Stimulus progression: Physiological

WHAT WE WILL DISCUSS

- On a physiological level, what are the *primary* objective(s) we trying to accomplish when we train? *(What causes a muscle to grow?)*
- What are some important physiological principles that govern our ability to meet these objectives?
- What are the tools at our disposal to accomplish these objectives, and what role do they play?
- On a physiological level, why does the ongoing adaptation progress require an increase in stimulus over time?
- How can training status impact how we manage the training stimulus?
- Why is rate of stimulus progression so important?

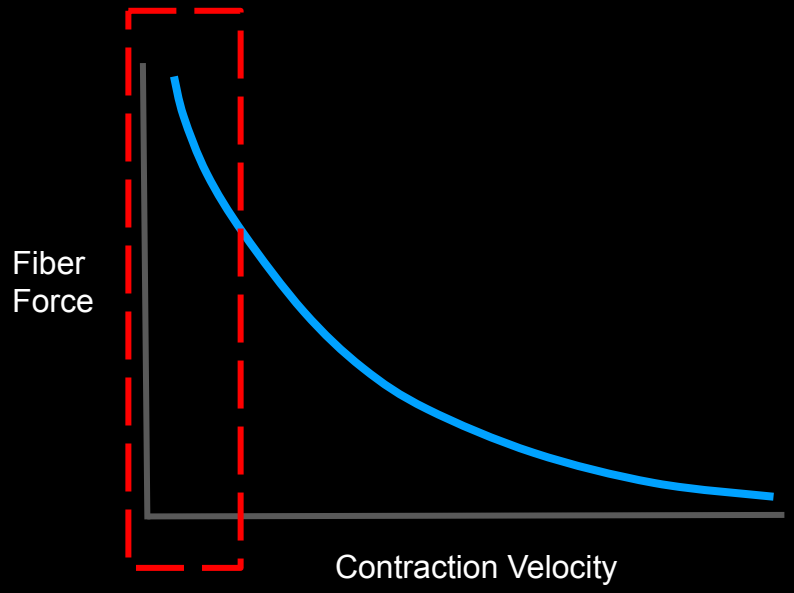
WHAT IS MECHANICAL TENSION?

- Mechanical tension is the *primary* mechanism by which muscle hypertrophy occurs.
  - Mechanosensors at the fiber level detect loading through both stretch and active tension (cross-bridging).
  - Mechanosensors are sensitive to both magnitude and duration of tension.

- Mechanotransduction is the process of mechanical stress (sensed by the mechanosensors) leading to a cascade of intracellular signaling processes, ultimately upregulating muscle protein synthesis (MPS).

HOW DOES MECHANICAL TENSION OCCUR?

- *Active* tension (force generated through cross-bridging) requires the motor unit (MU) to be recruited.
- MU recruitment increases on an as need basis to meet and/or maintain force output based on:
  - the magnitude of load
  - increased fatigue (decreased prox to failure)
  - contraction velocity.
- Higher force demands result in slower contraction velocities and greater degrees of cross-bridging.
  - Adequate load and/or effort ensures that not only are the high(er) threshold MUs recruited, but also accommodate slower contraction velocities.



MECHANICAL TENSION TOOLBOX

Per fiber force/tension (acute)

- Intensity of Load
- Intensity of effort
- Contraction velocity

Duration of exposure

- # reps within a set
  - For *hypertrophy*, sets < 6 reps *may* compromise the per set stimulus compared to sets of ≥ ~6 reps (1).
- # sets
  - *All else equal*, the more sets, the greater overall volume of stimulus
- tempo

