RECENT TRENDS IN VELOCITY BASED STRENGTH TRAINING

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Irish Institute of Sport
RESEARCHED APPLICATIONS OF VELOCITY BASED STRENGTH TRAINING

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ABSTRACT

Strength training is a critical exercise stimulus for inducing changes in muscular strength, size and power (6). Recently, linear position transducers have gained in popularity as a means to monitor velocity in strength training exercises. The measurement error of such devices has been shown to be low and both relative and absolute reliability have been shown to be acceptable (2, 7, 11). The purpose of this article is to provide the overview and benefits of monitoring movement velocity in strength training exercises, along with providing the basis for novel “velocity-based” strength training prescription. We have covered the following practical applications: Guidelines to develop a velocity/load profile for athletes; Using the velocity load/profile to predict and monitor changes to maximal strength; Using velocity monitoring to control fatigue effects of strength training; Using velocity monitoring as an immediate performance feedback to promote the highest level of effort in specific training exercises and stronger adaptive stimuli. Linear position transducers are reliable and valid tools to help strength and conditioning practitioners monitor and optimize their strength training programs.

Keywords – Strength, velocity, bench press, squat, linear position transducer.
WHAT IS **VELOCITY BASED TRAINING**?

VBT IS THE USE OF A VELOCITY MEASURING DEVICE TO PROVIDE FEEDBACK DURING STRENGTH TRAINING TO **OPTIMISE THE STRENGTH TRAINING PROCESS**.
WHAT IS VELOCITY BASED TRAINING?

VBT IS THE USE OF A VELOCITY MEASURING DEVICE TO PROVIDE FEEDBACK DURING STRENGTH TRAINING TO OPTIMISE THE STRENGTH TRAINING PROCESS
WHAT IS VELOCITY BASED TRAINING? AND WHAT IT’S NOT

LOAD, EFFORT & EXERTION
THE TERMINOLOGY OF INTENSITY

WHEN & WHY YOU DON’T NEED VBT
NOVICE ATHLETES & THE COACHING EYE

4 APPLICATIONS OF VBT
PUTTING IT INTO PRACTICE

TRAINING NOTES
THE POWER CLEAN
VELOCITY BASED TRAINING: WHAT IT'S NOT

IT IS NOT NEW!

IT IS NOT AN ALTERNATIVE TO STRENGTH TRAINING!

IT IS NOT NECESSARILY HIGH VELOCITY TRAINING!
VBT: THE TERMINOLOGY OF INTENSITY

LOAD: WEIGHT ON THE BAR, PERCENTAGE 1RM

EFFORT: “INTENT” TO PERFORM REPS WITH MAX. CONCENTRIC ACCELERATION & SPEED

EXERTION: PROXIMITY TO FAILURE IN A GIVEN SET

Jovanovic & Flanagan
Researched Applications of Velocity Based Strength Training
JASC 21 (1), 2014.
WHEN & WHY YOU DON’T NEED VBT

Consider VBT use in the context of our athlete population. Are they strong? Are they weak? Are they novices?

- Do we want to promote high intent of effort in athletes with poor motor patterns?

Consider VBT in the context of our own coaching development.

Use of VBT will distract your focus of attention.

- Have you served your time and “seen” thousands of reps?
- Is the coach:athlete ratio right?
- Will VBT use distract you from something more important?
FOUR APPLICATIONS OF VBT

AUGMENTED FEEDBACK – ENHANCING THE TRAINING “OUTPUT”

THE LOAD/VELOCITY PROFILE & 1RM PREDICTION

OPTIMISING THE RELATIVE LOAD & ACUTE TRAINING ADJUSTMENT

USING VBT TO LIMIT FATIGUE EFFECTS
FOUR APPLICATIONS OF VBT

AUGMENTED FEEDBACK – ENHANCING THE TRAINING “OUTPUT”

THE LOAD/VELOCITY PROFILE & 1RM PREDICTION

OPTIMISING THE RELATIVE LOAD & ACUTE TRAINING ADJUSTMENT

USING VBT TO LIMIT FATIGUE EFFECTS
Ankle dorsi-flexion training task
Ballistic vs Isometric contraction type
Maximal “intensity of effort” in both interventions
Similar increases in high velocity related contractile qualities
Intended rather than actual movement velocity determines velocity-specific training response

David G. Behm and Digi

It is also important to recognise the fact that the internal conduction velocity of muscle may be independent of external movement velocity; it may be that the ‘intention’ to move a load at high velocity is of greater importance than the actual movement velocities achieved. The load utilised may be less important for high-velocity power adaptation to occur, particularly if movements are performed with both maximal effort and intent.

