LECTURE

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ASCA President

“Using Velocity Measures To Improve Resistance Training Programming And Coaching”

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Using Velocity Measures to Improve Resistance Training

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I have been measuring velocity during resistance training since 1993!

- Mainly used to measure velocity/power adaptations in "power" exercises
- But over the last few years Spanish researchers have published studies showing the benefits of monitoring velocity adaptations also in "strength" exercises

Velocity & "Strength" v "Power" exercises

- When velocities are high and acceleration continues to end of ROM, it is a "Power" exercise

Strength exercise	Power exercise
Squat	Jump squat, squats with bands
Bench press	Bench press throws, bench press with bands
Deadlift	Clean variations – Power, hang, pull etc
Press	Jerk

This presentation will be in three parts…

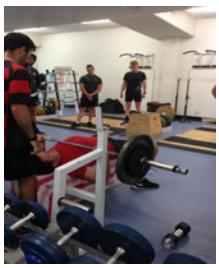
- Part 1 – Normative velocity data
- Part 2 – Velocity and fatigue data
- Part 3 – Using that velocity data in training, for monitoring and to improve coaching

Part 1. Normative velocity data

Measuring velocity during resistance training

- Force plates (many are now portable)
- Linear position transducers (eg. GymAware, Tendo)
- Digital filming systems eg. 3D filming – EliteForm
- Accelerometers (eg. MyoTest, Push, Bar Sensei, Beast, more in development)

Linear position transducers



Tendodyne

Original PlyometricPower System + GymAware

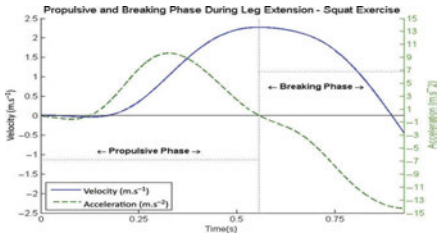
GymAware

Push accelerometer

Different measures of velocity

- Velocity (and power) has two main measures!
- **Mean** or **Average** Velocity = average velocity **of the** entire concentric Range of Movement (ROM)
- **Peak Velocity** = highest velocity at any measuring point **within the** entire concentric ROM
- eg. highest velocity in any sampling period eg. 1-msec or 5-msec sampling period

Mean Propulsive Velocity (MPV) is also used by the Spanish researchers
MPV for Half Squat, shown here as "positive net acceleration"
(Conceição et al. JSS 2015)



When resistances become higher than ~60% 1RM, there are less differences between Average (Mean) and Mean Propulsive velocity scores

Accordingly, I will only report Average or Mean Propulsive velocity scores for 60% 1RM above for strength exercises!

- "The lighter the load (and higher the velocity of movement), the greater the duration of this braking phase. When the load is sufficiently high, this braking phase disappears. Thus, although certain inter-subject variability does exist, approximately from 76% 1RM onwards the full concentric phase can be considered entirely propulsive, mean mechanical values of the whole concentric phase and mean propulsive values being identical"

(Sanchez-Medina L et al. Importance of the Propulsive Phase in Strength Assessment. Int J Sports Med 2010; 31: 123–129)

Which measure do I use?

- **Average/Mean/MPV** velocity for monitoring adaptations or changes in **1RM strength and/or fatigue throughout the set**
- **Peak velocity** for Olympic Weightlifting performance
- **Peak velocity** for monitoring adaptations or changes in BWT jumping and throwing
- But also plenty of data and support for using both **Average and Peak** for loaded jump squats and Weightlifting

Normative velocity data

- We need more research ~ especially "free weight" SQ, BP, DL, PC!
- Need different types of athletes to develop "normal scores"
- Some discrepancy in the data, especially for Olympic Weightlifting exercises, due to methodology issues!

Average velocity and %1RM in different key Strength exercises for "normal strength" athletes

Exercise	60% 1RM	70% 1RM	80% 1RM	90% 1RM	100% 1RM
Bench press (1)	0.77 (0.07)	0.61 (0.06)	0.46 (0.05)	0.31 (0.05)	0.17 (0.04)
Bench Pull (1)	1.06 (0.09)	0.92 (0.09)	0.79 (0.08)	0.65 (0.07)	0.52 (0.06)

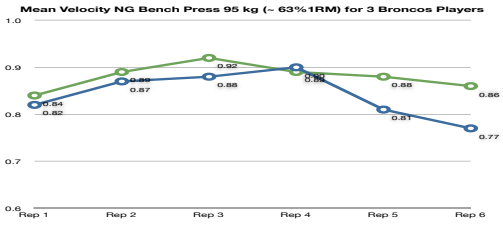
Sánchez-Medina et al. Int. J Sports Med. 2013

NB
Baker & Newton JSCR 2009 ~ 75% 1RM Bench press = 0.57 (0.07)
González-Badillo et al. Int J Sports Med 2010 ~ 75% 1RM Bench press 0.56 (0.04)

But some athletes are much faster –

Professional rugby players attaining > 0.9 m/s with 63% 1RM in the bench press compared to 0.75 m/s as the "normal" score –

Elite athletes are often EXCEPTIONAL not AVERAGE



- Set 2 in green v Set 3 in blue

Squats…

Squats	60% 1RM	70% 1RM	80% 1RM	90% 1RM	100% 1RM	Note
Elite Australian rowers Farris et al. Scan.JMSS 2015	0.56	0.47	0.37	~0.32	~< 0.3	
Resistance trained Pallares et al 2014	1.0	0.85	0.67	0.54	0.37	
Resistance trained Pallares et al 2014	0.81	0.71	0.61	0.51	0.39	Paused
Track & Field Sprints & jumps Portugal Conceição et al. JSS 2015	0.85	0.72	0.59	0.46	0.33	Paused
Elite Spain skiers Bautista et al. JSCR 2016	0.87	0.76				
U/19 Spain Soccer Hoyo et al. JSCR 2016	0.98					

A comparison of competitive lifters 1RM squat in training…(raw, full squats, no pause)