Per fiber tension X Duration of exposure = “Volume” of tension stimulus

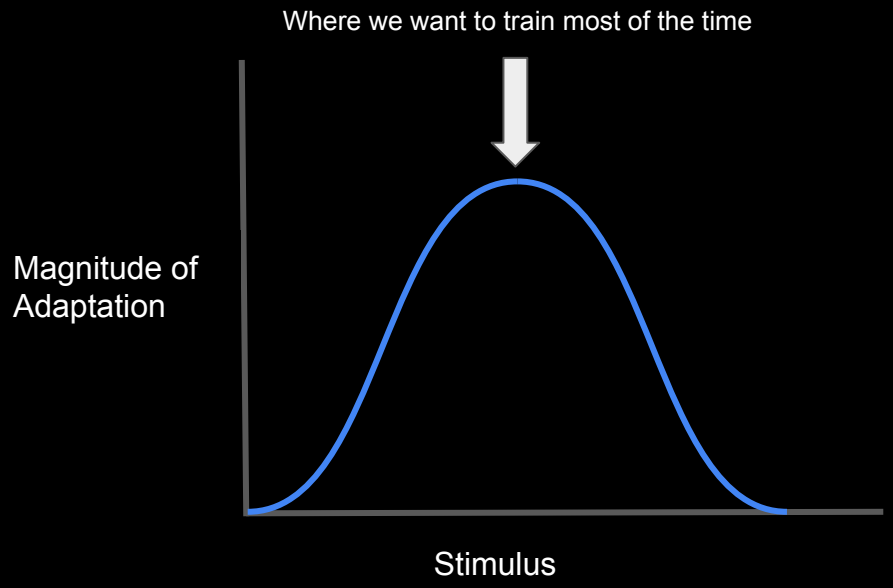
1. Baz-Valle, E., Fontes-Villalba, M., & Santos-Concejero, J. (2018). Total Number of Sets as a Training Volume Quantification Method for Muscle Hypertrophy: A Systematic Review. *Journal of Strength and Conditioning Research*.

WHAT ADAPTATIONS ARE OCCURRING AT THE PHYSIOLOGICAL LEVEL?

- Morphological
  - Muscle fiber hypertrophy = increased capacity for active cross-bridging
  - Connective tissue adaptations
    - Tendon stiffness
    - Lateral force transmission
- Neurological
  - Increased neural drive and muscle activation
  - Increased rate coding
  - Increase in inter and intra muscular coordination
- Metabolic adaptations

- **Every physiological adaptation has its own stimulus threshold**
- **Ultimately, adaptations require an increase in stimulus to keep pace with the increased stimulus threshold (caused by the adaptations)**