Possible Stimuli for Strength and Power Adaptation (Crewther, Cronin, Keogh)

Sports Med. 35. 2005

In both interventions, similar increases in high velocity related contractile qualities
Jump squat task, with & without velocity feedback
Moderate to Large improvements in “output” in the jump squat exercise
Small improvements in CMJ, 10/30m speed, HJ
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THE LOAD/VELOCITY PROFILE
There is a strong linear relationship between load & velocity

Example bench press data from professional rugby player with 127.5kg 1RM. *(GymAware)*

Each Subject achieved very similar velocities on their last rep in sets to failure (bench press).

Each subject hits similar velocities at the same % of 1RM

Minimum Velocity Threshold

NSD in “MVT” between a range of submax reps to failure & measured 1RM

The MVT is exercise specific

Mean concentric velocity measured at 4-6 loads
Range from 30-85% of 1RM

Conservative, randomised incremental load progression

Spread loads to ensure a 0.5 m/s decrease in velocity (40-80% in bench press; 30-85% in the squat)

Record highest mean velocity recorded @ each load

Plot load x-axis; plot velocity on y-axis

THE LOAD/VELOCITY PROFILE GUIDELINES

Load/velocity profile protocol

2-3 reps @ 30-40% 1RM
2 reps @ 40-50% 1RM
1-2 reps @ 60-70% 1RM
1 rep @ 70-80% 1RM
1 rep @ 80-85% 1RM
PREDICTING 1RM BASED ON LOAD/VELOCITY

\[ y = mx + c \]

Where,

- \( y \) = min. velocity threshold (0.1 m/s)
- \( m \) = slope (-0.0113)
- \( x \) = predicted 1RM load
- \( c \) = intercept (1.5757)

\[ \frac{y - c}{m} = x \]

\[ \frac{0.1 - 1.5757}{-0.011} = 130kg \]

Jidovtseff et al. JSCR. 25. 2011
FOUR APPLICATIONS OF VBT

AUGMENTED FEEDBACK – ENHANCING THE TRAINING “OUTPUT”

THE LOAD/VELOCITY PROFILE & 1RM PREDICTION

OPTIMISING THE RELATIVE LOAD & ACUTE TRAINING ADJUSTMENT

USING VBT TO LIMIT FATIGUE EFFECTS
STRENGTH REALISATION =
STRENGTH POTENTIAL – STRESS IMPACT

Too light & easy  Optimal Training Zone  Too heavy & hard

Stuart Yule
High Performance Training for Sports
Joyce, Lewindon (Eds); Human Kinetics, 2014
STRENGTH REALISATION = STRENGTH POTENTIAL – STRESS IMPACT

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Percentage 1RM</th>
</tr>
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<tbody>
<tr>
<td>Light (L)</td>
<td>&lt; 80</td>
</tr>
<tr>
<td>Medium (M)</td>
<td>80-85</td>
</tr>
<tr>
<td>Medium-Hard (MH)</td>
<td>85-90</td>
</tr>
<tr>
<td>Hard (H)</td>
<td>90-95</td>
</tr>
<tr>
<td>Very Hard (VH)</td>
<td>95-100</td>
</tr>
</tbody>
</table>
STRENGTH REALISATION = STRENGTH POTENTIAL – STRESS IMPACT

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Percentage 1RM</th>
<th>Reps in the tank</th>
<th>Bench Press Velocity &quot;Stop&quot; (m/s via Tendo Unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light (L)</td>
<td>&lt; 80</td>
<td>&gt; 5 reps in the tank</td>
<td>0.6</td>
</tr>
<tr>
<td>Medium (M)</td>
<td>80-85</td>
<td>&gt;4 reps short of Max Effort</td>
<td>0.52</td>
</tr>
<tr>
<td>Medium-Hard (MH)</td>
<td>85-90</td>
<td>2-4 reps short of Max Effort</td>
<td>0.42</td>
</tr>
<tr>
<td>Hard (H)</td>
<td>90-95</td>
<td>1-2 reps short of Max Effort</td>
<td>0.33</td>
</tr>
<tr>
<td>Very Hard (VH)</td>
<td>95-100</td>
<td>No additional reps / Failure</td>
<td>0.23</td>
</tr>
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FOUR APPLICATIONS OF VBT

AUGMENTED FEEDBACK – ENHANCING THE TRAINING “OUTPUT”

THE LOAD/VELOCITY PROFILE & 1RM PREDICTION

OPTIMISING THE RELATIVE LOAD & ACUTE TRAINING ADJUSTMENT

USING VBT TO LIMIT FATIGUE EFFECTS
Velocity slows as fatigue develops.

