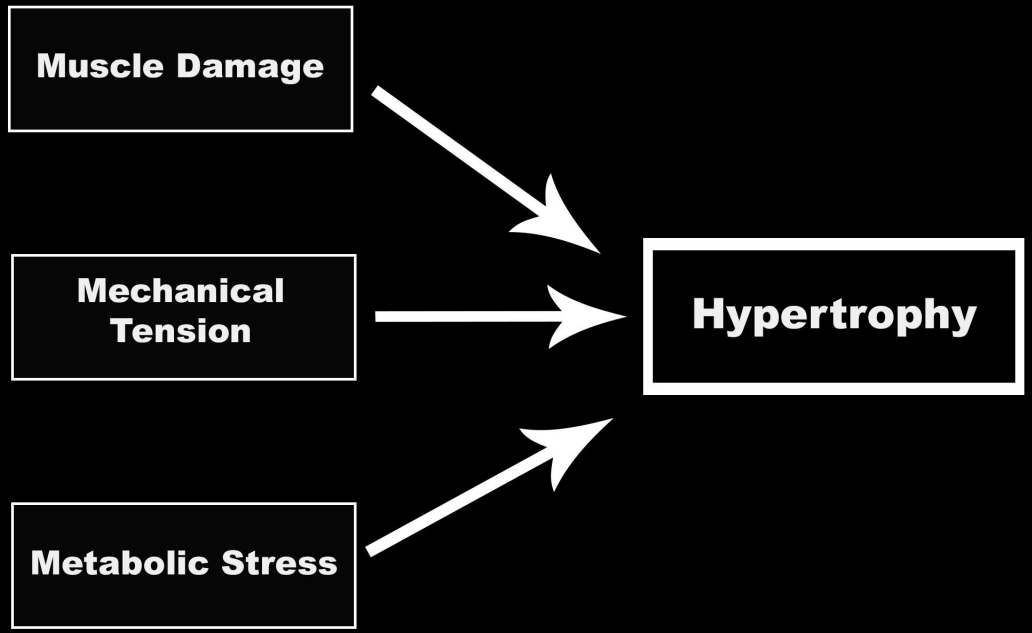
Using NIRS To Optimize & Individualize Hypertrophy Training

By Evan peikon

"All models are wrong, but some are useful."

