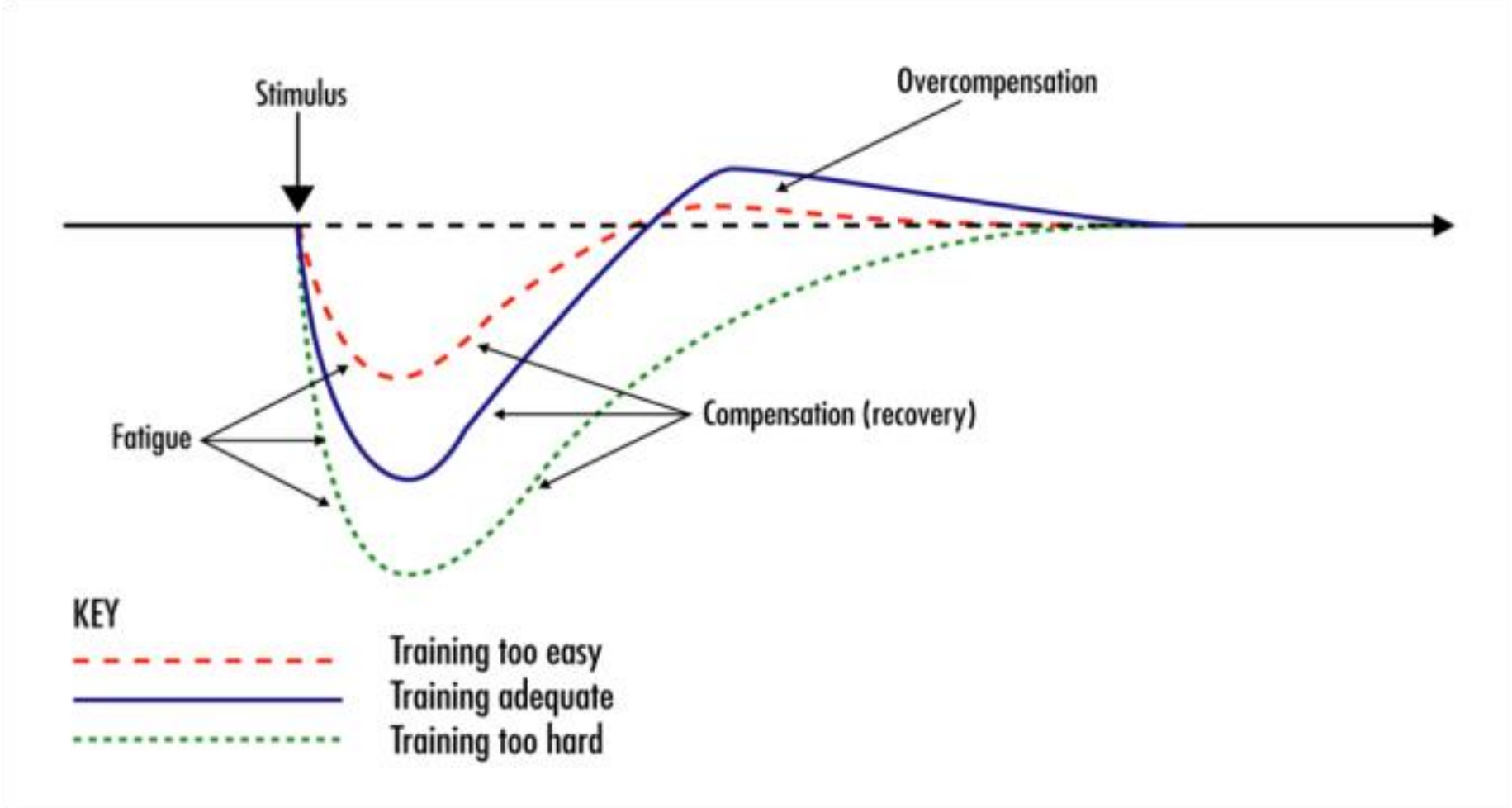
- I am not a Scientist!
- I am a coach, former athlete, sports marketer, communicator!
- Shared Vision

- Facilitator
- There is a difference between what a scientist needs to know and what a coach needs to know: Application of Science!

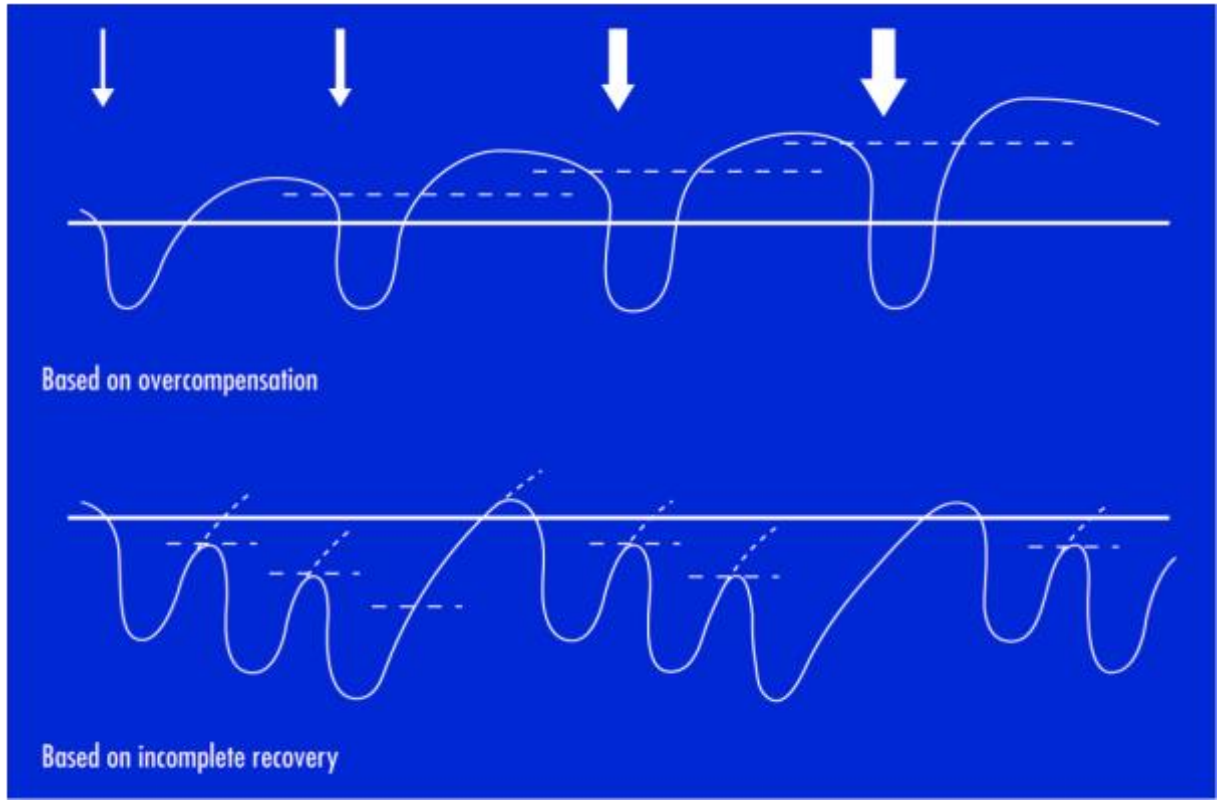
Modern Thinking

- I have been lucky to spend time with many current Top-Coaches, Athletes and Scientists.
- Now, less influence from past.
  - Less Reliance on ex-GDR / USSR.
  - Research was not always accurate…
  - Often Drugs would provide Recovery.
- Now more Focus on Athletic Strength
  - Training the “Athlete” not the Strongman
  - Power more relevant than Max Strength
  - Speed Element must also be observed

The Overload Principle of Training



The Progressive Overload Principle
Overload and not Overkill



Milo of Kroton

Specificity of Training?
Became good at carrying a Bull!
Did it translate to Wrestling?

Specificity of Training

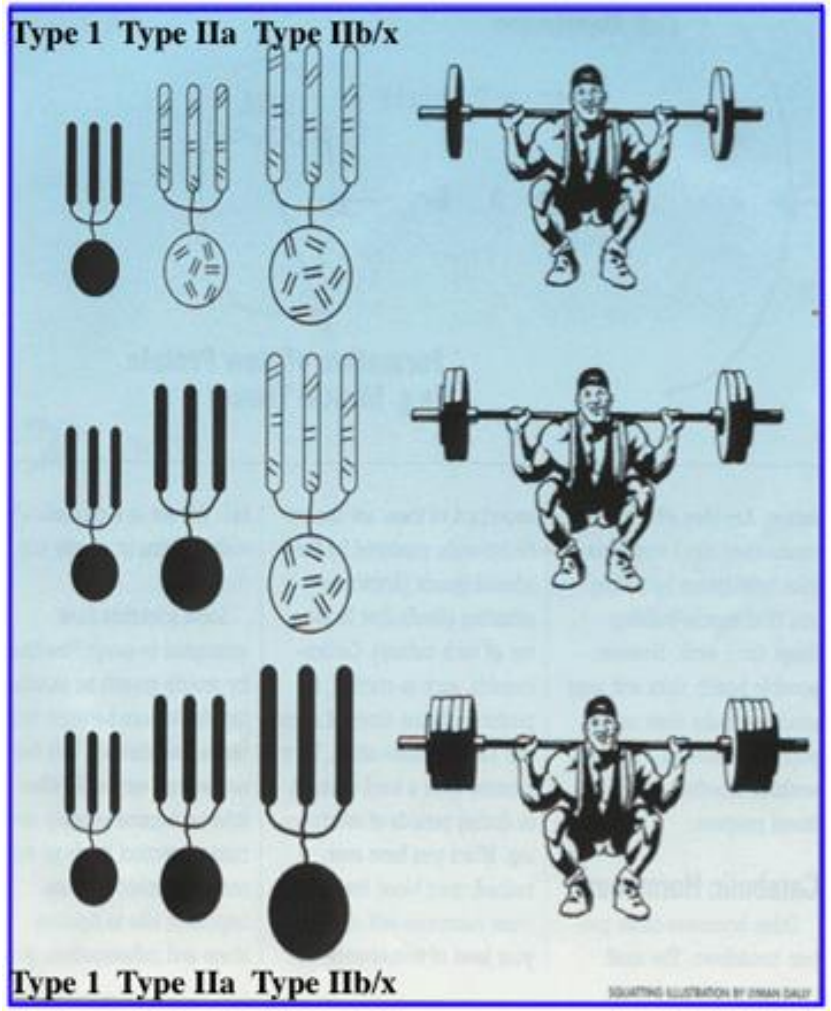
- **Specificity** is the principle of **training** that states what you do in the gym should be relevant and appropriate to your desired outcome.
- **Training** should go from general, at the beginning to specific as the program progresses
- The best form of training for an exercise…. is that exercise!
  - You get good at what you do, so spend as much effective time doing that.
  - Technique is a Skill! You need to practice that skill
  - Your focus as a Thrower should be on Throwing as much as recovery allows.
  - Bondarchuk: Correlation between Bench Press max and Shot Put max is 0.39!