Using velocity monitoring we can estimate metabolic stress and neuromuscular fatigue.

Lactate increases linearly; Ammonia increases curvilinearly.

Research suggests a maximum velocity loss of 30% in the squat and 35% in the bench press can be established to limit metabolic by-product accumulation.

Experienced strength trainers. Bench press with 85% 1RM.

Open ended sets & reps. Set terminated with velocity dropped >20% of initial velocity

7-9 sets of 2-3 reps @ 85% with maximal intensity of effort.

Significant increase in maximal strength (via $1RM_{\text{actual}}$) compared with "traditional" controls

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Means and standard deviation (± SD) of the maximum load 1 RM (ML), maximal speed 1 RM (MV); before and after training.</th>
</tr>
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<td>Group</td>
<td>Variable</td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>FPS</td>
<td>ML (kg)</td>
</tr>
<tr>
<td></td>
<td>MV (m·s⁻¹)</td>
</tr>
<tr>
<td>SPS</td>
<td>ML (kg)</td>
</tr>
<tr>
<td></td>
<td>MV (m·s⁻¹)</td>
</tr>
<tr>
<td>FPS = fixed pushing speed, SPS = self-selected speed; &quot;&quot;&quot;&quot;P&lt;0.05 vs. baseline</td>
<td></td>
</tr>
</tbody>
</table>

1RM Strength = 10.2%

1RM Speed = 2.2%

If appropriate thresholds are implemented:

Metabolic fatigue can be limited

Higher intensities of effort maintained

Maximal strength may be enhanced in short “peaking/variation” phases

Table 1  Means and standard deviation (± SD) of the maximum load 1 RM (ML), maximal speed 1 RM (MV); before and after training.

<table>
<thead>
<tr>
<th>Group</th>
<th>Variable</th>
<th>Baseline</th>
<th>Week 3</th>
<th>Percent change (Δ%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPS</td>
<td>ML (kg)</td>
<td>99.7 ± 3.08</td>
<td>109.8 ± 4.06</td>
<td>10.20*</td>
</tr>
<tr>
<td></td>
<td>MV (m·s⁻¹)</td>
<td>0.150 ± 0.07</td>
<td>0.154 ± 0.08</td>
<td>2.22*</td>
</tr>
<tr>
<td>SPS</td>
<td>ML (kg)</td>
<td>97.5 ± 1.90</td>
<td>97.7 ± 2.14</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>MV (m·s⁻¹)</td>
<td>0.146 ± 0.04</td>
<td>0.146 ± 0.09</td>
<td>0.11</td>
</tr>
</tbody>
</table>

FPS = fixed pushing speed, SPS = self-selected speed; **P < 0.05 vs. baseline

1RM Strength = 10.2%
1RM Speed = 2.2%

THE POWER CLEAN

Photo credit: @hookgrip
“The peak velocity occurs at top of the second pull of the clean or snatch when the movement is done properly. Thus, peak velocity helps define the critical moment of the movement and thus is a clearer determinant of the success of the lift”

Bryan Mann
Velocity Based Training in Football
NSCA SCJ, 2016
**THE POWER CLEAN**

Shallower load/velocity slope compared with traditional STR exercises

Velocity decreases to a lesser extent with increase in load
The Power Clean

Shallower load/velocity slope compared with traditional STR exercises

Velocity decreases to a lesser extent with increase in load

This results in high power @ moderate to high loads
Shallower load/velocity slope compared with traditional STR exercises

Velocity decreases to a lesser extent with increase in load

This results in high power @ moderate to high loads

70-80% produces high power and moderate to high loads
"... as resistance goes up, power also goes up because the velocity is fairly stable — you need a certain velocity to make a successful lift... "  

Dan Baker

The power clean offers a unique opportunity to train high force ability and high power ability simultaneously
Training data – Irish 85kg weightlifter
Cathal Byrd
Power Clean
100.0 kg
Rep
Peak Velocity (m/s)
THE POWER CLEAN

There may be a “tipping point” at which there is a sudden shift in strategy.

Bar speed may be sacrificed for speed/depth under the bar or other “max lift” strategy.

S&C coaches should consider this. What is the goal of the exercise in the S&C program?
THE POWER CLEAN
Don’t get too hung up on 1RM\textsubscript{s} or velocity.

Is the load heavy enough to stimulate adaptation (70-80\% 1RM)?

Is the movement smooth and “fluid”? 