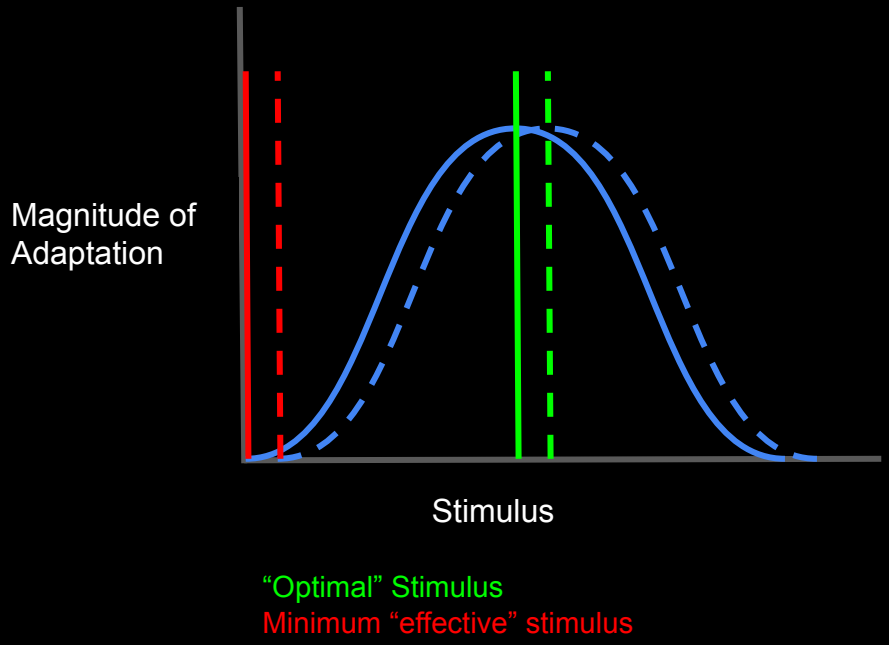
EFFECTIVE DOES NOT ALWAYS MEAN OPTIMAL



- The magnitude of benefit of total volume on both hypertrophy (1) and strength (2) outcomes appears to be inverted U shaped.
- Everything above the x axis would be considered “effective” (i.e., reaching the stimulus threshold for desired adaptation)
  - Different adaptations require “specific” types of stimuli
  - Different adaptations posses different stimulus thresholds
- Simply reaching the stimulus threshold for a specific adaptation *does not* necessarily mean the stimulus is *optimal*.
- Conversely, training below or above the optimal “range” at a given time does not preclude positive adaptations from occurring.

1. Heaselgrave, S. R., Blacker, J., Smeuninx, B., McKendry, J., & Breen, L. (2019). Dose-Response Relationship of Weekly Resistance-Training Volume and Frequency on Muscular Adaptations in Trained Men. *International Journal of Sports Physiology and Performance*, *14*(3), 360–368.
2. González-Badillo, J. J., Gorostiaga, E. M., Arellano, R., & Izquierdo, M. (2005). Moderate resistance training volume produces more favorable strength gains than high or low volumes during a short-term training cycle. *Journal of Strength and Conditioning Research*, *19*(3), 689–697.

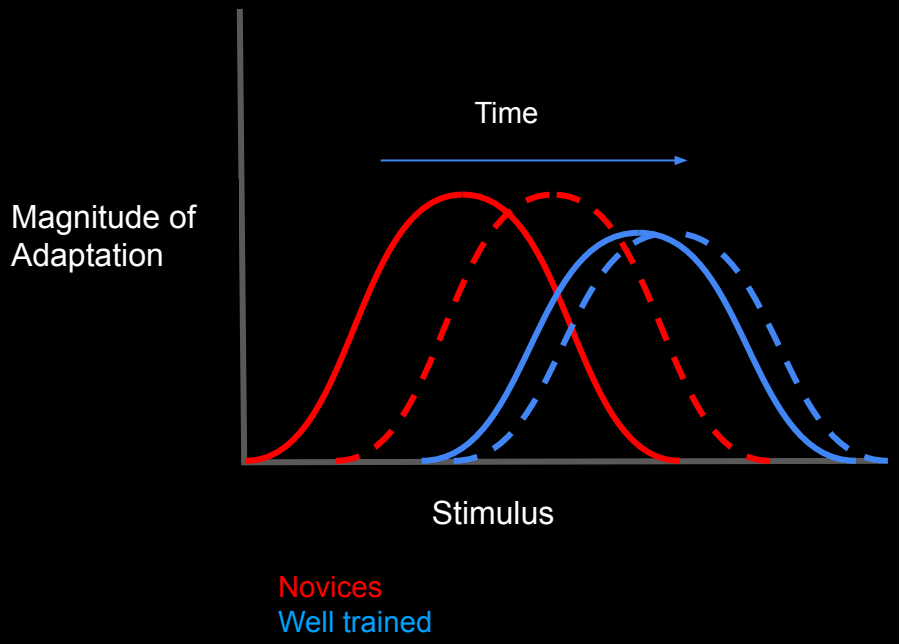
WHAT HAPPENS AS POSITIVE ADAPTATIONS OCCUR?



- As we make progress (acquire positive adaptations), the curve shifts to the right.
  - The threshold for the minimum "effective" stimulus increases, as does the stimulus required for optimal adaptations.