-George E.P. Box

The Mechanisms of Muscle Hypertrophy

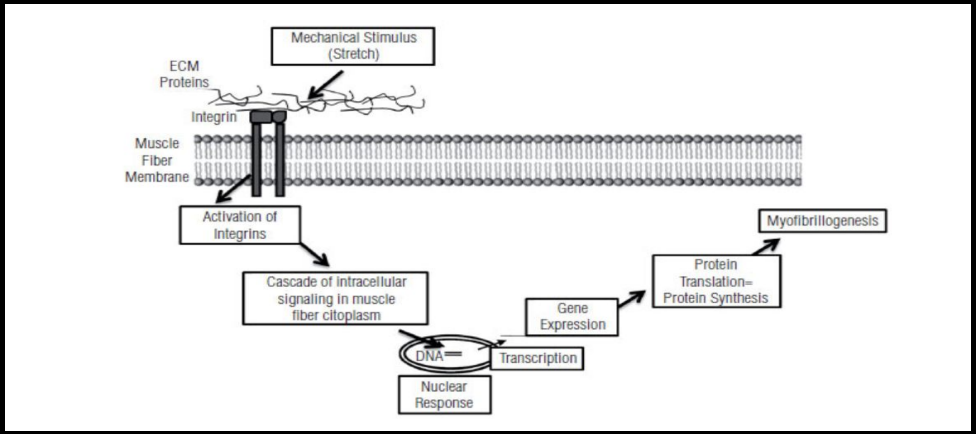


PMID: 20847704

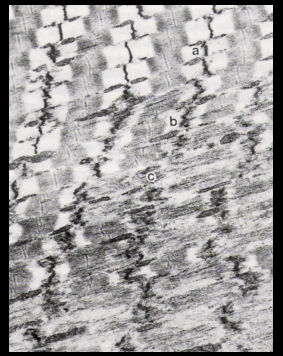
Mechanical Tension

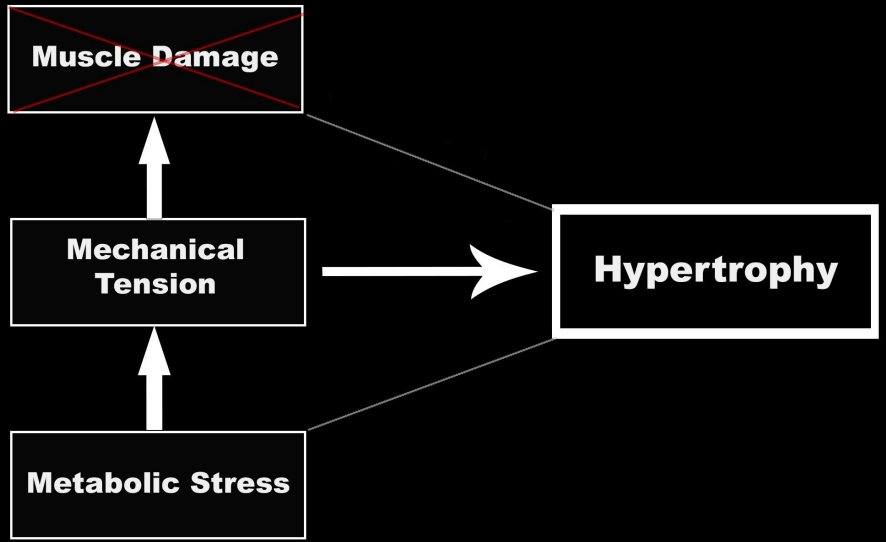
“It is believed that tension associated with resistance training disturbs the integrity of skeletal muscle, causing mechano-chemically transduced molecular and cellular responses in myofibers and satellite cells (182). Upstream signaling is thought to occur through a cascade of events that involve growth factors, cytokines, stretch-activated channels, and focal adhesion complexes (23,48,162). Evidence suggests that the downstream process is regulated via the AKT/mTOR pathway, either through direct interaction or by modulating production of phosphatidic acid” -Brad Schoenfeld

"The importance of mechanical tension in promoting muscle growth is indisputable" -Brad Schoenfeld



Muscle Damage & Metabolic Stress





Muscle Damage:

-Correlation doesn't imply causation

-*The development of skeletal muscle hypertrophy through resistance training: the role of muscle damage and muscle protein* synthesis

Metabolic Stress:

-Accumulation of metabolic by-products in the muscle: lactate, phosphate, H+, and hypoxia

-MS appears to only be anabolic in the presence of mechanical tension (back door path)