Male Powerlifter 195 kg	62%	70%	85%	92%	100%
	0.74	0.67	0.43	0.38	0.25
Male Weightlifter 185 kg	60%	70%	81%	89%	100%
	0.62	0.62	0.51	0.39	0.23
Female Weightlifter 130 kg	54%	70%	85%	92%	100%
	0.69	0.71	0.64	0.43	0.23

No real difference at ~1RM and it is difficult to squat > ~ 0.75-0.8 m/s Average velocity (< 60%) without feet raising on a free weigh Squat…

More recent squat data… Experienced, strong squatters versus Average, less experienced squatters

(Zourdos et al. 2016)

Squats	60% 1RM	75% 1RM	90% 1RM	100% 1RM
Experienced Squatters 1RM = 171.9 kg @ 91.6 kg BWT	~0.72	~0.55	0.34	0.24
Average trainers 1RM = 91.2 kg @ 80.3 kg BWT	~0.67	~0.60	0.46	0.34

Competitive powerlifters! (Helms et al JSCR 2016)

Males BWT = 87.9 (n=12)		80% 1RM	85% 1RM	90% 1RM	95% 1%M	100% 1RM
1RM = 202.5 kg	Squat	0.66	0.54	0.44	0.33	0.23
1RM = 131.8 kg	Bench Press	0.44	0.35	0.24	0.17	0.10
1RM = 237.3 kg	Deadlift	0.46	0.37	0.29	0.21	0.14

So at sub-max resistances below 80% 1RM, different strength level athletes can be similar in velocities but not at > 80-100%1RM…?

	100% 1RM	95% 1%M	90% 1RM	85% 1RM	80% 1RM
Squat - Strong	~ 0.23	0.33	0.44	0.54	0.66
Squat – Less Strong	~ 0.34	0.40	0.47	0.53	0.60
Bench press – Paused rep	~ 0.10	0.17	0.24	0.35	0.44
Bench Press – Normal rep, no pause	~ 0.17	0.24	0.31	0.39	0.46
Deadlift – Very strong	~ 0.14	0.21	0.29	0.37	0.46

More recent work by Singh et al. on rugby union and rugby league players (in review)…

Rugby union players, squat

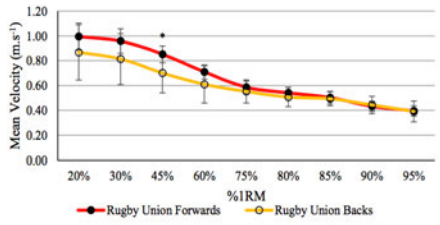


Figure 4. Rugby union forwards and backs mean velocity spectrum for the back squat exercise across loading intensities of 20-95% 1RM. The mean velocity achieved for each loading intensity is plotted from each positional groups mean with 95% confidence intervals. * = significant difference

Rugby union players, bench press

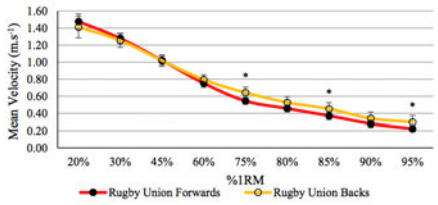


Figure 3. Rugby union forwards and backs mean velocity spectrum for the bench press exercise across loading intensities of 20-95% 1RM. The mean velocity achieved for each loading intensity is plotted from each positional groups mean with 95% confidence intervals. * = significant difference

Rugby league players, back squat

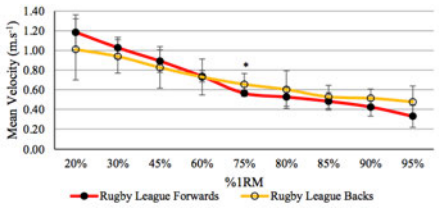


Figure 7. Rugby league forwards and backs mean velocity spectrum for the back squat exercise across loading intensities of 20-95% 1RM. The mean velocity achieved for each loading intensity is plotted from each positional groups mean with 95% confidence intervals. * = significant difference

Rugby league players, bench press

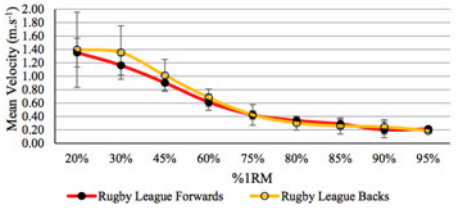


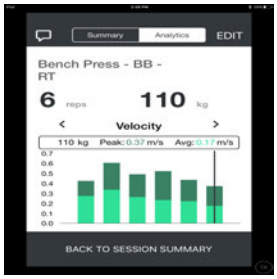
Figure 6. Rugby league forwards and backs mean velocity spectrum for the bench press exercise across loading intensities of 20-95% 1RM. The mean velocity achieved for each loading intensity is plotted from each positional groups mean with 95% confidence intervals. * = significant difference

One of the most important things to know is…

- The 1RM velocity is also the velocity of the last rep before failure
- eg. the third rep of a 3RM, the fifth rep of a 5RM
- If you know an athletes 1RM velocity (or fatigue velocity), you can control training much better
- Inter-relatedness of velocity and RPE methods

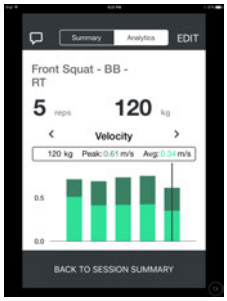
Bench Press
1RM and and the last rep of 85%1RM

Athlete whose 1RM velocity is 0.19 m/s and whose 6RM (@85%1RM) was 0.17



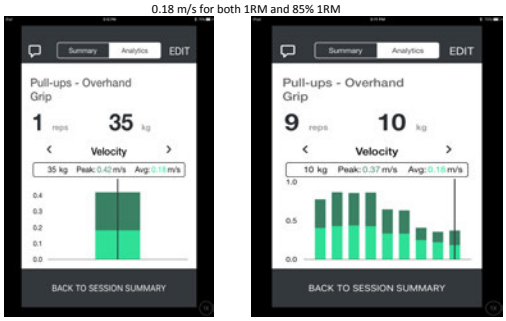
Front squat
1RM and and the last rep of 85%1RM

Athlete whose 1RM velocity is 0.34 m/s and whose 5RM (@85%1RM) was 0.34



Pull-ups…
1RM and and the last rep of 85%1RM

0.18 m/s for both 1RM and 85% 1RM



Key take home points for strength exercises...