Specificity of Strength Training

- Our Goal must be to improve relevance to throw
  - How to perform the exercise is also important
- Choose your time wisely when planning training
  - If it does not benefit, then why spend time on it?
  - If it is not done properly, what is the benefit, can it be improved?
  - There is an effective amount of time spent in gym. More ≠ Better
- **Train as much as necessary and not as much as possible!**

Motor Unit Recruitment

- All or nothing principle!
- In voluntary contractions, there is a pattern of motor-unit recruitment in which small motor-units are recruited first with larger motor-units recruited later if needed.
- It is more difficult to recruit the larger motor-units than the smaller units. Strength training can increase motor-unit firing.
- In general the smaller motor-units consist of slow twitch (type I) muscle fibers, and the larger motor-units which are harder to activate are fast twitch (type IIa & IIb) muscle fibers.

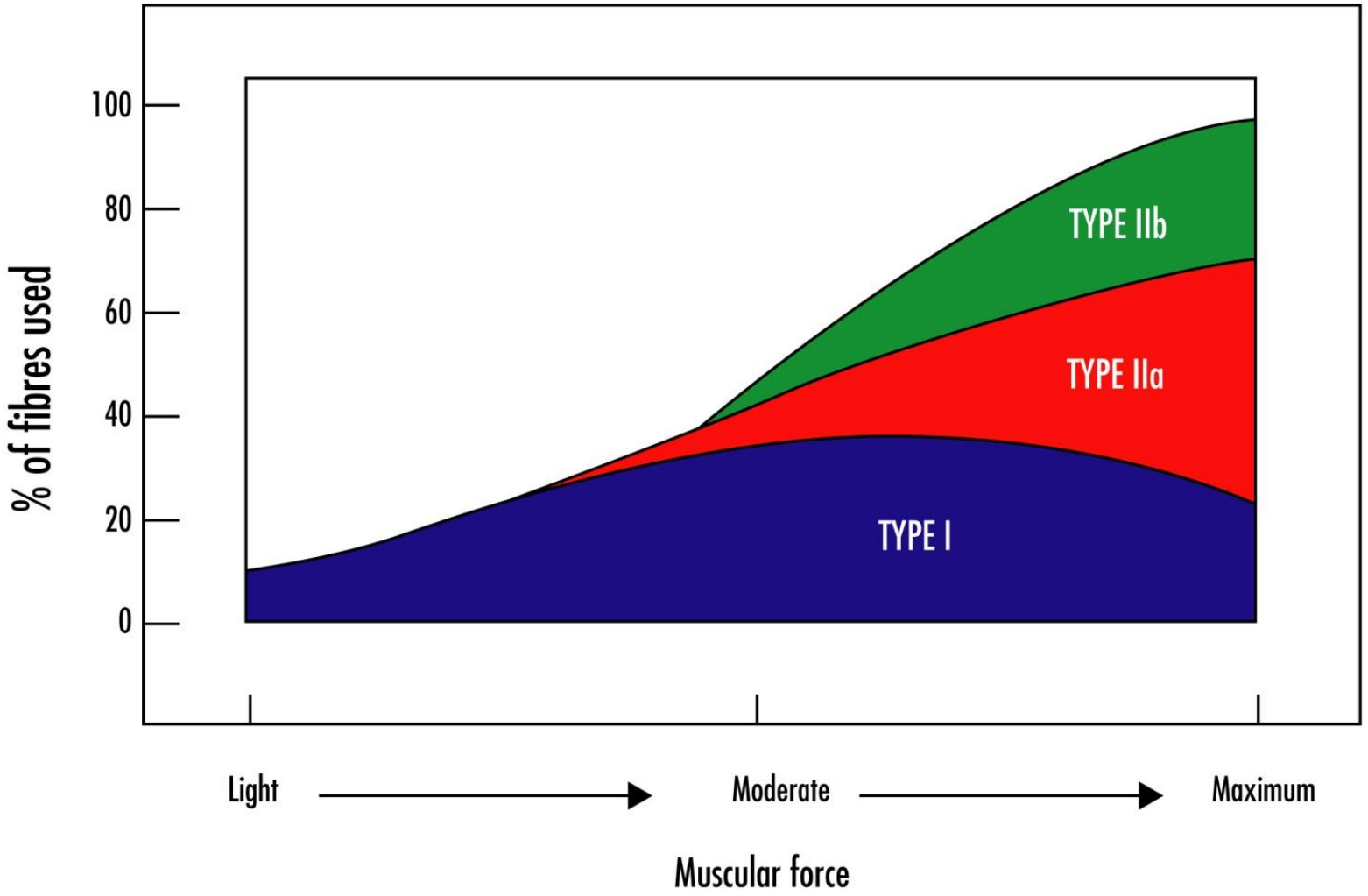


Motor Unit Recruitment

To recruit fast twitch fibres, the muscle requires a high level of force to be demanded of it.

This can be due to high load or high intensity, or intent to move the load, for example at a high speed.

Type IIb recruited last



Hypertrophy and Hyperplasia

- Mechanism of action:

1. Myofibrils increase in mass and CSA due to addition of actin/myosin to periphery
2. Myofibrils reach critical mass where forceful actions tear Z-lines longitudinally
3. Myofibril splits

- Hypertrophy of different fiber types:

- Fast twitch:
  - Mechanism: Mainly increased rate of synthesis
  - Potential for hypertrophy: High
  - Stimulation: Forceful/high intensity actions

- Slow twitch:
  - Mechanism: Mainly decreased rate of degradation
  - Potential of hypertrophy: Low
  - Stimulation: Low intensity repetitive actions
  - -FT may atrophy as ST hypertrophy

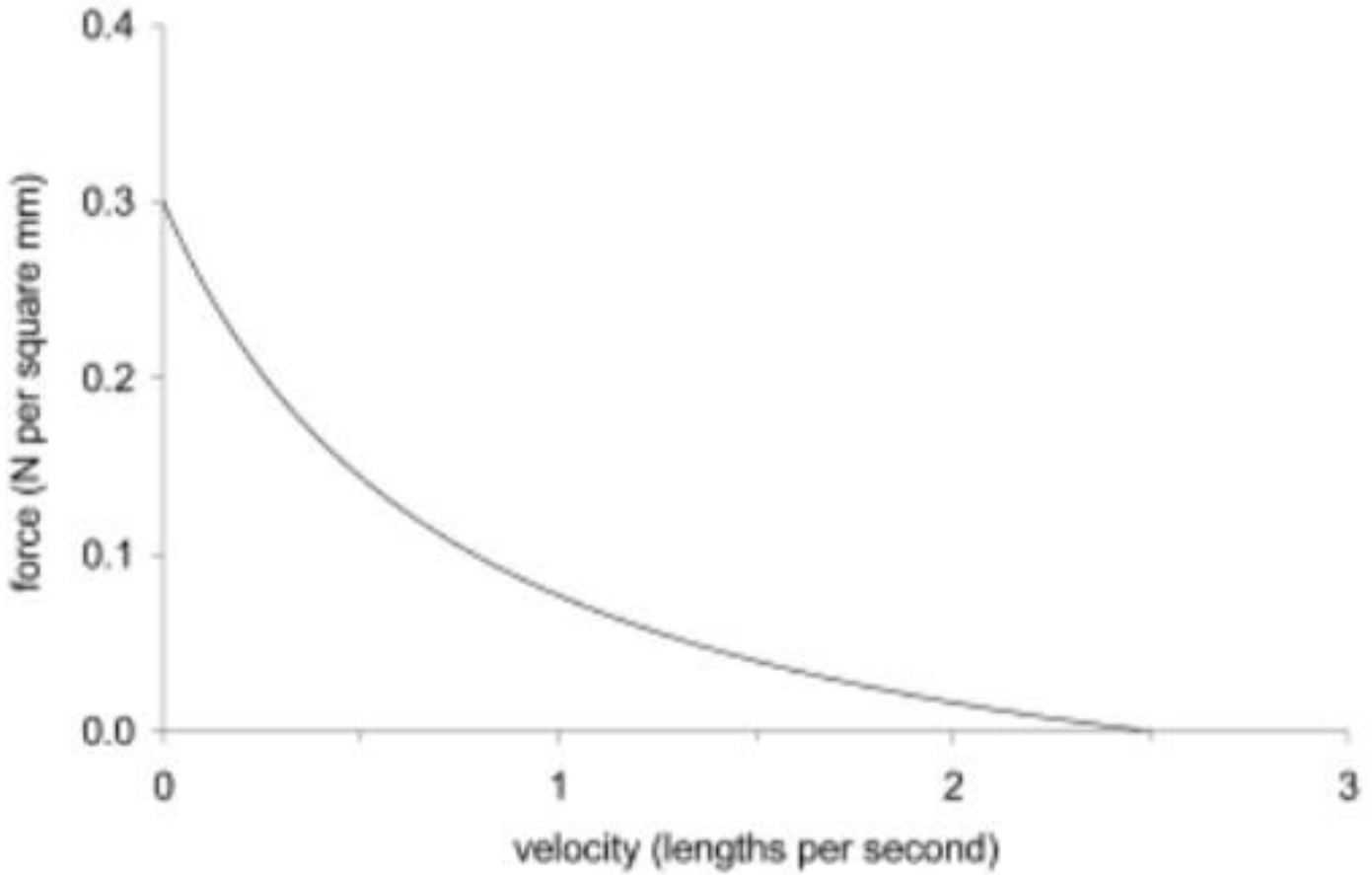
Fibers can get bigger and can split (multiply), but you cannot change types, so you need to train the right type for your needs

The Hill Equation (1928)

(F + a) (v + b) = (Fo + a) b

where F is the force generated by the muscle, v is the velocity of shortening, Fo is the maximum (isometric) force exerted by the muscle, and a and b are constants.

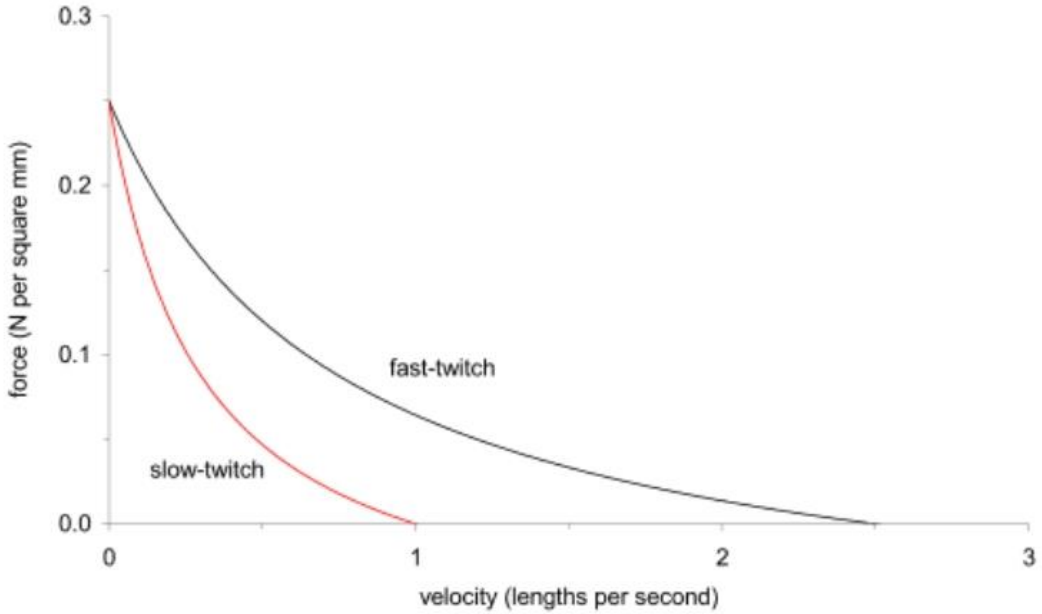
The force a muscle or muscle fibre can produce decreases as the speed of contraction is increased.