PMID: 29282529
PMID: 28630575
PMID: 25491331
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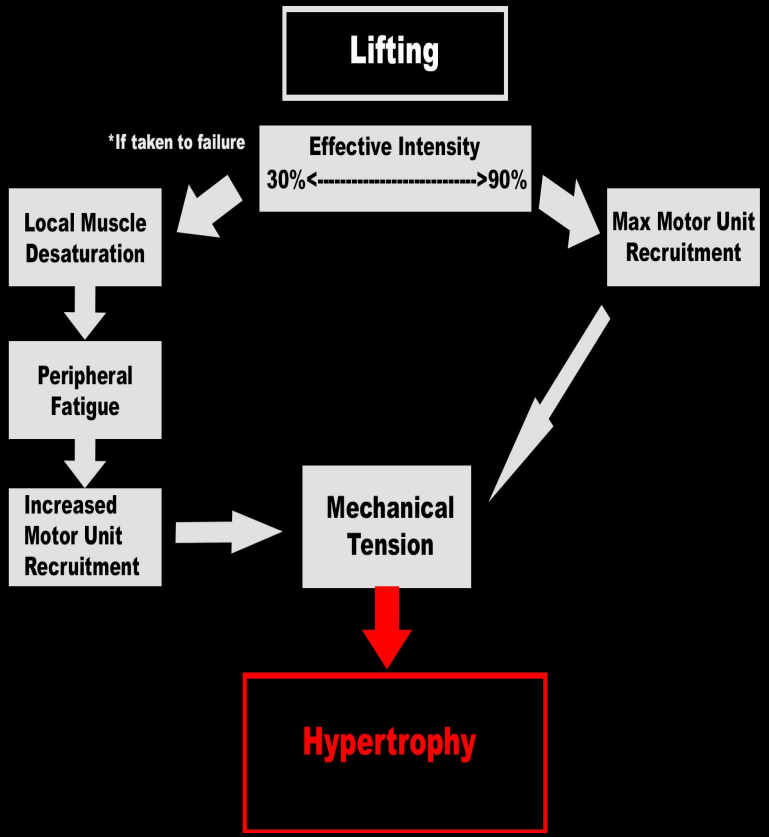
PMID: 30694972

Balancing Mechanisms of Muscle Growth



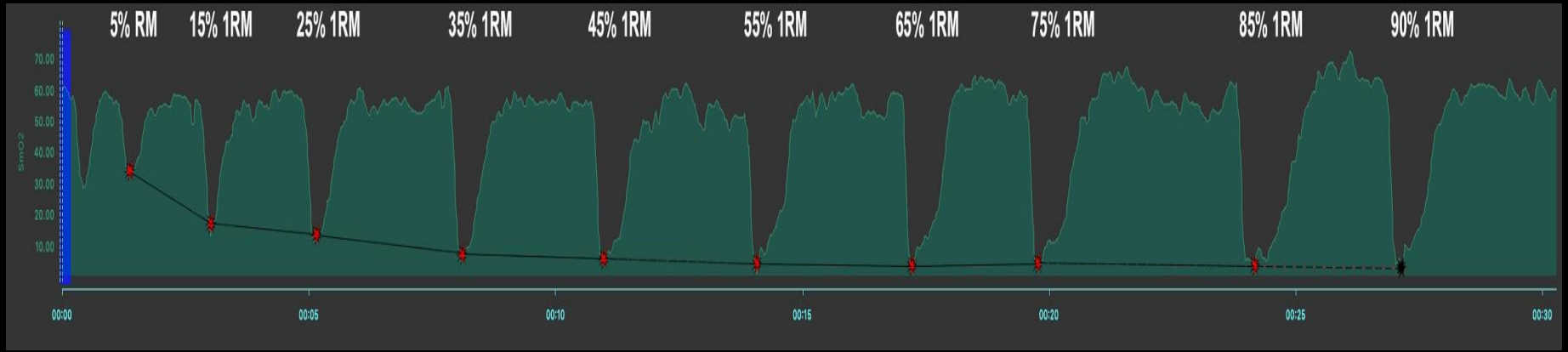
When force output is maintained during exercise, muscle activation and perception of effort rapidly increase as blood flow is impaired, resulting in decreased SmO2.When blood flow and SmO2 return to pre-compromised levels muscle activation and perception of effort are reduced.This suggests that an oxygen-conforming response exists and is able to modify perception of effort and muscle fiber force production

“TOI decreased for all loads and phases but less for the 20 % than 60 and 80 % loads, and for LEN compared with SHO phase. At failure, TOI was negatively associated with aEMG during the SHO and LEN phases, while TOI and aEMG were positively associated with load magnitude in both movement phases. This study emphasizes the influence of load magnitude and movement phase on neuromuscular and oxidative adjustments during movements that involve lifting and lowering a load until failure. “
-Baudry et al.

PMID: 31070953
PMID: 17962573
PMID: 18162480
PMID: 23471683

Balancing Mechanisms of Muscle Growth (cont.)