- 1. There are normative scores for some key strength exercises
- 2. But each exercise has a different velocity profile
- 3. Individuals vary, especially “explosive” athletes
- 4. Need more data, especially on free weight exercises with different athletes, to better establish “norms”

Power exercises

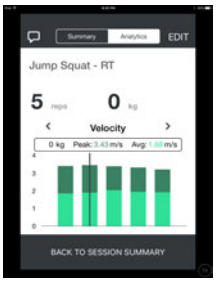
- Plenty of data on jump squats, bench press throws etc using Peak or Average or MPV
- Data on Weightlifting exercises is a little less “agreeable”…

Peak velocity measures of jump squats

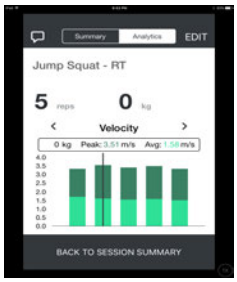
Peak velocity	BWT	50% BWT	75% BWT	100% BWT
International Rugby 7's players Mitchell et al., JSCR 2015	**3.9**			
High Level MMA fighters James et al IJSPP 2016	**3.77**	2.50	2.15	1.86
Lower Level MMA fighters James et al IJSPP 2016	**3.29**	2.34	2.01	1.74
U/18 Male team sport Athletes Taylor & Taylor, JASC 2014	**3.1**	2.35		
U/18 Female team sport Athletes Taylor & Taylor, JASC 2014	**3.0**	2.1		
Male National swimmers (68.2kg) Garcia-Ramos et al SS & M 2015		2.09	1.83	1.62
Female National swimmers (57.6 kg) Garcia-Ramos et al SS & M 2015		1.78	1.52	1.34
		40 kg	**60 kg**	**80 kg**
Untrained Cormie et al 2007	**3.09**	2.15	1.86	1.62

Simple "readiness" or monitoring test…
Jump squat with dowel rod
5-reps x 1-3 sets, 1-2/week, record
Best Peak Velocity

Athlete 1



Athlete 2



Average or MPV for jump squats

- Recently, Loturco et al 2015 established that the Pmax occurs at a MPV of ~ 1.0 m/s or 20 cm jump height…
- Re-analysing my published data using Average velocity..

Study reference	Subject type	Average velocity m/s
Baker, JASC 8(4): 2000	Pro Rugby League	1.05
Baker et al. JSCR 15(1):2001	Pro Rugby League	1.01
Baker et al. JSCR 15(1):2001	Pro Rugby League	1.00
Baker et al. JSCR 15(1):2001	Semi-Pro Rugby League	0.97
Baker et al. JSCR 15(2):2001	Pro Rugby League	0.97
Baker et al. JSCR 15(2):2001	Pro Rugby League	0.96
Baker & Newton, JSCR 22(1):2008	Pro Rugby League	1.00
Baker & Newton, JSCR 22(1):2008	Semi-Pro Rugby League	0.99
Baker & Newton, JASC 16(1):2008	Pro Rugby League	1.02
Average of above papers		**1.0 m/s**

The Average velocity where Maximum Average Power occurs during bench press throws…

Study reference	Subject type	Average velocity m/s
Baker, D. et al. 15(1). 2001.	Pro Rugby League	0.87
Baker, D. 15(1). 2001.	Pro Rugby League	0.90
Baker, D. 15(1). 2001.	Semi-pro Rugby League	0.86
Baker, D. 15(1). 2001.	Very strong Pro RL	0.92
Baker, D. 15(1). 2001.	Less strong Pro RL	0.87
Baker, D. 15(2). 2001.	Pro Rugby League	0.92
Baker, D. 15(2). 2001 A.	Semi-pro Rugby League	0.87
Baker, D. 15(2). 2001 B.	Pro Rugby League	0.92
Baker, D. 15(2). 2001 B.	Semi-pro Rugby League	0.88
Baker, D. 15(2). 2001 B.	U/20 yrs Rugby League	0.85
Average of above papers		**0.89**

Key take home points for non-WL power exercises...

- Bodyweight only Jump squat test = Explosive athletes tend to be **PEAK VELOCITY** > 3.5 m/s and ≥ to 4.0 m/s
- For heavier, loaded jump squats (JS), the best **AVERAGE POWER** occurs at around 1.0 m/s **AVERAGE VELOCITY**
- For bench press and bench press throws (BT), the best **AVERAGE POWER** occurs at around 0.85 to 0.9 m/s **AVERAGE VELOCITY**
- **This is usually around 50% 1RM (can be different for tall or strong athletes)**
- **But TRAINING for Jump squats and Bench throws, use loads of mainly 20-45% 1RM**

Peak velocities of Elite Olympic Weightlifters

Elite lifters Ho et al, JSCR 2014 Review:	Snatch 1.68 –1.98	Snatch 1st pull 1.13 – 1.26
Chinese Female (Deming et al)	Clean 1.57	Clean 1st pull 0.96
Male elite Garhammer 1991	Clean 1.59	Clean 1st pull 0.87

Peak velocity measures of Weightlifting exercises

		50%	60%	70%	80%	90%	100%
College athletes, (1)	Power clean	2.5	2.4	2.3	2.2	2.1	2.02 (2)
College athletes, (3)	Power clean				2.0 (0.05)		
Athletes (4)	Mid-thigh Clean Pull		60% 1.6	80% 1.4	100% 1.25	120% 1.15	140% 1.0
Athletes (5)	Mid-thigh Clean Pull	45% 1.95 (0.18)	60% 1.78 (0.14)	80% 1.68 (0.14)			
Athletes (6)	Clean pull				90% 1.72 (0.06)		120% 1.37 (0.05)

1. Cormie et al, MSSE, 2007 2. SuchomeL et al JSCR 2015 3. Hardee et al, JSCR 2012 4. Comfort et al, JSCR 2012 5. Jones et al. JSCR 2007. 6. Haff et al JSCR 2003