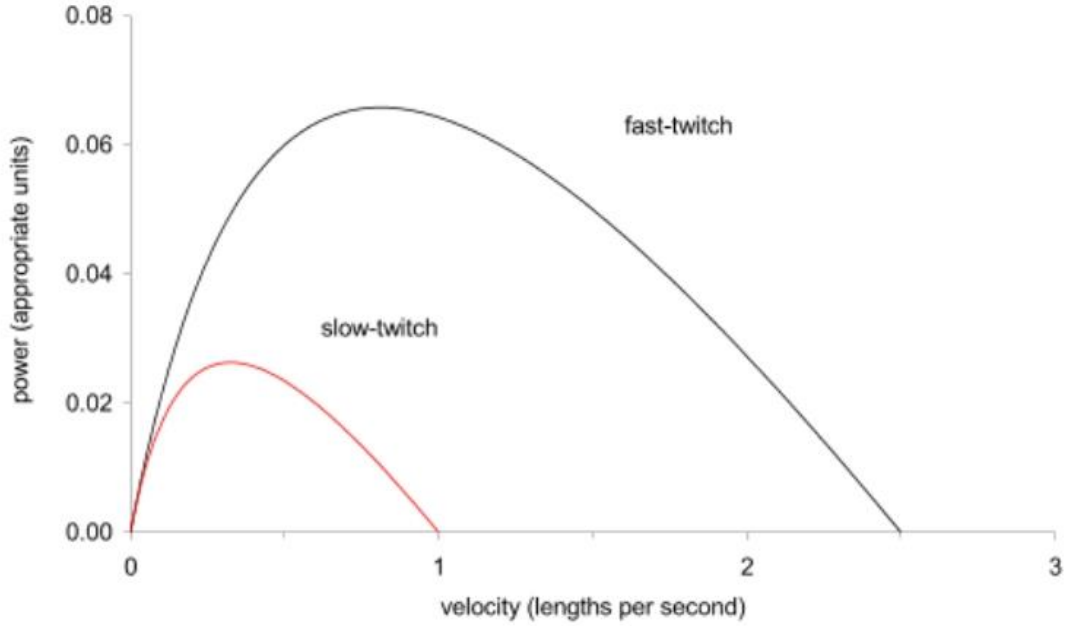


Power – Velocity Relationship

The force-velocity relation for a fast-twitch muscle fibre with that for a slow-twitch fibre. The force per cross-sectional area of a fast-twitch and a slow-twitch muscle fibre are about the same. That is, both types of fibre have the same value of Fo in the Hill equation. However, a fast-twitch fibre has a greater maximum speed of contraction (hence has a higher value of b)

P = Fv





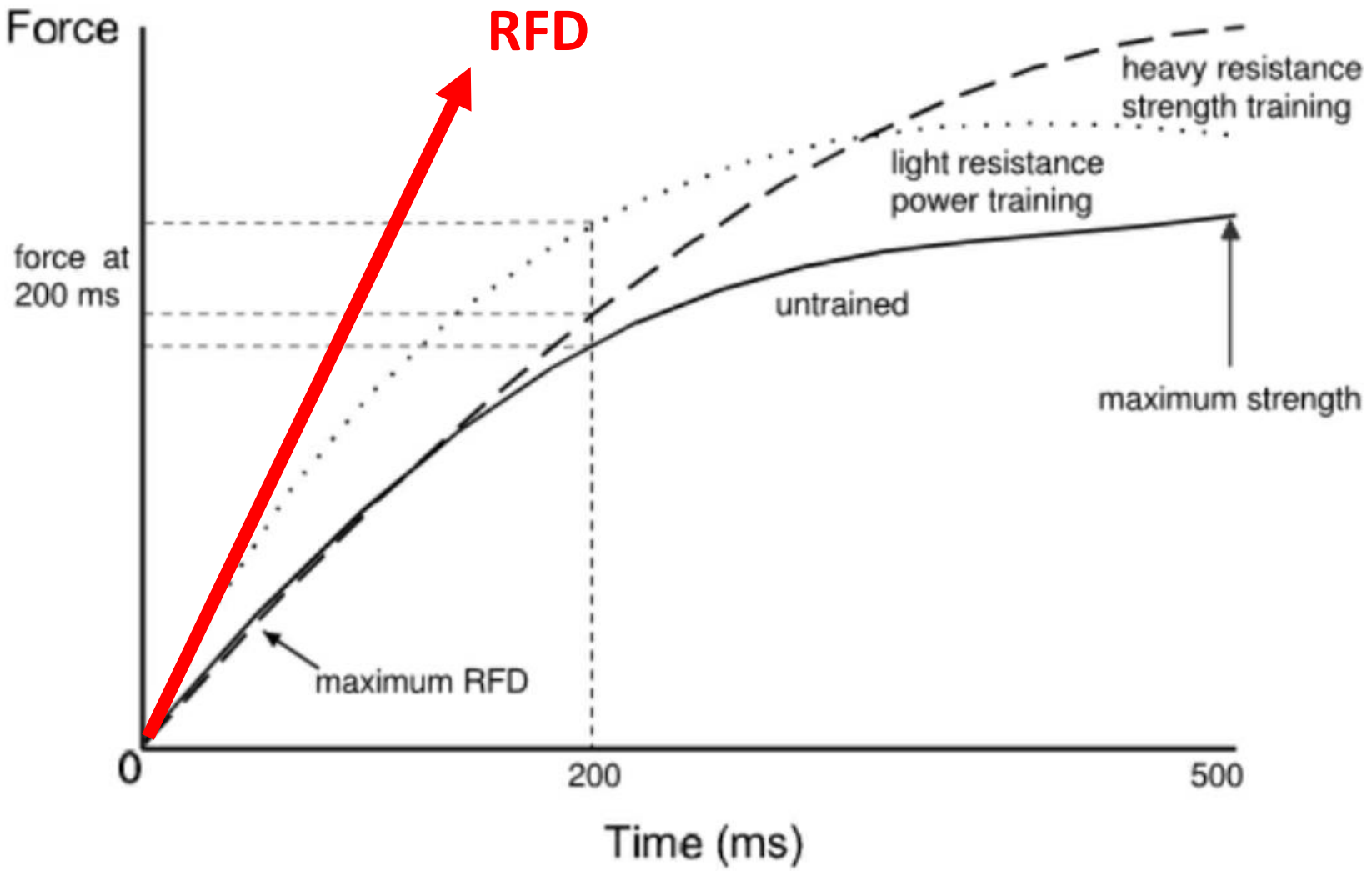
Power: The need for speed!

- Utilization of muscular forces for the production of specific movements or events.
- Power Oriented. P = F x V.
  - (F x D)/t or Work/t
  - Strength x Speed.
  - High Starting Strength.
  - High Rate of Force Development.
  - High Peak Power.
- High Force over Long Distance in Short Time Period.
- Must be speed component!

The Need for Speed:
Rate of Force Development

Isometric force-time curve indicating maximum strength, maximum rate of force development and force at 200ms for untrained, heavy resistance strength trained and light resistance, power trained subjects

(adapted from Häkkinen and Komi, 1985a; Häkkinen and Komi, 1985b).



Andreas Thorkildsen
What is his favourite exercise?

200kg Bench Press!

Lots of Plyometrics…not always an option!

Speed of Release of Implement

- **Speed of Release** is the most important of the three parameters that determine the throwing distance. Speed of Release: Height of Release: Angle of Release

- These are the relative speeds of release for world class throwers.