“the involvement of an oxygen-conforming response, referring to the rapid adjustment of force production at a given motor neuron activation to match changes in muscle oxygenation. In the case of reduced oxygenation during contractions, force production “conforms” to a reduced aerobic ATP supply capacity at a given phosphorylation and redox potential. Importantly, the “oxygen-conforming” response is rapidly abolished upon restoration of muscle blood flow, unlike peripheral muscle fatigue. The implication of the oxygen-conformer response for exercise where force production must be maintained is that integrated electromyography (iEMG) must increase when muscle oxygenation is reduced.”
-Patrick J. Drouin and Michael E. Tschakovsky



Training for Muscle Hypertrophy

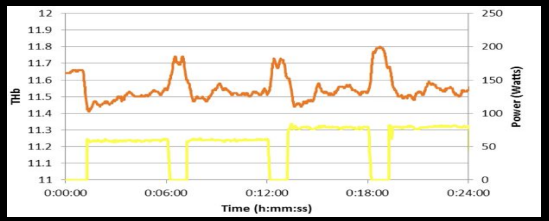
If you accept that mechanical tension and metabolic stress are the two main drivers of muscle hypertrophy, any choice of training intensity represents a tradeoff between those two mechanisms. The heavier you go, the more tension you develop, but the less local muscular fatigue and subsequently metabolic stress you develop before the point of fatigue and vice versa. However, it seems that there needs to be some balance of both mechanisms to maximize growth.

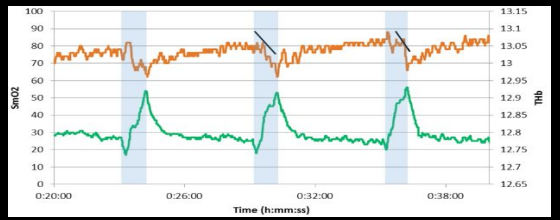
- Intensity: how heavy is heavy enough and where's the limit?
- Volume: how is it tracked and what is it's roll ?
- Frequency: how it is derived from volume?

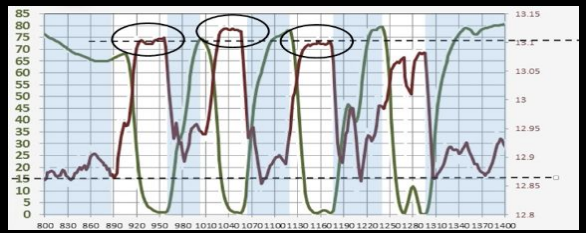
PMID: 25853914
PMID: 28611677
PMID: 26159316

Using NIRS to Determine Intra-Individual Intensity Cut Offs

- **Effects of different intensities of resistance training with equated volume load on muscle strength and hypertrophy (**Lasevicius et al.)
- Blood flow & tHB reactions