- **To continue to optimize progress, we need the imposed training stress to "keep pace" with our rate of physiological adaptations.**

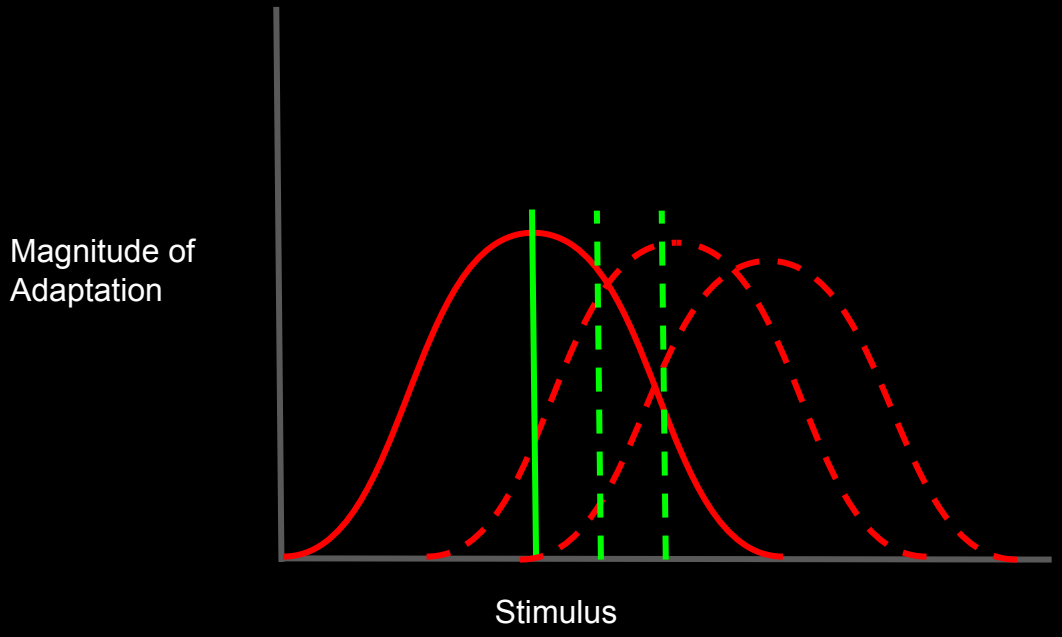
THE EFFECT OF TRAINING STATUS



- **Novices** will experience greater magnitudes and rates of adaptations compared to **well trained individuals**
    - For *a given timeframe*, curve will see a larger rightward shift in novices
- As we become more well trained, we see a lowered ROI.
    - require a larger stimulus for a given magnitude of adaptations / will have a lower absolute return for a given stimulus
- With increased training age, there is a *reduced rate and magnitude* at which we need to increase the stimulus in order to stay above the stimulus threshold/maintain optimal stimulus.
    - Adaptations generally do not hinge on beating the log book every session
    - In what situations may that be the case?

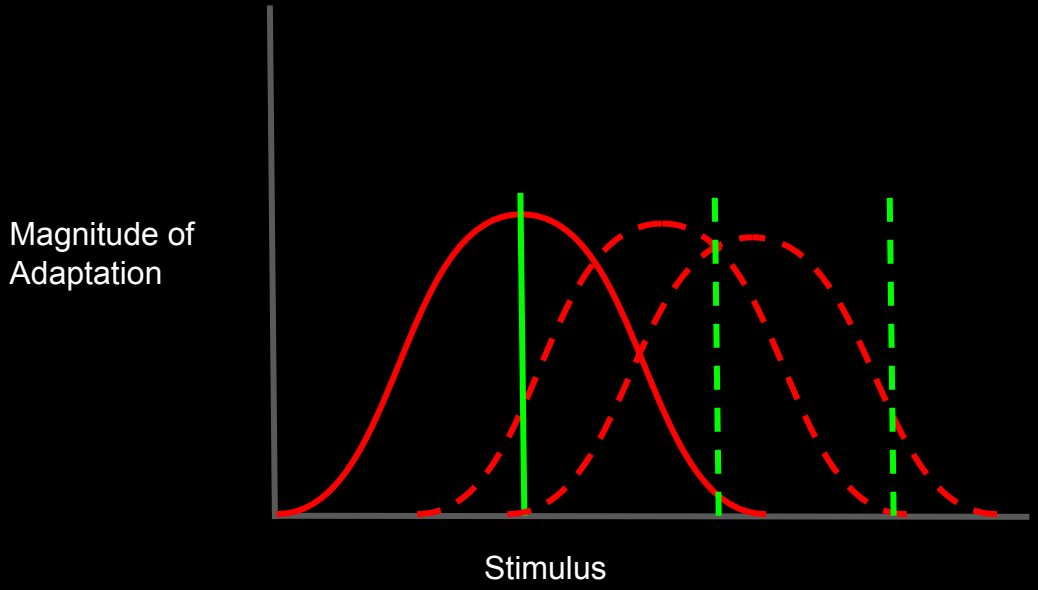
WHY RATE OF PROGRESSION IS IMPORTANT:

What happens if we progress the stimulus sub-optimally?