Some Power clean data

Barbell weight	Peak velocity	Average velocity	Peak velocity	Average velocity
80 kg ~ 55% 1RM	1.58 m/s	1.13 m/s	1.85 m/s	1.33 m/s
100 kg ~ 69% 1RM	1.59 m/s	1.13 m/s	1.91 m/s	1.37 m/s
110 kg ~ 76% 1RM	1.53 m/s	1.1 m/s	1.66 m/s	1.19 m/s
120 kg ~ 83% 1RM	1.59 m/s	1.14 m/s	1.71 m/s	1.22 m/s
130 kg ~ 90% 1RM	1.44 m/s	1.03 m/s	1.78 m/s	1.27 m/s
140 kg ~ 97% 1RM	1.43 m/s	1.02 m/s	1.91 m/s	1.37 m/s
145 kg = 100% 1RM	1.36 m/s	0.97 m/s	1.46 m/s	1.04 m/s

Three different athletes, Very Strong v Strong…
100% 1RM are similar velocities…

Barbell weight	Athlete 1 Peak velocity	Athlete 1 Average velocity	Athlete 2 Peak velocity	Athlete 2 Average velocity	Athlete 3 Peak velocity	Athlete 3 Average velocity
60 kg	40% 1RM 2.18 m/s	40% 1RM 1.58 m/s			49% 1RM 2.22 m/s	49% 1RM 1.61 m/s
80 kg	53% 1RM 1.91 m/s	53% 1RM 1.38 m/s	57% 1RM 1.64 m/s	57% 1RM 1.19 m/s	66% 1RM 2.15 m/s	66% 1RM 1.56 m/s
100 kg	67% 1RM 2.17 m/s	67% 1RM 1.58 m/s	71% 1RM 1.76 m/s	71% 1RM 1.28 m/s	81% 1RM 1.86 m/s	81% 1RM 1.35 m/s
120 kg	80% 1RM 1.64 m/s	80% 1RM 1.19 m/s	110 kg 79% 1.48 m/s	110 kg 79% 1.08 m/s		
130 kg	87% 1RM 1.55 m/s	87% 1RM 1.12 m/s	120 kg 86% 1.57 m/s	120 kg 86% 1.14 m/s		
135 kg	90% 1RM 1.60 m/s	90% 1RM 1.16 m/s			110 kg 90% 1.67 m/s	110 kg 90% 1.21 m/s
140 kg	93% 1RM 1.53 m/s	93% 1RM 1.11 m/s	130 kg 93% 1.67 m/s	130 kg 93% 1.21 m/s	115 kg 93% 1.79 m/s	115 kg 93% 1.29 m/s
145 kg	97% 1RM 1.51 m/s	97% 1RM 1.10 m/s			120 kg 97% 1.52 m/s	120 kg 97% 1.10 m/s
150 kg	100% 1RM 1.42 m/s	100% 1RM 1.03 m/s	140 kg 100% 1.28 m/s	140 kg 100% 0.93 m/s	123 kg 100% 1.31 m/s	123 kg 100% 0.95 m/s

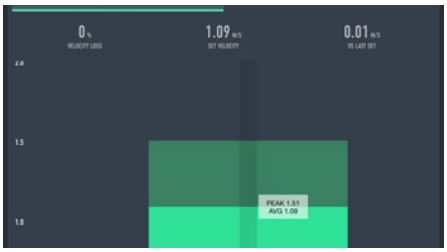
Comparison of Less Strong Male (left) and Strong Female (Right)

Barbell weight	Peak velocity	Average velocity	Barbell weight	Peak velocity	Average velocity
60 kg 71% 1RM	1.51 m/s	1.08 m/s	50 kg 71%	1.64 m/s	1.19 m/s
70 kg 82% 1RM	1.48 m/s	1.05 m/s	55 kg 79% 1RM	1.64 m/s	1.19 m/s
			60 kg 86% 1RM	1.60 m/s	1.16 m/s
80 kg 94% 1RM	1.28 m/s	0.91 m/s	65 kg 93% 1RM	1.59 m/s	1.15 m/s
85 kg = 100% 1RM	1.43 m/s	1.03 m/s	70 kg = 100% 1RM	1.5 m/s	1.08 m/s

This athlete:

Squat 1RM = 221 kg.
They failed this power clean with 132.5 kg with a Peak velocity of 1.51 m/s and average velocity of 1.09 m/s.

Did they fail due to strength or technique?



Key take home Points for Weightlifting exercises…

- Most sports athletes are different in stature and technical proficiency to competitive Weightlifters
- Can use velocity measures to help discern problems and improve coaching

A simple lower body Force-Velocity profile for S & C coaches

- **1. Velocity**
- **Jump squat** (use a dowel rod/PVC pipe) – **PEAK velocity**
- ~ can also use this as a weekly test of "readiness"

- **2. Force**
- **1RM full squat** - **AVERAGE velocity**

- Now we need something in the middle, to analyze how the athlete uses their force producing capabilities combined with velocity

3. The combined measure of force and velocity capabilities….

- **Jump squat** with extra resistance, 4 main choices eg:
- **Jump squat with 50% 1RM full squat**
-
- **Jump squat with 75-100% BWT (males) & 50-75% (females)**
- **Determine the JS 1m/s load**
- **JS Sports specific resistance** (correlates to success/selection eg 40 kg or 100 kg) –
- Or
- **1RM power clean/hang power clean** ~ will also be around 1m/s (Average Velocity)

- Either way, look at **both Peak and Average Velocity**

Some unpublished jump squat data…

Using Average velocity to distinguish between rugby players…Pro's versus U/20yrs

Squad	20 kg Av. vel.	60 kg Av. vel.	100 kg Av. vel.	1 m/s load	1RM Full Squat	100 kg as %1RM	1 m/s load as %1RM
NRL (n=17)	1.51 m/s	1.24 m/s	0.92 m/s	90.6 kg	174.4 kg	58.5%	51.9 %
U/20 yrs (n=17)	1.50 m/s	1.11 m/s	0.81 m/s	73.6 kg	141.9 kg	71.1%	52.1%

Maybe a quicker test is to do a jump squat test with 50% 1RM(full squat) – the Average velocity will be around 1 m/s and you be very close to Pmax

Or Determine **WHAT IS THE BEST RESISTANCE TO TEST FOR YOUR SPORT?**

Part 2. Velocity and fatigue data

- Fatigue and velocity loss – Upper v Lower body
- The velocity-fatigue profile across a set for "strength" versus "power" exercises
- Effects of stopping a set at a pre-determined velocity loss or score…

A tale of three great studies:

Study#1.