Is the athlete expressing maximally?
Summary

VBT isn’t an essential part of S&C delivery but does have some simple and effective applications

Don’t let technology distract you from your own coaching development and “easy wins” in novice athletes

VBT can be a great tool to:
- Gather a greater depth of data from our strength testing
- Stimulate greater intent in strength & power exercises
- Help us make acute adjustments in high “stress” periods and limit metabolic fatigue effects

Make sure you think critically around your VBT use and “look under the hood” in terms of reliability of devices.
THANK YOU!

Eamonn Flanagan, PhD.
@eamonnflanagan
PREDICTING 1RM BASED ON LOAD/VELOCITY

Accurate & highly correlated with measured 1RM\textsubscript{actual}

High correlations but different 1RM values

Appropriate to measure training induced adaptation

Don’t interchange 1RM\textsubscript{pred} & 1RM\textsubscript{actual}

Jidovtseff et al. JSCR. 25. 2011
y = mx + c

Where,

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\[
\frac{y - c}{m} = x
\]

\[
\frac{0.1 - 1.5757}{-0.011} = 130kg
\]

O’Donovan, McGrath, Flanagan, Kenny & Collins
Data collection still underway
Predicting 1RM Based on Load/Velocity

\[ y = mx + c \]

Where,
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- \( m \) = slope (-0.0113)
- \( x \) = predicted 1RM load
- \( c \) = intercept (1.5757)

\[ \frac{y - c}{m} = x \]

\[ \frac{0.1 - 1.5757}{-0.011} = 130 \text{kg} \]

O’Donovan, McGrath, Flanagan, Kenny & Collins
Data collection still underway
# Fixed Load Velocity Test

## Mean Velocity (m/s)

<table>
<thead>
<tr>
<th></th>
<th>Mean Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline Score</strong></td>
<td>0.85</td>
</tr>
<tr>
<td><strong>St Dev</strong></td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Upper Limit (Large Effect)</strong></td>
<td>0.91</td>
</tr>
<tr>
<td><strong>Lower Limit 1 (Moderate Effect)</strong></td>
<td>0.81</td>
</tr>
<tr>
<td><strong>Lower Limit 2 (Large Effect)</strong></td>
<td>0.78</td>
</tr>
</tbody>
</table>

## Today's Scores:

<table>
<thead>
<tr>
<th>Rep</th>
<th>Mean Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep 1</td>
<td>0.91</td>
</tr>
<tr>
<td>Rep 2</td>
<td>0.9</td>
</tr>
<tr>
<td>Rep 3</td>
<td>0.93</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>0.91</strong></td>
</tr>
</tbody>
</table>

## Today's Feedback:

- **High Level**
STRENGTH REALISATION =
STRENGTH POTENTIAL – STRESS IMPACT

FIXED LOAD VELOCITY TEST

<table>
<thead>
<tr>
<th>Date</th>
<th>Mean Velocity (m/s)</th>
<th>Mean Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/03/20</td>
<td>0.81</td>
<td>408</td>
</tr>
<tr>
<td>16/03/20</td>
<td>0.78</td>
<td>380</td>
</tr>
<tr>
<td>23/03/20</td>
<td>0.89</td>
<td>410</td>
</tr>
<tr>
<td>15/04/20</td>
<td>0.88</td>
<td>420</td>
</tr>
<tr>
<td>20/04/20</td>
<td>0.91</td>
<td>440</td>
</tr>
</tbody>
</table>

Today's Scores:
- Rep 1: 0.91, 440
- Rep 2: 0.90, 420
- Rep 3: 0.93, 450

Average: 0.91, 440

Today's Feedback: High Level High Level
Both devices were strongly correlated with the “gold standard”:

- **TENDO** (nearly perfect)
  \[ r^2 = 0.985 \]

- **PUSH** (strong)
  \[ r^2 = 0.853 \]
Push vs Tendo (Back Squat)

10-40% Rel. Load

Push ave vel. = 0.96 (±0.2)
Tendo ave vel. = 1.17 (±0.2)
ES = 1.16 (Mod. Effect)
TTest: p < 0.05

40-60% Rel. Load

Push ave vel. = 0.68 (±0.07)
Tendo ave vel. = 0.77 (±0.08)
ES = 1.16 (Mod. Effect)
TTest: p < 0.05

60-80% Rel. Load

Push ave vel. = 0.52 (±0.07)
Tendo ave vel. = 0.52 (±0.12)
ES = 0.05 (Trivial)
TTest: p > 0.05

Mean Concentric Velocity (m/s)

Relative Intensity (%)
Push vs 3D MoCap

Tendo vs 3D MoCap

3D MoCap = 0.720 ± 0.26 m/s
Tendo = 0.75 ± 0.31 m/s
Push = 0.510 ± 0.25 m/s

McGrath, Flanagan, O’Donovan, Kenny & Collins
Under review