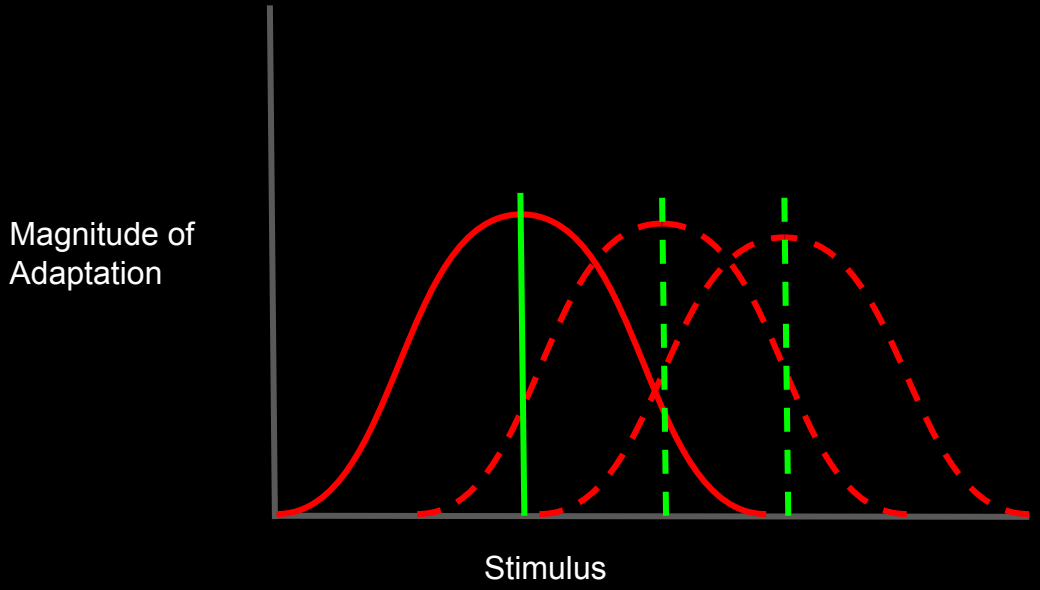
WHY RATE OF PROGRESSION IS IMPORTANT:

What happens if we have an excessive rate/magnitude of progression?



WHY RATE OF PROGRESSION IS IMPORTANT:

What does “optimal” look like on a session to session basis?



PRINCIPLE DIFFERENCES IN PROGRESSION STRATEGIES

WHAT WE WILL DISCUSS

- What is the best proxy for volume of work?
- Understanding the relationship between %1RM, reps, and effort
- How can we best describe the volume of stimulus?
- How do progressions in the training variables impact volume of stimulus?
- What is the stimulus:work ratio and when may it be worth considering?

VOLUME OF WORK/TONNAGE

- Tonnage = Sets x Reps x Load
  - Ex: 3 x 8 @ 150 lbs = 3,600 lbs
  - The smaller the variable that is increased (in relation to others), the larger the relative increase on tonnage.

Increase in # sets	Increase in # reps	Increase in load
4 x 8 @ 150 = 4,800 lbs	3 x **9** @ 150 = 4,050 lbs	3 x 8 @ **155** = 3,720

RELATIONSHIP BETWEEN % 1 RM, REPS, AND EFFORT

Percentages below are rough averages. There is a lot of individual variability here.