Velocity decline, fatigue, lactate and ammonia levels across 3 sets with different reps and "effort"...

	SQ vel. dec %	BP vel. dec. %	SQ lactate	BP lactate	SQ ammonia	BP ammonia
3 x 12RM	46.5	63.3	12.5	8.9	125	111
3 x 10RM	45.7	58.4	11.7	7.8	97	89
3 x 8RM	39.8	56.9	10.4	7.5	78	79
3 x 6RM	41.9	56.8	10.0	6.9	65	68
3 x 4RM	32.0	49.8	6.9	4.9	61	53
3 x 8 (10RM)	32.3	46.1	8.6	6.0	62	64
3 x 6 (10RM)	22.0	29.8	6.3	4.6	48	47
3 x 3 (6RM)	19.6	23.7	3.5	3.1	47	51
3 x 2 (4RM)	16.6	18.9	3.0	2.6	41	48

Sanchez-Medina et al. MSSE 2011

Study#2.

Comparing the effects of Bench Press & Squat workouts…

3 x 4 @8RM v 3 x 8 @8RM ~ 80%1RM

Variable	Bench Press Differences	Squat Differences
MP velocity loss across the 3-sets	34.5% v 69.6%	36.6% v 57.7%
48-hrs V-1m/s @ 48-hrs - % of initial pre-test score	104.9% v 98.4%	102.1% v 100.8%
	Combined workout effects	
48-hrs CMJ - % of initial pre-test score	101.9 % v 95.6%	

For some variables, scores return to base-line at 6hrs for 3 x 4 (8RM) eg. CMJ

Also velocity loss correlated moderately with changes in Testosterone, Cortisol & CK levels

Gonzales-Badillo et al. 2015 Int. J Sports Med

Study#3.
Using velocity loss across the set to determine the end of the set…
Longer-term (8-wks) effects

(Pareja-Blanco et al. Scan J Med Sci Sports 2016)

- Study using Squats (Smith Machine) & 8-wk periodized program (ranging from ~ 70% to 85% 1RM)
- 20% v 40% MP velocity across the set to determine the end of the set x 3 sets x 4-min. recovery (+ warmup sets)
- Adjust training weights on velocity within session (if needed)
- **Deliberate low volume (appeal to "sports" athletes, not lifters) – V20% group performed only 60% of the volume of the V40% group**

- **Results**:
- Similar gains in 1RM strength
- Trend towards better gains in the V20% group for velocity with sub-max loads
- Greater gains in CMJ for V20% group
- No difference in 20-m sprint (no change)
- V40% group had greater hypertrophy
- V40% group had decrease % of MHC 11X fiber type

Key Take Home Points – "Strength" exercises, fatigue and velocity loss…

- If **high repetitions** are performed or
- If **more than 66% of the possible repetitions** are performed or
- If **velocity loss of greater than 20% (Squats) or 30% (bench press) within a set occurs**…
- Greater lactate accumulation & ammonia levels within a set and across 3 sets – more "damage"
- Implications for in-season training or those **who do not wish to gain muscle**!!
- Consider the short-term nature of studies (8wks) – will minimal hypertrophy continue to see gains in strength/adaptations after longer periods…?

"Power" exercises, fatigue and velocity decline

- Exercises that are defined as "power" exercises have a different velocity decline profile
- As a certain velocity is critical for success in the exercise, there will or should not be large velocity declines in a set or across 3 or more sets

Power clean "Peak" Velocity decline
~ 3 x 6 reps with 80%, 3-minutes rest between sets
(Hardee et al, JSCR 2012)

	Rep #1	Rep #6	% decline
Set 1	2.00 (0.05)	1.79 (0.03)	10.5%
Set 2	1.98 (0.04)	1.80 (0.03)	9.1%
Set 3	1.95 (0.05)	1.79 (0.03)	8.9%

Power Exercises –
Snatch Grip Push Press 4 x 8 @ 70% 1RM (~15 RM)
Power Exercises exhibit less velocity loss across each set!

Mean Velocity	#1	#2	#3	#4	#5	#6	#7	#8	Average
Set 1 - 75 kg	0.99	0.94	0.95	0.94	1.00	0.98	0.96	0.96	**0.97**
Set 2 - 75 kg	0.95	0.99	0.96	1.01	1.00	1.03	0.85	0.98	**0.97**
Set 3 - 75kg	0.92	1.06	0.98	0.99	0.97	1.13	1.06	1.04	**1.02**
Set 4 - 75 kg	1.04	0.98	1.00	0.98	0.90	1.02	0.91	0.99	**0.98**

Key Take Home Points –
"Power" exercises, fatigue and velocity loss…

- Power exercises have less velocity drop off as they are more "velocity dependent"
- Stop the set at ~ **5- 10% Velocity Loss** within a set OR
- Prescribe about ≤ 66% of POSSIBLE REPS (eg. do 3-reps or less at a 5RM)

Part 3.
Using velocity data in training, for monitoring and to improve coaching

- Acute, short, medium and long term monitoring & tracking of velocity during resistance training
- "Periodizing" reps, %1RM, velocity and effort
- Using velocity to motivate athletes during resistance training or accountability!
- Using velocity to improve coaching and the provision of corrective coaching cues

Short-term & medium-term tracking of velocity during strength training

- Changes in Velocity with any given resistance can indicate changes in strength and/or fatigue suppression of strength (temporary)
- Do not have to measure 1RM as regularly, if velocities are known for resistances from about 60% 1RM (especially 80+%1RM)
- Average Velocity allows an estimate of the Daily Maximum Strength level that can be assessed during warm-up sets (above 60% 1RM)?