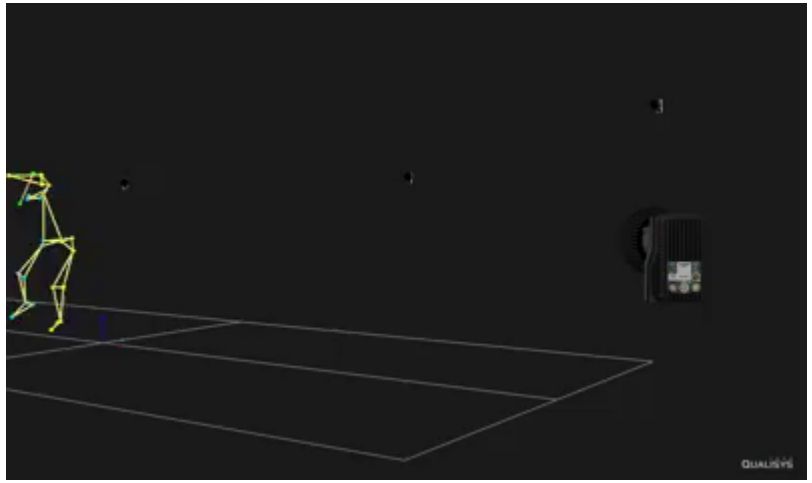
Shot Put: 13-14 m/s

Discus: 23-25 m/s

Hammer: 27-28 m/s

Javelin: 26-30 m/s

Contribution to the Final Release Speed in the Delivery Phase: Javelin

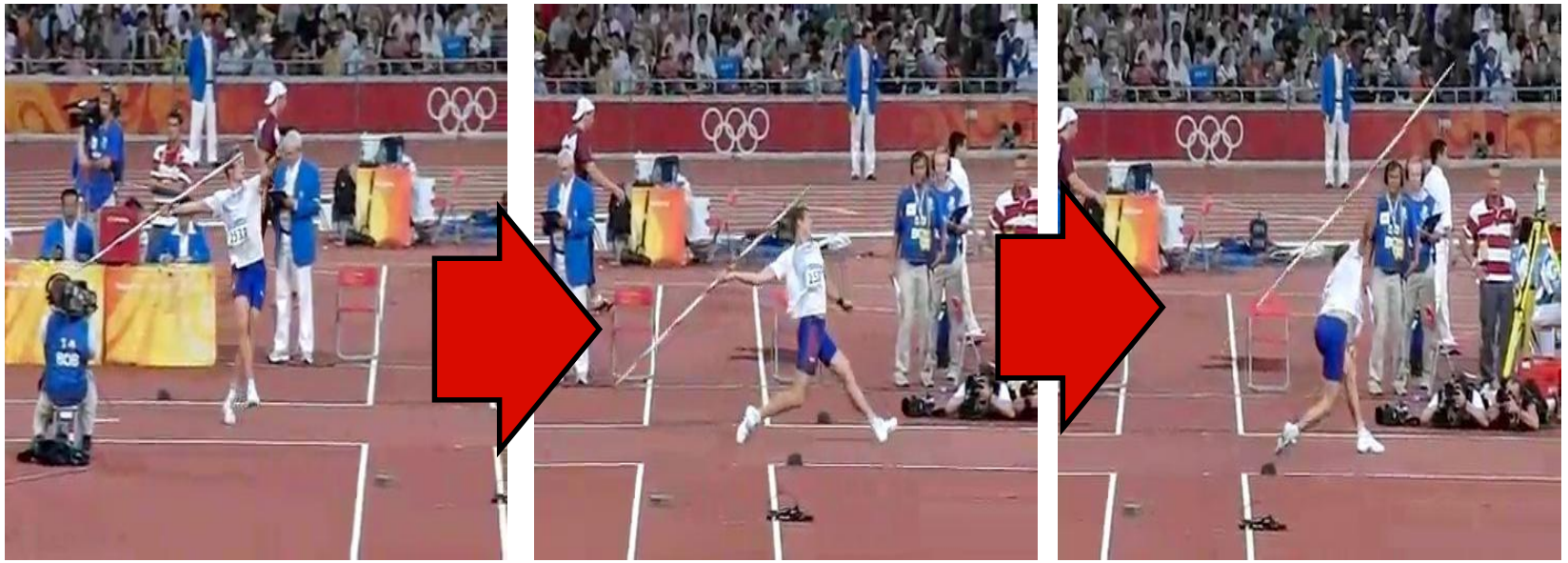


7 m/s

6.5 m/s

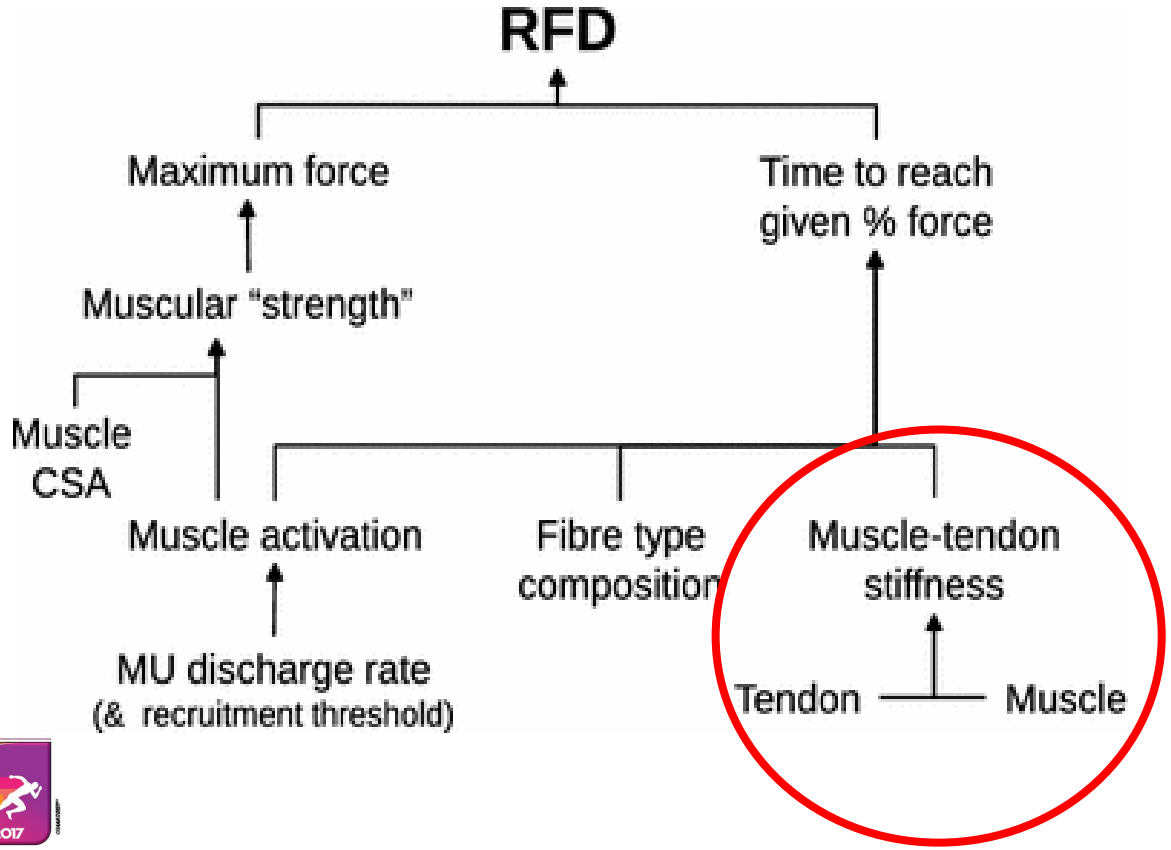
28 m/s

- The Delivery Phase, produces roughly 75% of the final release speed.
- This is true for both men and women.



Stretch Shortening Cycle

The stretch-shortening cycle (SSC) refers to the ‘pre-stretch’ or ‘countermovement’ action that is commonly observed during typical human movements such as jumping. This pre-stretch allows the athlete to produce more force and move quicker.



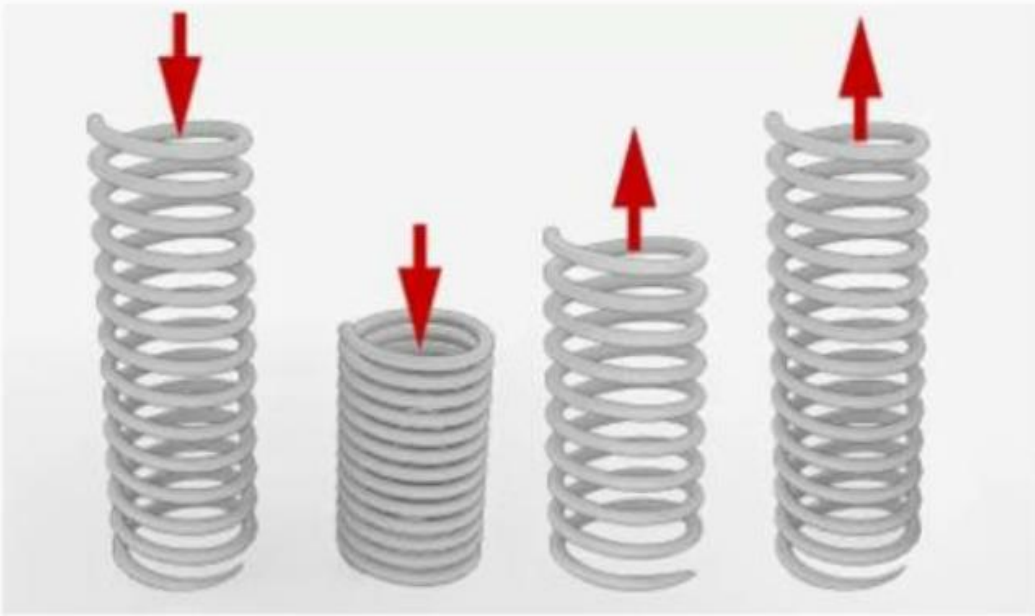


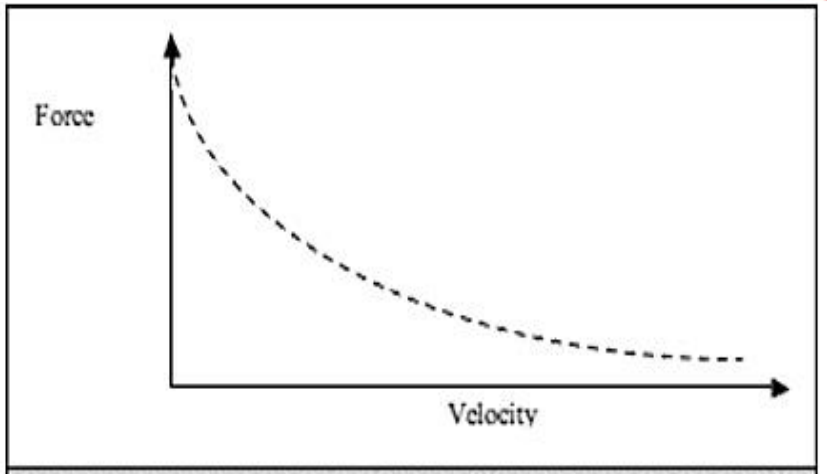
Figure 2. Spring-like mechanism of the SSC.

SSC impact on the Hill Curve
Komi

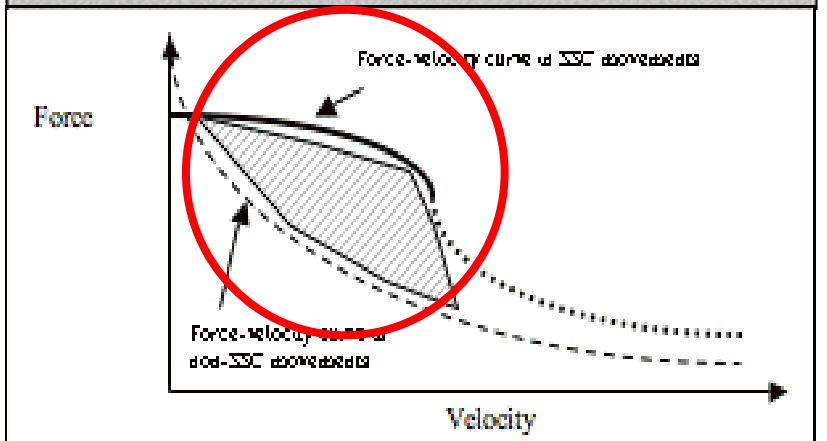
Hopping and running, activities which are often used as models of a human SSC, seem very suitable for possible interaction from stretch reflexes. These activities seem very elective due to the following fundamental conditions:

(1) the muscles are pre-activated before touch down (and the braking phase);
(2) the eccentric (lengthening phase) is short and fast,
(3) there is an immediate transition (Short delay) between stretch (eccentric) and shortening (concentric) phases.

Because stretch reflexes play an important role in stiffness regulation (Holler and Andreassen,1981), their possible interaction in SSC activities could mean a net contribution to muscle stiffness already during the eccentric part of a SSC.



The force-velocity curve during the concentric portion of a movement indicates that the body is less apt at showcasing force as velocity increases



This figure clearly shows that when a SSC is used, the body is able to generate a high level of force even during high-velocity movements.