	REPS															
RPE	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	RIR
10	59.90%	62.60%	65.30%	68.00%	70.70%	73.90%	76.20%	78.60%	81.10%	83.70%	86.30%	89.20%	92.20%	95.50%	100.00%	0
9.5	58.60%	61.30%	64.00%	66.70%	69.40%	72.30%	75.10%	77.40%	79.90%	82.40%	85.00%	87.80%	90.70%	93.90%	97.00%	0.5
9	57.20%	59.90%	62.60%	65.30%	68.00%	70.70%	73.90%	76.20%	78.60%	81.10%	83.70%	86.30%	89.20%	92.20%	95.50%	1
8.5	55.80%	58.60%	61.30%	64.00%	66.70%	69.40%	72.30%	75.10%	77.40%	79.90%	82.40%	85.00%	87.80%	90.70%	93.90%	1.5
8	54.40%	57.20%	59.90%	62.60%	65.30%	68.00%	70.70%	73.90%	76.20%	78.60%	81.10%	83.70%	86.30%	89.20%	92.20%	2
7.5	53.00%	55.80%	58.60%	61.30%	64.00%	66.70%	69.40%	72.30%	75.10%	77.40%	79.90%	82.40%	85.00%	87.80%	90.70%	2.5
7	51.60%	54.40%	57.20%	59.90%	62.60%	65.30%	68.00%	70.70%	73.90%	76.20%	78.60%	81.10%	83.70%	86.30%	89.20%	3
6.5	50.20%	53.00%	55.80%	58.60%	61.30%	64.00%	66.70%	69.40%	72.30%	75.10%	77.40%	79.90%	82.40%	85.00%	87.80%	3.5
6	48.80%	51.60%	54.40%	57.20%	59.90%	62.60%	65.30%	68.00%	70.70%	73.90%	76.20%	78.60%	81.10%	83.70%	86.30%	4
5.5	47.10%	50.20%	53.00%	55.80%	58.60%	61.30%	64.00%	66.70%	69.40%	72.30%	75.10%	77.40%	79.90%	82.40%	85.00%	4.5
5	46.00%	48.80%	51.60%	54.40%	57.20%	59.90%	62.60%	65.30%	68.00%	70.70%	73.90%	76.20%	78.60%	81.10%	83.70%	5

*Charts adapted from ReactiveTrainingSystems.com

VOLUME OF STIMULUS (VOS)

- VOS refers to the work that is contributing to subsequent adaptations.

- The relationship between volume of work and stimulus is dependent on exercise and the goal at hand.

- Hypertrophy appears to require adequate volume of tension (“impulse”) on a fiber level
  - Hypertrophy is impacted by load and effort/proximity to failure more than volume of work alone.

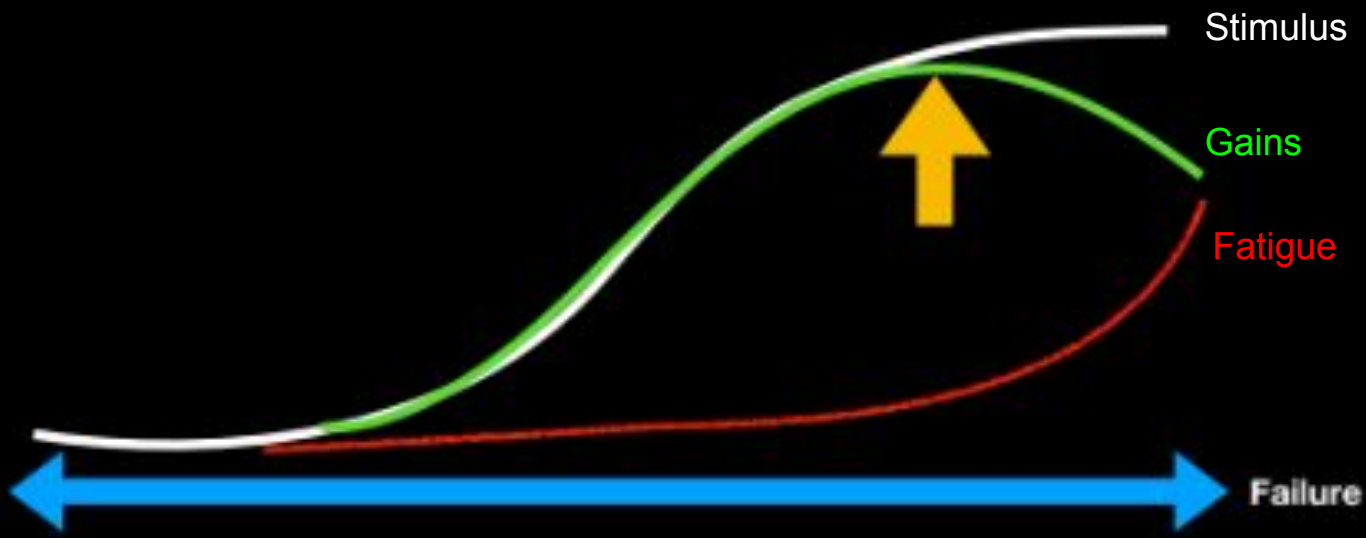
- How can we estimate volume of stimulus?
  - “Hard” sets
  - “Effective/High Stimulus” reps
    - Disclaimer: There isn’t enough evidence to support a rigid RIR cutoff for what’s deemed “effective”. *For sake of illustration alone, let’s use the idea of reps within ≤ 5 RIR.*