Testing of 1RM strength allows the S & C coach to collect some data

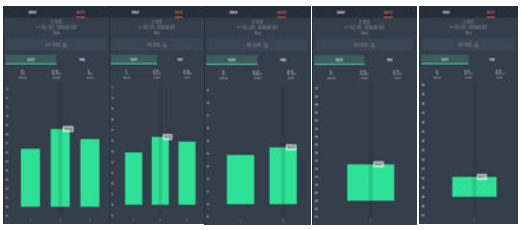


Figure 1. BWT x 3-reps BEST REP = 0.86 m/s | Figure 2. +15 kg x 2-reps BEST REP = 0.63 m/s | Figure 3. +25 kg x 2-reps BEST REP = 0.45 m/s | Figure 4. SUCESSFUL BEST REP = 0.23 m/s | Figure 5. +40 kg, FAIL! 0.11 m/s = Rep halted!

Due to linear relationship between points, we can therefore extrapolate velocity scores for +5 kg (0.78 m/s), +10 kg (0.70 m/s), +20 kg (0.54 m/s) and +30kg (0.34 m/s), even though we did not directly test those resistances

Velocity and changes in upper body strength levels….

- **For Bench Press** = About 0.08 M/s (0/07 to 0.09) for every 5% 1RM increment.
- **For Bench Pull =** About 0.07 M/s for every 5% 1RM increment.
- A change in the velocity of 0.07 to 0.08 m/s either way between training sessions could be deemed to equate to a change in 1RM strength of 5% (Sanchez-Medina et al. 2013)

Velocity and changes in lower body strength levels….

- **Squats & Half Squats** = About 0.06 m/s for every 5% 1RM increment for lower level strength athletes
- **Incline Leg Press** = About 0.08 m/s for every 5% 1RM increment.
- (Pallares et al 2014, Conceição et al 2015)
- **For experienced, strong squatters** = About 0.08 to 0.11 m/s every 5% 1RM increment (Helms et al 2016)
- **For experienced, strong deadlifters** = About 0.06 to 0.10 m/s every 5% 1RM increment (Helms et al 2016)

2-weeks

Two Squat workouts –
132.5 kg + 35 kg bands resistance x 6 sets of 3-reps
The 7% increase in velocity equivalent ~ 2.5% in 1RM
ie. If 0.06 m/s = 5% 1RM, the change of ~ 0.03 m/s = 2.5% 1RM

	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Workout mean
Rep #1	0.45	0.39	0.47	0.52	0.34	0.43	**0.43**
Rep #2	0.38	0.33	0.38	0.37	0.41	0.39	**0.38**
Rep #3	0.4	0.4	0.31	0.37	0.41	0.37	**0.38**
Mean	**0.41**	**0.37**	**0.39**	**0.42**	**0.39**	**0.4**	**0.40**
Rep #1	0.46	0.46	0.42	0.45	0.55	0.43	**0.46**
Rep #2	0.42	0.42	0.41	0.4	0.43	0.42	**0.42**
Rep #3	0.43	0.3	0.34	0.43	0.49	0.52	**0.42**
Mean	**0.44**	**0.39**	**0.39**	**0.43**	**0.49**	**0.46**	**0.43**

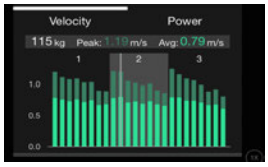
3-weeks

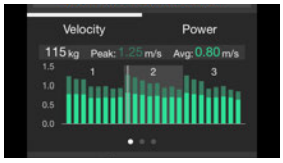
RDL 115 kg x 8 - Determining if "real change" has occurred?

Looking at best & worst average velocity per set

	Set 1- 1st to last rep	Set 2 - - 1st to last rep	Set 3 - - 1st to last rep
2-11-2015	0.77 -> 0.67	0.79 -> 0.65	0.78 -> 0.60
23-2-2015	0.77 -> 0.67	0.80 -> 0.68	0.80 -> 0.62

Has any "real change" occurred?





4-weeks

Two Snatch Push Press workouts – 13-20% increase in velocity with the same resistances = about 5-7% increase in 1RM strength!

Mar 25	Rep #1	#2	#3	#4	#5	#6	Set Average	
Set #1 - 75 kg	0.83	0.83	0.86	0.88	0.89	0.89	**0.86**	
Set #2 - 80 kg	0.77	0.82	0.86	0.85	0.85	0.86	**0.84**	
Set #3 - 85 kg	0.79	0.67	0.69	0.81	0.86	NA	**0.76**	
Set #4 - 90 kg	0.81	0.78	0.80	0.83	0.83	0.85	**0.82**	
Apr 21	**Rep #1**	**#2**	**#3**	**#4**	**#5**	**#6**	**Set Average**	**% Change**
Set #1 - 75 kg	0.96	1.00	1.00	0.98	0.96	0.96	**0.98**	**13.1**
Set #2 - 80 kg	1.04	1.02	0.94	0.90	0.96	0.90	**0.96**	**15.0**
Set #3 - 85 kg	0.99	0.98	0.89	0.94	0.97	0.93	**0.95**	**24.3**
Set #4 - 90 kg	0.91	1.00	0.94	1.00	1.04	1.00	**0.98**	**20.2**

10-weeks

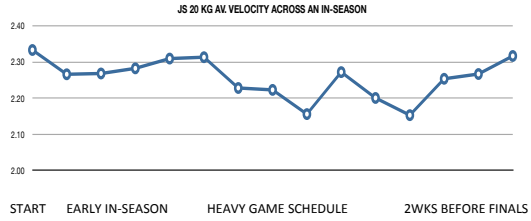
A 5kg change in weight lifted, but is that the "true amount" of change?