Training Zones by F/V Curve

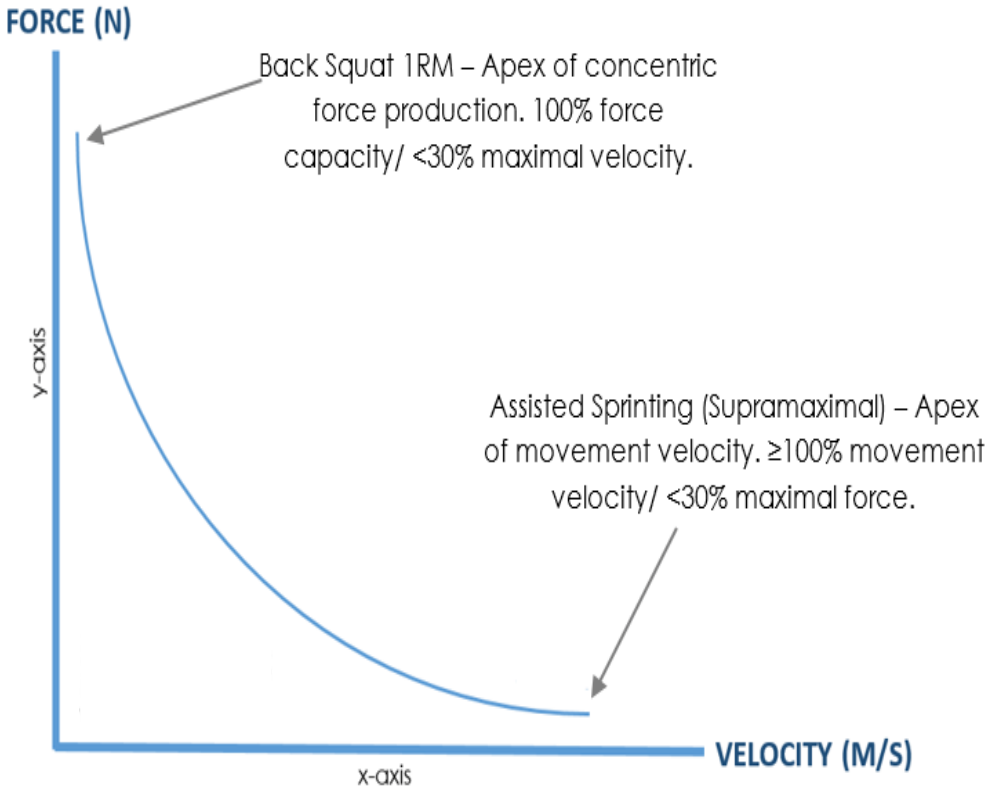


Figure 4. The apex's of the concentric-only force-velocity curve

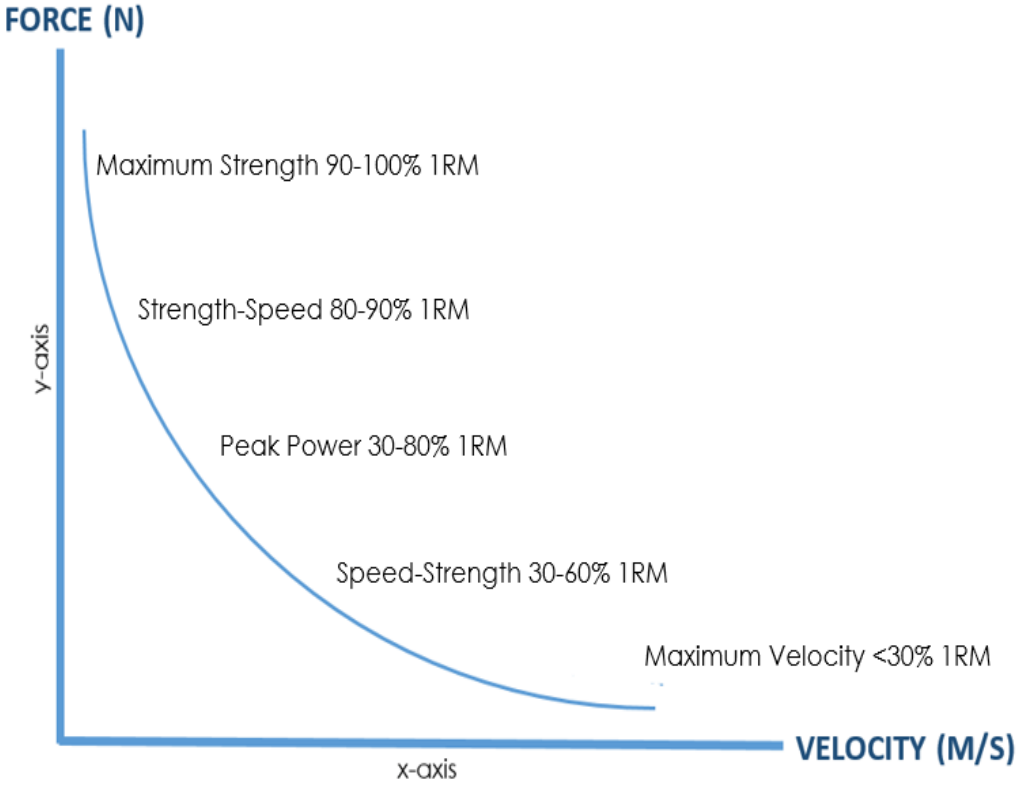


Figure 1. The Force-Velocity Curve

Impacting on F/V curve

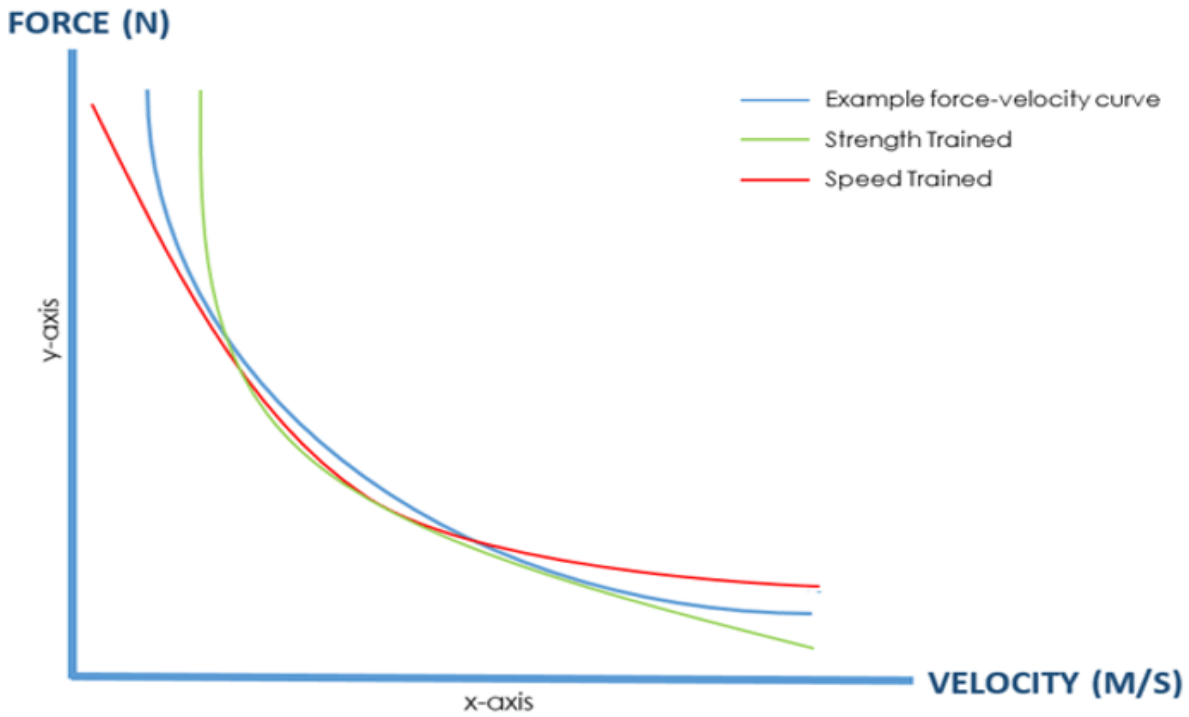


Figure 3. Force-velocity curve after training specific elements.