Effective Reps or “more effective” reps?

- What needs to occur for a rep to contribute to muscle growth?

- “Impulse” model
  - When lifting with max intent, MU recruitment will still be relatively high, and HTMUs will still contribute to total force output.
  - Therefore, perhaps even reps early on will contribute to hypertrophy via stimulus “AUC”, *but with an exponentially greater contribution as set goes on and contraction velocity slows.*
  - Where is the tipping point for that exponential increase in effect?
  - Fatigue also increases exponentially as we approach 0 RIR

Effective Reps or “more effective” reps?



VOS: IMPACTS OF INCREASING SPECIFIC VARIABLES

Week 1: 3 x 8 @ ~2 RIR (~150 lbs), e1RM of ~205 lbs

- Scenario 1: Minimal to no adaptations have occurred before next session:

Increase in # sets	Increase in # reps	Increase in load
4 x 8 @ ~2 RIR (150 lbs) ~12 “effective reps” *Tonnage: 4800 lbs*	3 x **9** @ ~1 RIR (150 lbs) ~12 “effective reps” *Tonnage: 4,050 lbs*	3 x 8 @ ~1 RIR **(155 lbs)** ~12 “effective reps” *Tonnage: 3,720 lbs*

- Scenario 2: Let’s say e1RM has increased to ~210 lbs before next session:

Increase in # sets	Increase in # reps	Increase in load
4 x 8 @ ~2-3 RIR (150 lbs) ~8-9 “effective reps” *Tonnage: 4800 lbs*	3 x **9** @ ~2 RIR (150 lbs) ~9 “effective reps” *Tonnage: 4,050 lbs*	3 x 8 @ ~2 RIR **(155 lbs)** ~9 “effective reps” *Tonnage: 3,720 lbs*

Main takeaway: The same relationship between variable adjustment for VOW often does not directly apply to VOS.

SHOULD WE ALWAYS AIM TO MAXIMIZE THE STIMULUS:WORK RATIO?

- Stimulus: Work is similar in concept to ROI, but in a practical sense one's investment extends beyond simply the volume of work.
  - Investment needs to consider the goal, residual effects/consequences, and the practicality of a protocol for a given exercise
  - Higher tonnage/VOW does not necessarily mean a greater recovery debt on the physiological level.
    - *In and of itself*, volume of work does not account for proximity to failure

Goal: Hypertrophy	Lateral Raises	Back Squats
Option 1	3 x 6 @ 1 RIR/~81%= 1,458	**3 x 6 @ 3 RIR/~76% = 1,368**
Option 2	**3 x 12 @ 1 RIR/~65%= 2,340**	3 x 15 @ 3 RIR/~52% = 2,340