Squat	First rep	Last rep
Dec. 23 = 160 kg x 6-reps	0.42 m/s	0.32 m/s
March 9 = 165 kg x 6-reps	0.54 m/s	0.36 m/s

6-months
Monitoring velocity across periods of 6-months

Monitoring velocity to observe "readiness" or "recovery" across a 6-month in-season in Professional rugby players using 20 kg jump squat

The team average IS 2.33 M/S at the START & "Real Change" is about 4-7%



START EARLY IN-SEASON HEAVY GAME SCHEDULE 2WKS BEFORE FINALS

One year
Changes in velocity
squatting 160 kg across one year

	Best 160 kg Velocity	Estimated 1RM
March 2015	0.35	180 kg
March 2016	0.63	205 kg

Three years
Case Study – Olympic diver 1993-96
Jump Squat Average velocity changes

	November 1993	December 1995	% Change
JS 20 kg	1.37 m/s	1.54 m/s	12.4%
JS 80 kg	0.95 m/s	1.16 m/s	22.1%

Note well, 5RM squat improved by 50%

Baker, SCJ 23(1): 2001.

Managing Training via "Effort", Velocity and Strength levels!

- The first (or best) indicate current strength levels and the last rep in a set can indicate "Effort"/fatigue levels
- Eg.
- For upper body pressing "strength" exercises, Average velocity of ~ 0.15- 0.20+ m/s is usually associated with 1RM!
- Or the last possible repetition before failure
- Eg. the third rep in a 3RM, the 5th rep in a 5RM, the 8th rep in a 8RM etc.

Upper body pressing exercises – Relationship between Effort and velocity of the last/worst rep performed in a set

	Max Effort set or RPE 10	Near Max Effort set (1-2 in the tank) or RPE 9 to 8.5	Hard Effort set (2-3+ in the tank) or RPE 8 to 7.5	Medium effort set (3-5+ in the tank) or RPE 7 to 6
Last rep m/s	~ < 0.20	~ 0.22-0.28	~ 0.29-0.35	~ >0.36

Squat… Relationship between Effort and velocity of the last/worst rep performed in a set..?

	Max Effort set or RPE 10	Near Max Effort set (1-2 in the tank) or RPE 9 to 8.5	Hard Effort set (2-3+ in the tank) or RPE 8 to 7.5	Medium effort set (3-5+ in the tank) or RPE 7 to 6
Last rep m/s	~ < 0.23-0.3	~ 0.29-0.36	~ 0.37-0.44	~ >0.45

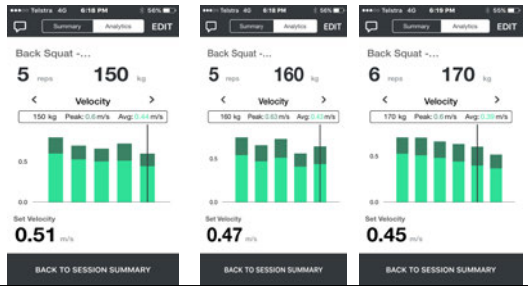
Eg. A few heavy squat workouts that establish the Max Effort velocities

Effort level	Best rep	Last rep
6RM	0.52 m/s	0.32 m/s
3RM	0.38 m/s	0.27 m/s
2RM	0.34 m/s	0.25 m/s
1RM	0.25 m/s	0.25 m/s

Within the workout

Coaching this athlete across three sets, using the velocity of the last rep to guide weight increases…

First rep with 170 kg = 0.52 m/s, Last rep (6th) with 170 kg = 0.36 m/s



Key take home points

- Your first/best rep tells you your strength level for that day
- Your last rep in the set tells you your acute fatigue level and how close that set is to failure or max effort ~ what RPE it is
- By "knowing" these two velocity scores, training weights and set RPE levels are easy to monitor and prescribe

Using velocity to improve programming

- Implications and examples from team sport athletes
- Can we minimize the "effective resistance training dosage?"
- Can we more accurately prescribe exact resistances?

"Periodizing" reps, %1RM, velocity and effort

	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6
Set x Reps	3 x 8	3 x 6	3 x 6	3 x 4	3 x 4	3 x 3
%1RM	60%	65%	70%	75%	75%	80%
Mean velocity	0.79	0.70	0.62	0.55	0.55	0.47

GONZÁLEZ-BADILLO et al. European Journal of Sport Science, 2014

Why such low reps at any given %1RM?

To minimize leg fatigue! – "sports athletes"

Another example – Australian Rugby Union Training Squad Players

Upper body Strength day	Wk 1	Wk 2	Wk 3
S X R	3 x 8	3 x 8	3 x 5
%1RM (planned)	70%	75%	75-80-85%
Mean velocity **(actual)**	0.67	0.55	0.5
Mean velocity **(planned)**	0.65	0.56	0.41
Upper body Power day			
S X R	6x4	6x4	5x3
%1RM	60%	64%	70%
Mean velocity **(actual)**	0.83	0.83	0.73
Mean velocity **(planned)**	0.85	0.75	0.70

Australian Rugby Union Players

Lower body Strength day	Wk1	Wk2	Wk3
S X R	4 x 5	5 x 5	3 x 5
%1RM (planned)	60%	67%	75%
Mean velocity **(actual)**	0.96	0.70	0.65
Mean velocity **(planned)**	0.60	0.55	0.5
Lower body Power day			
S X R	6x4	6x4	5x3
%1RM	55%	63%	70%
Mean velocity **(actual)**	0.94	0.80	0.72
Mean velocity **(planned)**	0.75	0.68	0.6

Australian Rugby Union Players – where there is no real 1RM…Power Shrug jumps… prescribe resistance via velocity!

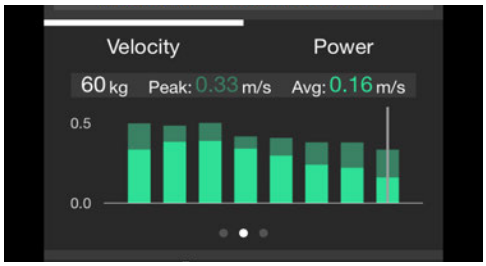
N=10	Wk 1	Wk 2	Wk 3
S X R	3 x 5	3 x 5	3 x 3
Weight (KG)	116.7	130.0	135.6
Mean velocity **(actual)**	1.25	1.05	0.98
Mean velocity **(planned)**	> 1.2	> 1.05	> 1.0

Some other Programming decisions…

- Given the data on high reps, fatigue, RPE, velocity loss, muscle damage (and the implications for recovery)…
- We have to make choices with athletes sometimes….
- High reps…stay with the prescribed load or reduce it when fatigued…?