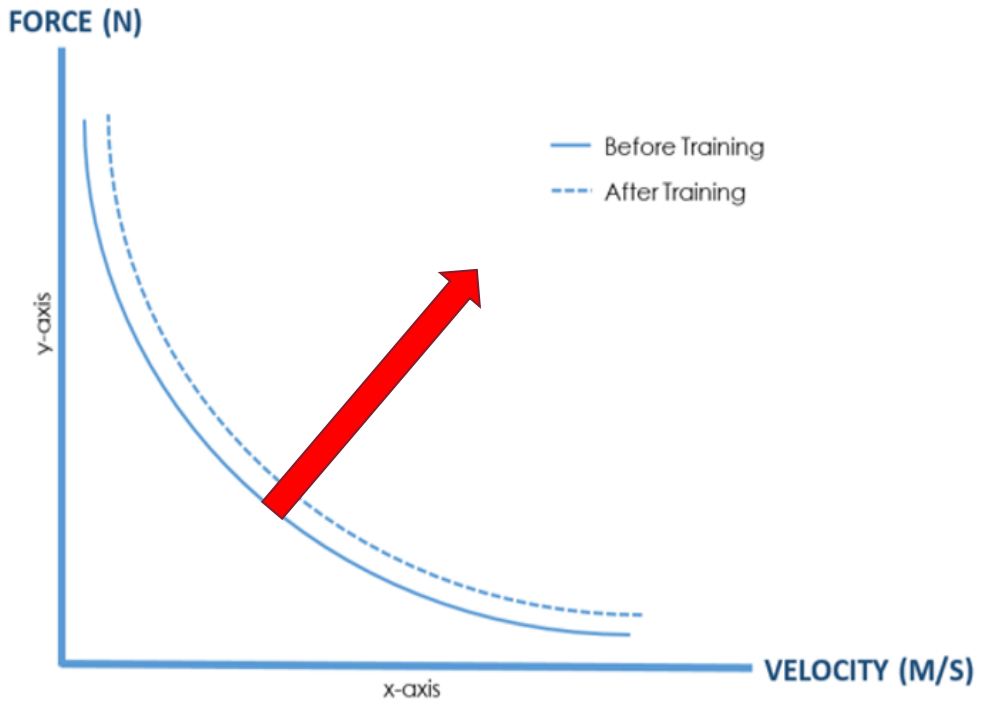


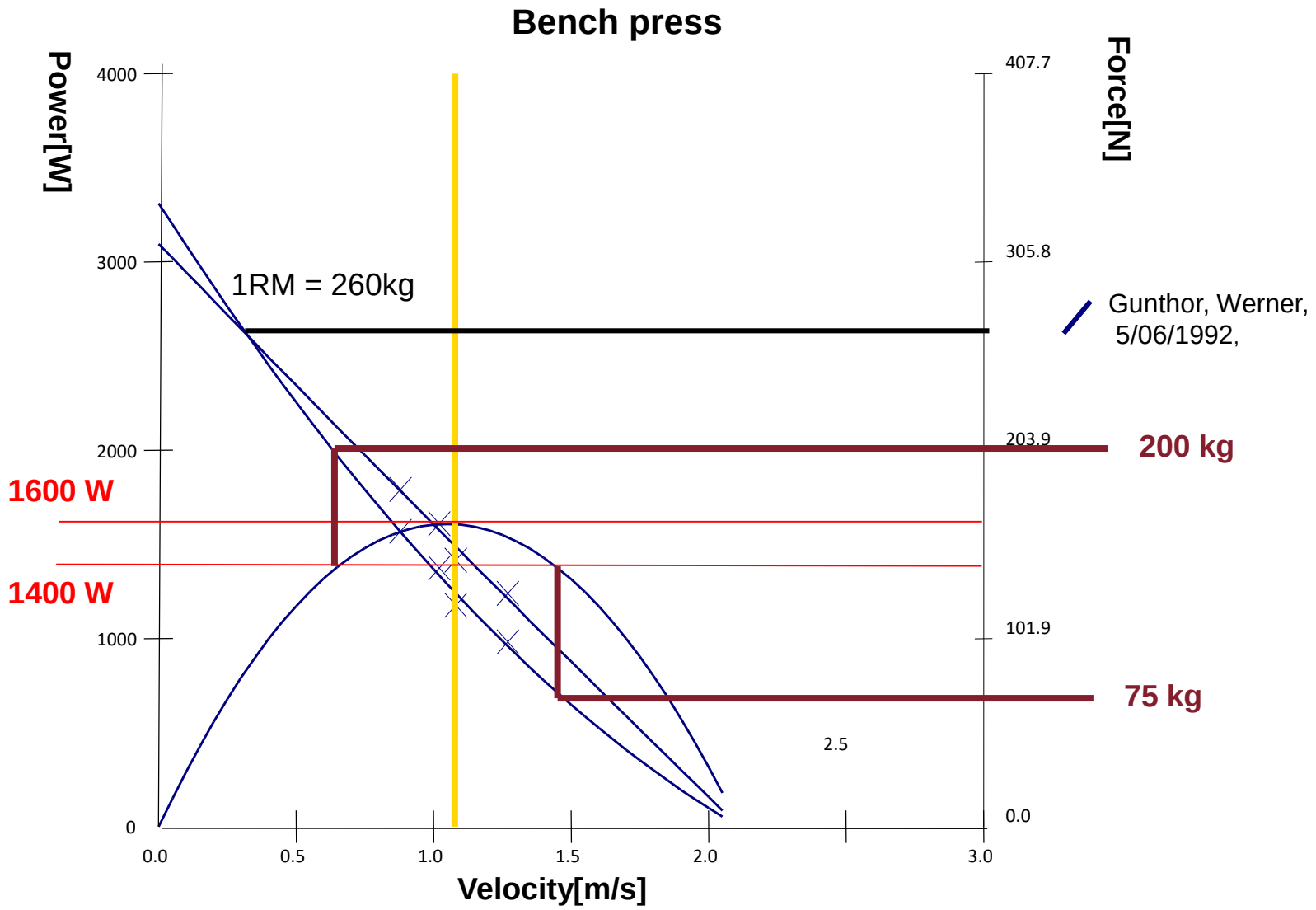
Figure 2. Shift in the force-velocity curve after an effective training programme.

Goal is to move F/V Curve to the Right!

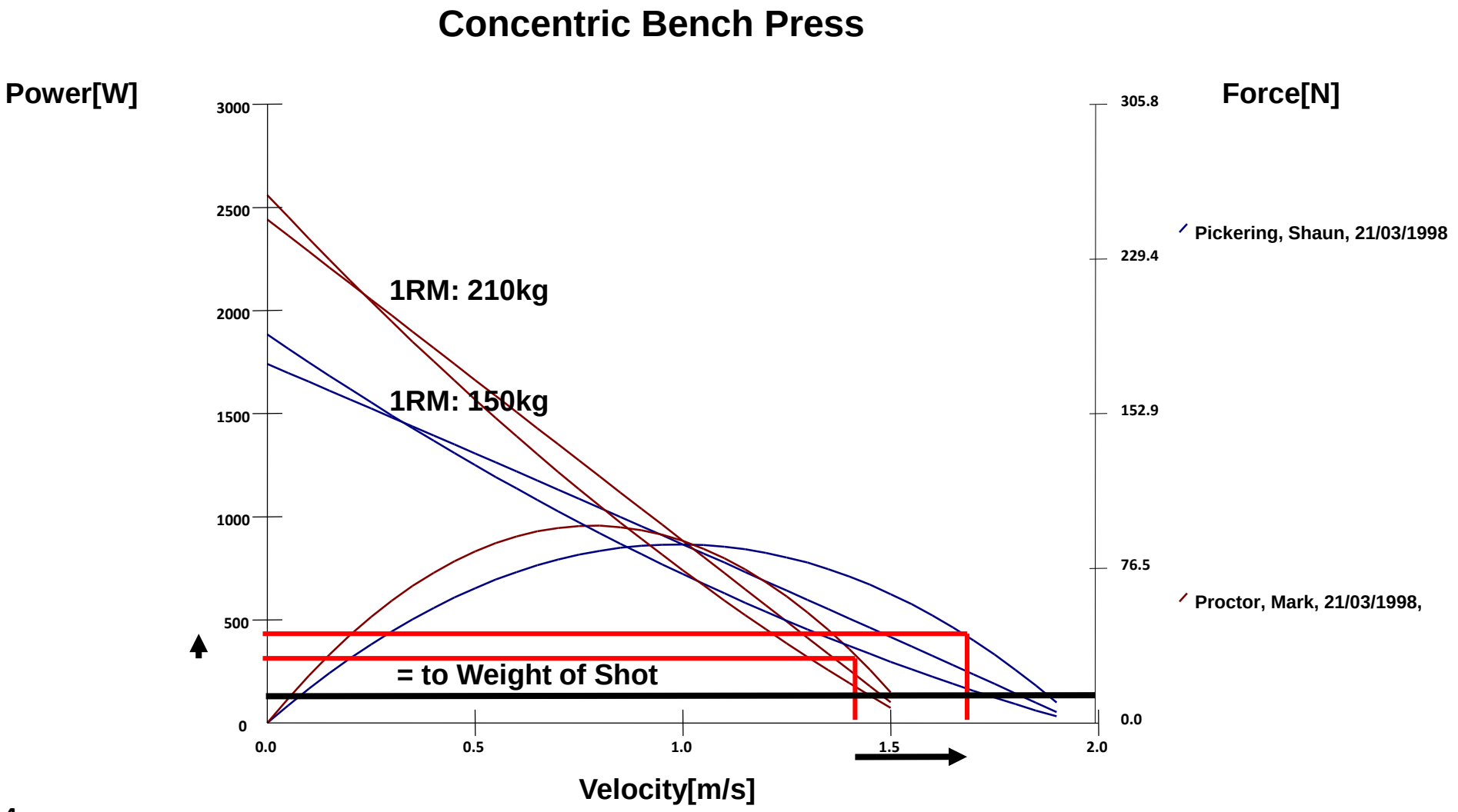
A Better Way?

- Power Lifts: Squat and Bench Press
  - Max Strength
    - 90 – 100% 1RM
    - > 90% Max Power at Load
  - Max Power
    - 40 – 50% 1RM
    - > 90% Max Power at Load
  - Good Option?
    - 60 – 80% 1RM
    - > 90% Max Power at Load
    - Reps Not Fixed ?
    - Increased Testosterone/Decreased Cortisol

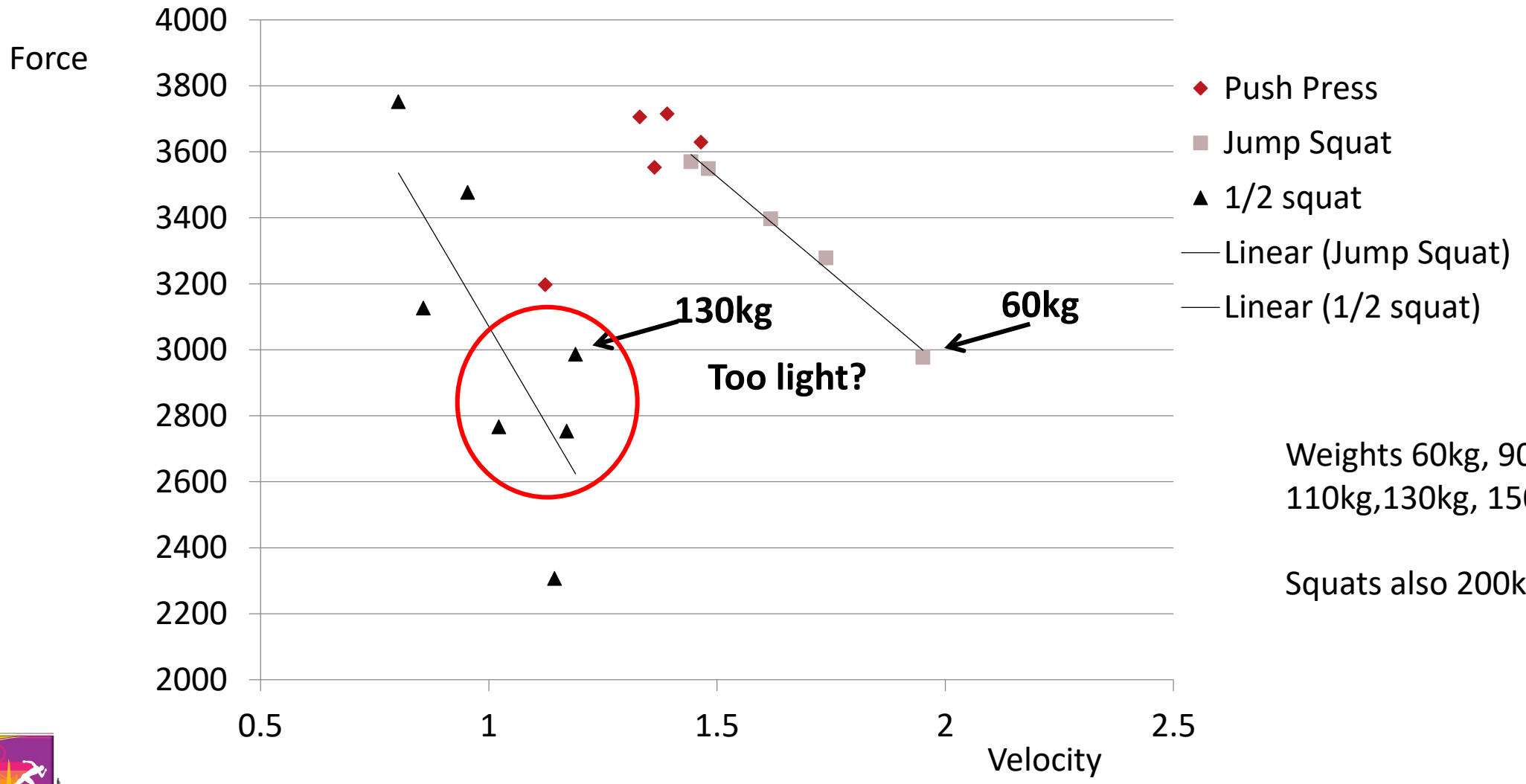
Wide Range of Power



Applicable Strength?



Force – Velocity
Selecting Exercises



Weights 60kg, 90kg, 110kg,130kg, 150kg

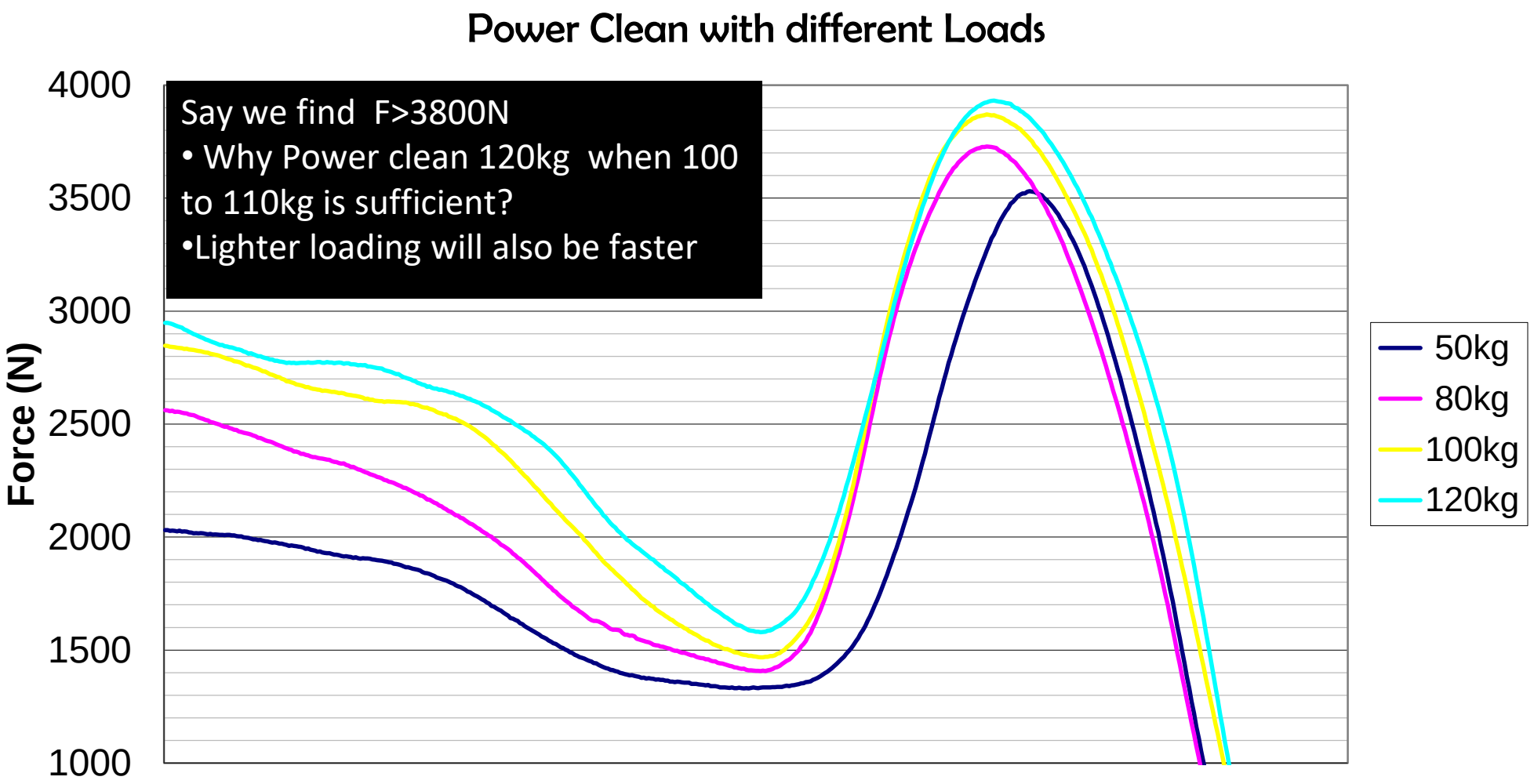
Squats also 200kg, 240kg

How Strong is Strong Enough?

Of course the goal is to get strong, but at what point is their a law of diminishing returns.

With increased load also comes increased risk.

Rush slowly!



Full or Hang?

Snatch from Floor

Hang Snatch

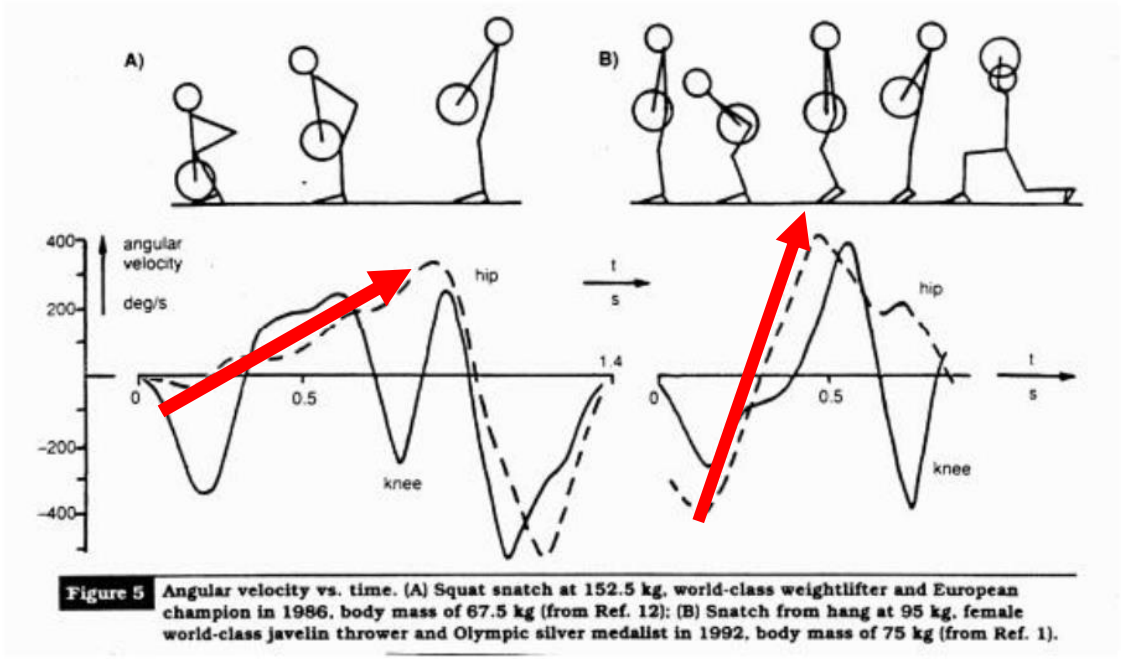
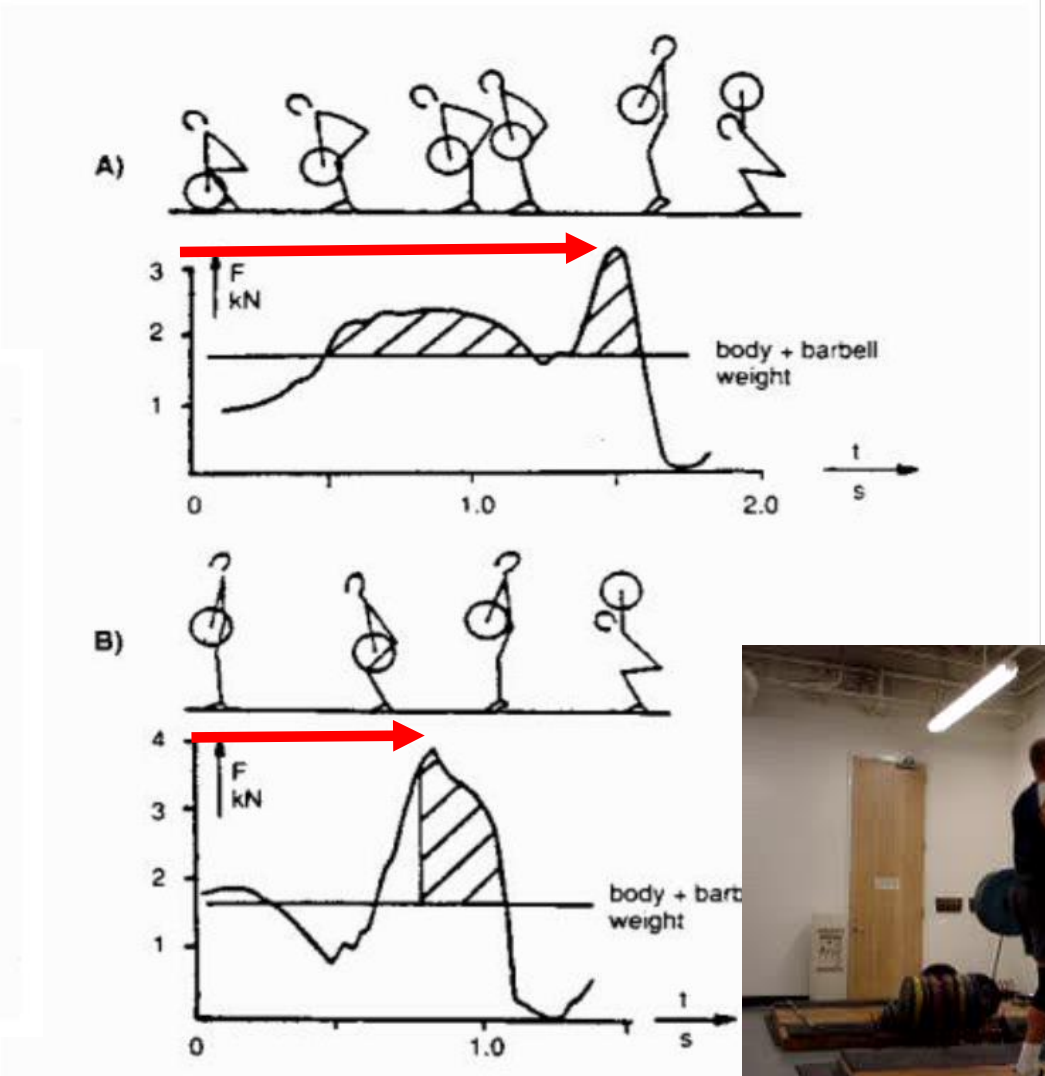


Figure 5 Angular velocity vs. time. (A) Squat snatch at 152.5 kg, world-class weightlifter and European champion in 1986, body mass of 67.5 kg (from Ref. 12); (B) Snatch from hang at 95 kg, female world-class javelin thrower and Olympic silver medalist in 1992, body mass of 75 kg (from Ref. 1).