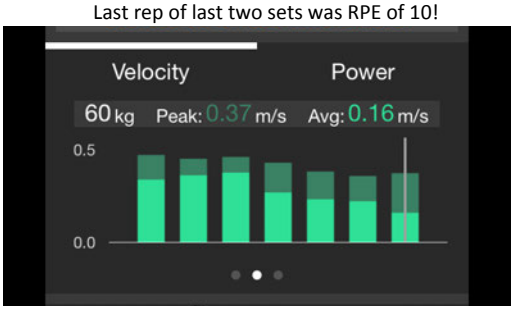
During the session – Decision time

Trying to perform 3 x 8 on press b neck with 60 kg ~
But on the second set, the last rep = 0.16 m/s
Do we stay at 60 kg (intensity choice) or reduce the weight to ~ 55kg to get 8 reps out (volume load choice) and/or not go to failure again ?



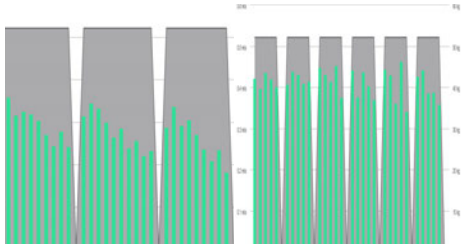
Staying at 60 kg

Only 7 reps could be performed, the last rep at 0.16 m/s!
Last rep of last two sets was RPE of 10!



For hypertrophy training,

do I choose a
Fatigue-based (FBT) protocol (eg 3 x 10RM)
or a
Velocity-based (VBT) protocol (6 x 5 @10RM)
(the same resistance is used)?



Differing outcomes lifting the same weight… which would you choose for a thrower or sprinter?

	Set 1	Set 2	Set 3
Fatigue-based	Highest rep = 0.39 m/s Lowest rep = 0.24 m/s Set average = 0.30 m/s	Highest rep = 0.34 m/s Lowest rep = 0.22 m/s Set average = 0.28 m/s	Highest rep = 0.34 m/s Lowest rep = 0.18 m/s Set average = 0.26 m/s * Only 9-reps
Velocity-based	Set 1 Highest rep = 0.43 m/s Lowest rep = 0.40 m/s Set average = 0.41 m/s	Set 2 Highest rep = 0.44 m/s Lowest rep = 0.41 m/s Set average = 0.42 m/s	Set 3 Highest rep = 0.45 m/s Lowest rep = 0.38 m/s Set average = 0.42 m/s
	Set 4 Highest rep = 0.44 m/s Lowest rep = 0.37 m/s Set average = 0.41 m/s	Set 5 Highest rep = 0.46 m/s Lowest rep = 0.34 m/s Set average = 0.41 m/s	Set 6 Highest rep = 0.44 m/s Lowest rep = 0.36 m/s Set average = 0.40 m/s

NB VBT had 22 out of 30 reps $\geq$ 0.40 m/s @ 0.41 m/s average per rep
~ FBT had no reps out of 29 $\geq$ 0.40 m/s @ 0.28 m/s average per rep

Using velocity to motivate athletes or keep them accountable for volitional effort!

Romanian style Deadlift 3 x 8 reps @110 kg

RDL	Rep 1	#2	#3	#4	#5	#6	#7	#8	Set Average
Set 1	0.56	0.53	0.56	0.54	0.56	0.54	0.51	0.45	0.53
Set 2	0.65	0.68	0.64	0.58	0.54	0.56	0.60	0.52	0.59
Set 3	0.60	0.58	0.59	0.59	0.58	0.54	0.54	0.47	0.56

Using velocity to improve coaching and the provision of corrective coaching cues

Snatch grip Push Press	Rep #1	#2	#3	#4	#5	#6
Mean Velocity	0.92	0.88	0.81	0.99	0.98	0.99

For the first three reps, the athlete is not performing the technique of the exercise as well as usual

The coach provides the appropriate "corrective coaching cues"

The athlete implements the appropriate changes within the set and as a result, the mean velocity of the last three reps improves dramatically, back to their usual level for this athlete

Eg. Prescribing resistances for the lower body

Training objective	Exercise type (eg)	Velocity ranges
Ballistic & Maximal Power	Jumps	BWT jumps = PK > 3.0 m/s = Av > 1.4 m/s
	Jump squats	10-45% 1RM = PK 1.8 - 2.8 m/s = Av 1.0 - 1.4 m/s
Explosive Speed-Strength	Squats with bands/ chains	50-60+%+B/C = PK 1.10 -1.50 m/s = Av 0.7- 1.0 m/s
	Power clean	60-90% 1RM = PK 1.30 – 1.90 m/s = Av 1.00 – 1.30 m/s
General Strength	Squats (all types)	70-80% = Av 0.45 – 0.7 m/s
Maximal Strength	Squats (all types)	80-100% = Av 0.25 – 0.45 m/s

Eg. Prescribing resistances for upper body pressing

Training objective	Exercise type (eg)	Velocity ranges
Ballistic Power	Medicine ball throws	eg. 5kg = PK > 3.5 m/s
Maximal Power	Bench press throws (Smith Machine)	15-45% 1RM = PK 1.3 - >2.2 m/s = Av 1.0 – 1.8 m/s
Explosive Speed-Strength	Bench press with bands/chains	45-65%+B/C = PK 1.00 - >1.25 m/s = Av 0.75 - 1.0 m/s
	Push press	60-90% = PK 1.30 - 1.90 m/s = Av 0.75 - 1.2 m/s
General Strength	Bench & OH press	70-80% = Av 0.45 - 0.75 m/s
Maximal Strength	Bench & OH press	80-100% = Av 0.20 - 0.45 m/s

Conclusions

- Velocity can be used to prescribe resistances

Or

- Velocity can “influence” programming, training and coaching decisions