Speed and Load
Encouraging Stretch Reflex

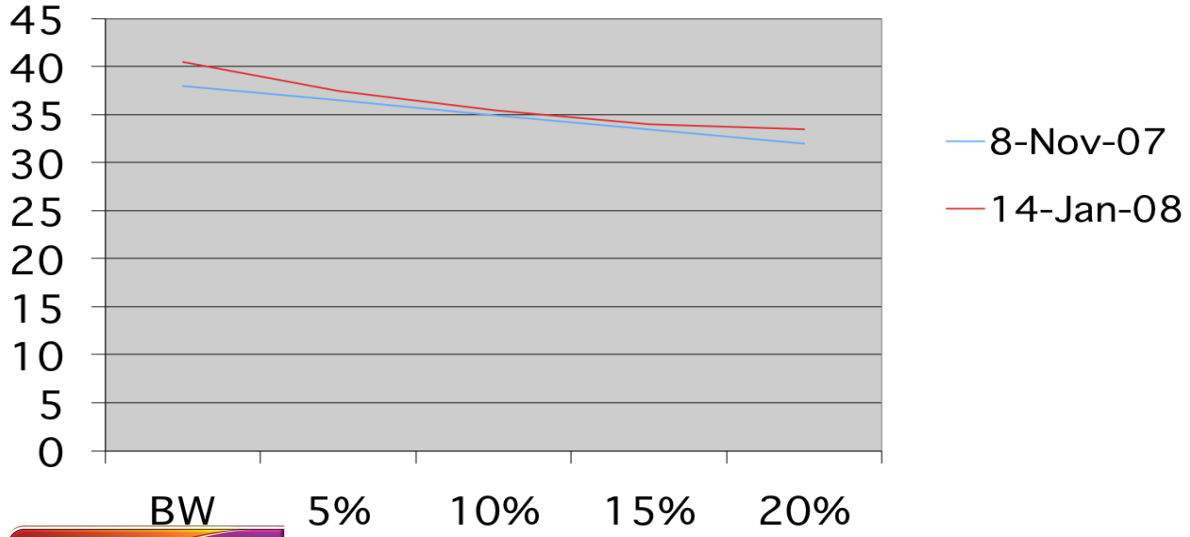
Pre-Tension

Eccentric Overload

How to Assess the Effects of Power Training: The Abalakov Test

- The test is performed by taking two vertical jump readings at each level:

- Body weight (BW),
- BW + 5%,
- BW + 10%,
- BW + 15%, and
- BW + 20%.

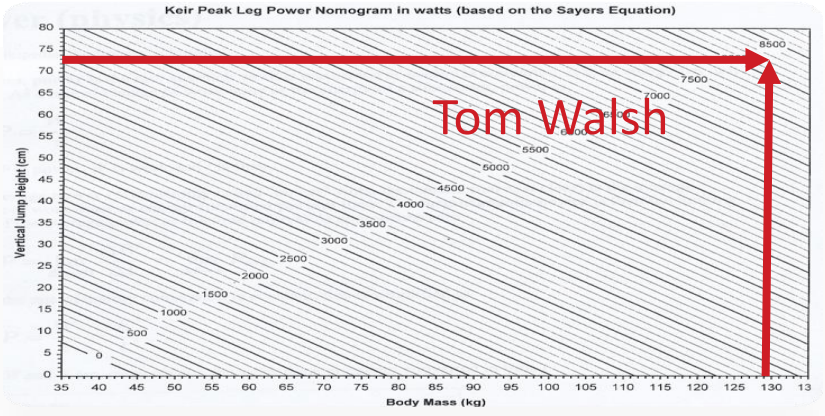


Koji Murofushi 2008

Methods of Comparison of Peak Power

- **Using Sayers regression equation: Peak Power (W) = (60.7 x vertical jump [cm]) + (45.3 x body mass [kg]) – 2055**
- Koji Murofushi (84.86m HT), vertical jump = 104cm @ 102kg BW = 8878.4W
- Reese Hoffa (22.43m SP), vertical jump = 76cm @ 140kg BW = 8900.2W
- Tom Walsh (22.21m SP), vertical jump = 72cm @ 129kg BW = 8159.1 W

Keir Peak Leg Power Nomogram



- Power Index (P.I.)
  - √ Bodyweight x √ Vertical Jump
    - College male athlete = ±70-80
    - International male athlete = ±80-90
    - Olympic male athlete = ± 90-100

- Koji Murofushi VJ= 104cm @ 102kg BW
  PI = 103.01
- Reese Hoffa VJ= 76cm @ 140kg BW
  PI = 103.10
- Tom Walsh VJ= 72cm @ 129kg BW
  PI = 96.37

What are the Top Athletes doing?

- Can we learn something?

Tom Walsh

CMJ Important Exercise

Lots of Rotational Strength work

Lots of Mobility work

Age: 25yrs

Height: 1.83m

Weight: 129kg

Activity	Personal Best	
Shot Put	22.21m	
30m/40yd/100m		
Vertical Jump	72cm	
Standing Long Jump		
Overhead Shot		
Underhand Shot		
Power Clean	180kg	
Power/Hang Snatch		
Bench Press	215kg	
Jerk Behind Neck		
Back Squat	260kg	
Front Squat		
Dead Lift		

Tom Walsh
Typical Training Plan

Notes:

In Season plan

Using 6.8kg /7kg Shots

(in off season uses lighter shots up to 6.5kg)

Also in off season Tom works as a builder 3 mornings a week.

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
AM	Throw	Lift	Throw	Throw	Lift	Hard Throw	**Rest**
PM	Conditioning / Circuit	Conditioning / Circuit	**Rest**	Gymnastics	Conditioning / Circuit	Conditioning / Circuit	**Rest**
Evening			Throw				**Rest**

Tom and his coach, Dale Stevenson, look at Throwing shot as a skill that has to be practiced frequently, so that it is learned and reliable. Dale explained " my goal for a throwing session is to try and get through the session without having to say anything!"

Sophie Hitchon

Focus is on Throwing

Lots of Specific Strength Work

Specific Exercises to support technique

Age: 26yrs

Height: 1.73m

Weight: 76.5kg

Activity	Personal Best	
Hammer Throw	74.55m	
30m/40yd/100m		
Vertical Jump		
Standing Long Jump	2.90m	
Overhead Shot	18.50m	
Underhand Shot		
Power Clean	102.5kg x2	
Power/Hang Snatch		
Bench Press		
Jerk Behind Neck	80kg easy	
Back Squat	100kg reps	
Front Squat	90kg reps	
Dead Lift		

Sophie Hitchon
Typical Training Plan

Notes:

Out of Season plan

In season they reduce to 1 session on Friday

Technical Exercises before Throws then Lift

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
AM	Technical exercise + Throw	Technical exercise + Throw	**Rest**	Technical exercise + Throw	Technical exercise + Throw	Technical exercise + Throw+ Weights Jump	**Rest**
PM	Technical exercise Throw+ Weights Jump	Technical exercise Throw+ Weights Jump	**Rest**	Technical exercise Throw+ Weights Jump	Technical exercise Throw+ Weights Jump		**Rest**

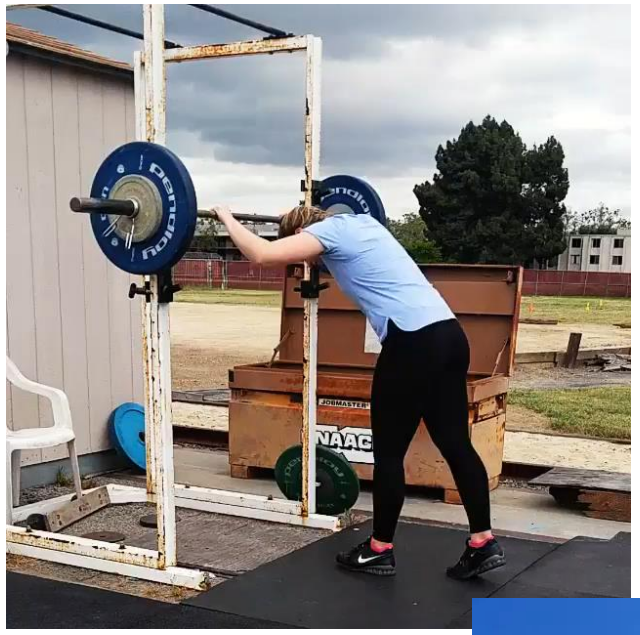
4 week training 1 week recovery.

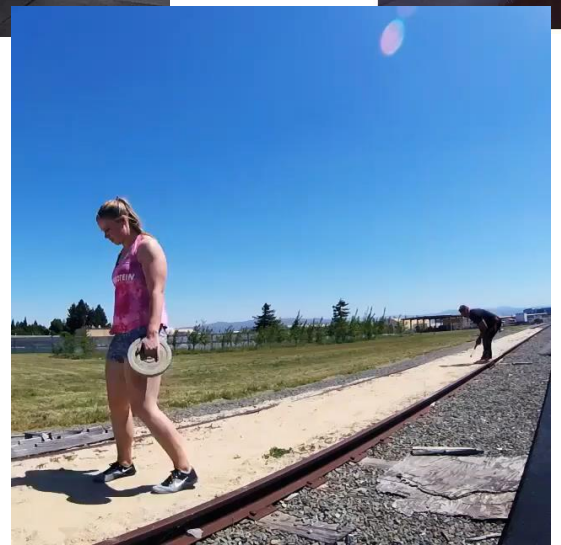
Sprints will be alternated in 2 days a week and jumps will be removed on alternate cycle.

Hammers used 4kg, 4.5kg, 5kg during season a few 3.5kg.

Throwing is focused on technical execution.

Sophie Hitchon





Fedrick Banjay Dacres

Focus is on Building Better Athlete

Lots of Athletic work

Lots of Sprints work

Age: 26yrs

Height: 1.92m

Weight: 122kg

Activity	Personal Best	
Discus	68.88m	
30m/40yd/100m	Not timed	
Vertical Jump		
Standing Long Jump		
Overhead Shot		
Underhand Shot		
Power/Hang Clean	170kg	
Power/Hang Snatch	130kg	
Bench Press	200kg	
Jerk Behind Neck	210kg	
¼ Back Squat	420kg	
¼ Front Squat	285kg	
Dead Lift	265kg	

Fedrick Dacres
Typical Training Plan

Notes:

Out of Season plan

In season they reduce to 5 days M-F

Lift then Throw

Add Hurdle Bounds 2x Week

Sprint or Hurdle Bounds each session

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
AM							
PM							
Evening	Lift Throw Sprint	Lift Throw	Lift Throw Sprint	Lift Throw	Throw Sprint	Lift Throw	

Comments:

Coach Julian Robinson: "I try to build an Athlete. An Athlete who is fast, explosive, strong and flexible."

Fedrick Dacres

Simon Pettersson

Former Decathlete

April 2013: 50.89m with 1.75kg

2013: 49.71
2014: 55.39
2015: 60.25
2016: 63.10
2017: 64.88

Age: 23yrs
Height: 1.98m
Weight: 106kg

Activity	Personal Best	
Discus	64.88m	
30m/40yd/100m		
Vertical Jump	On to 145cm box	
Standing Long Jump	3.42m	
Overhead Shot		
Underhand Shot		
Power Clean	140kg	
Power Snatch	110kg	
Bench Press	152.5kg	
Jerk Behind Neck	155kg	
Back Squat	210kg	
Front Squat	180kg	
Dead Lift	240kg	

Thank You
Any Questions?