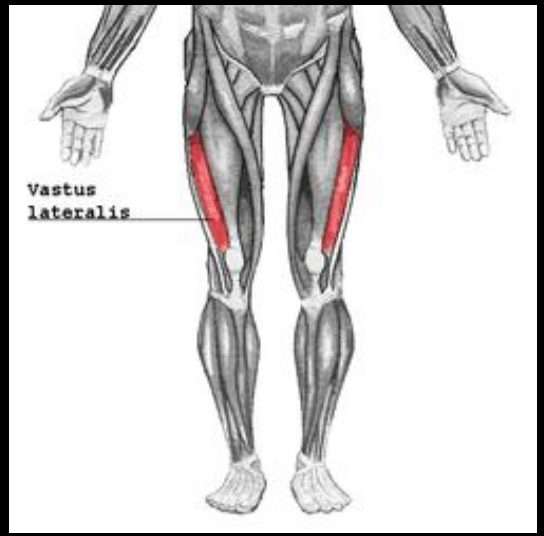


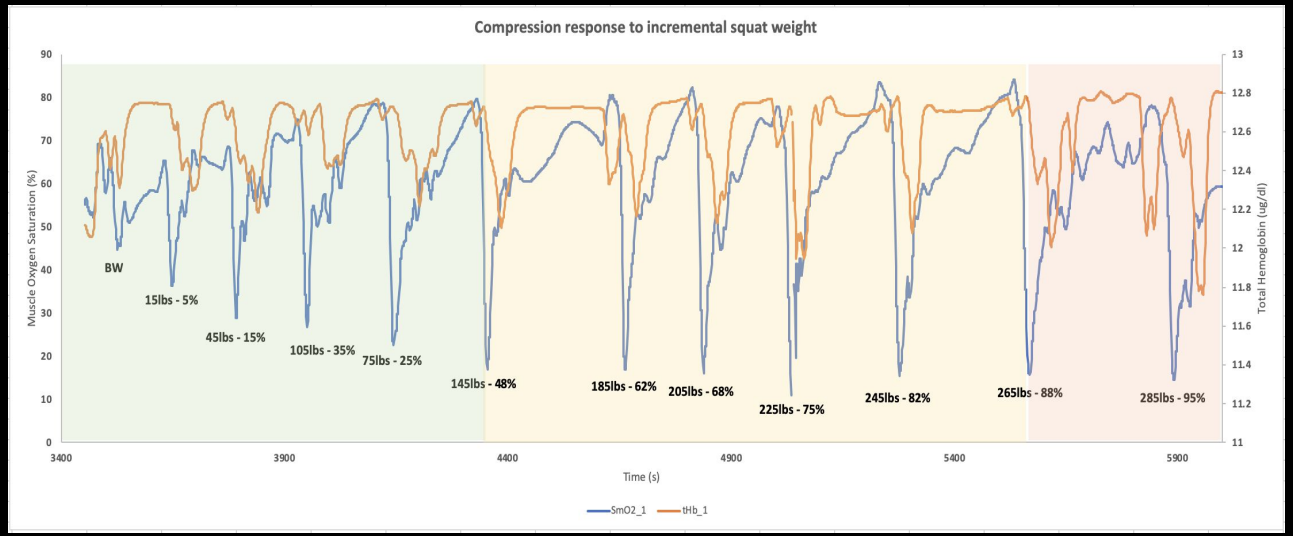




Using NIRs to Determine Intra-Individual Intensity Cut Offs

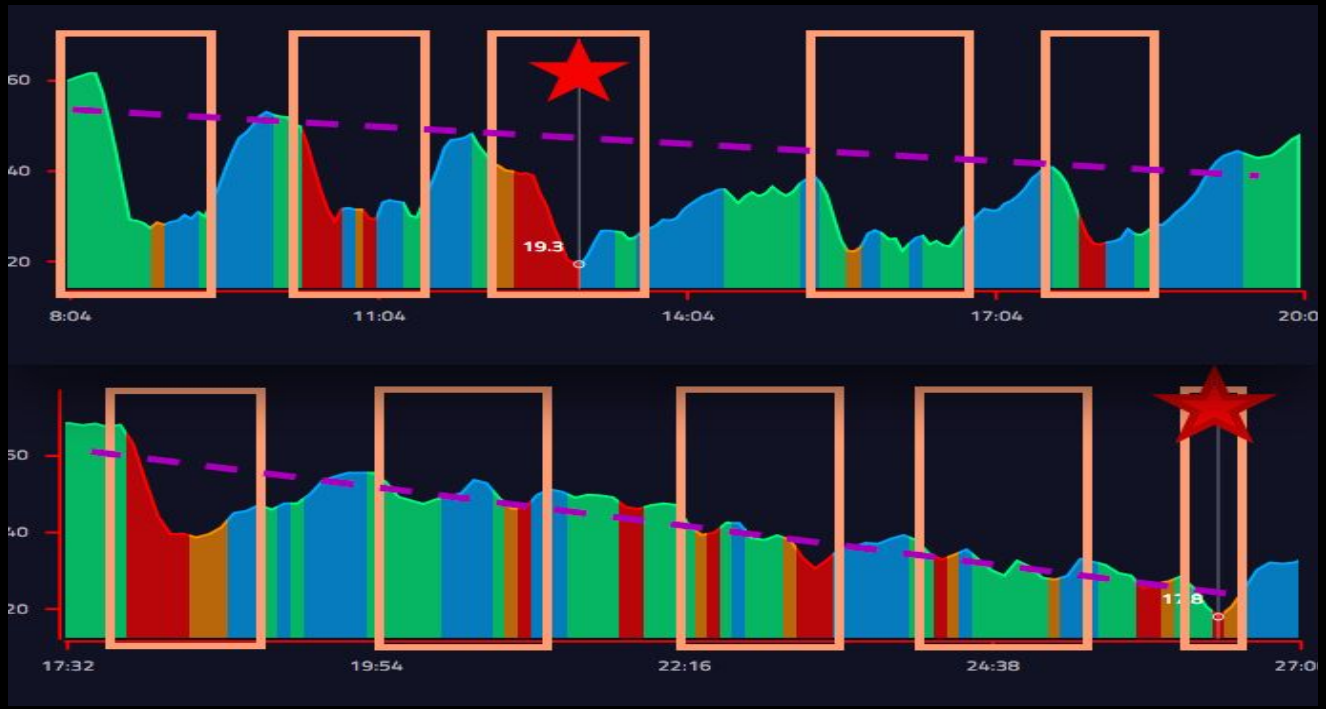
- *Muscle Specific Hypertrophy:*



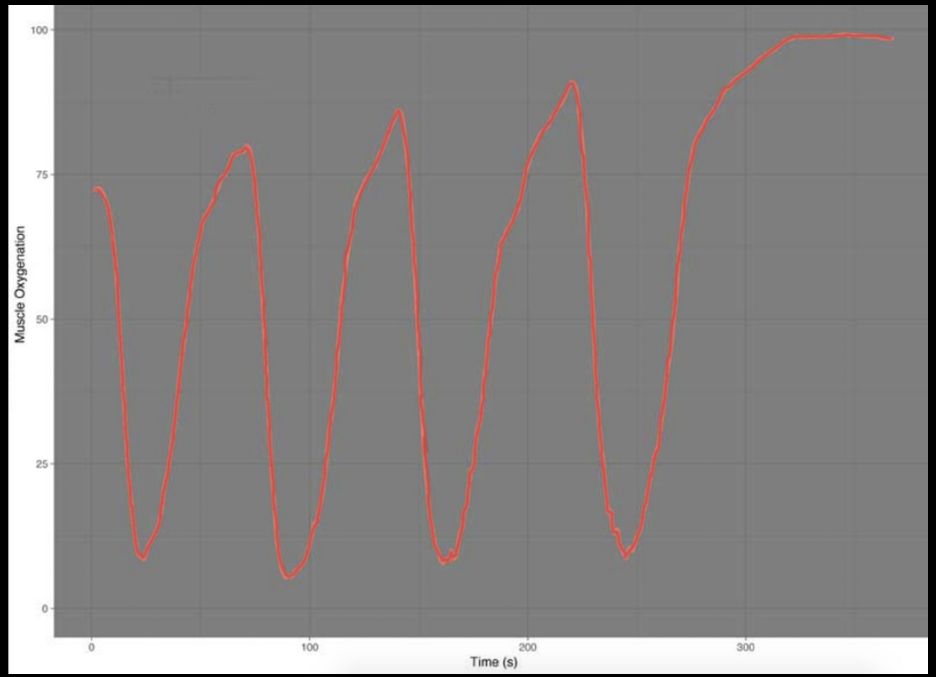


Assessment - Occlusion Response to Strength Training:
http://my.moxymonitor.com/blog/assessment-occlusion-response-to-strength-training

Same workout, but different reactions



Using NIRs to Determine Maximum Productive Training Volume



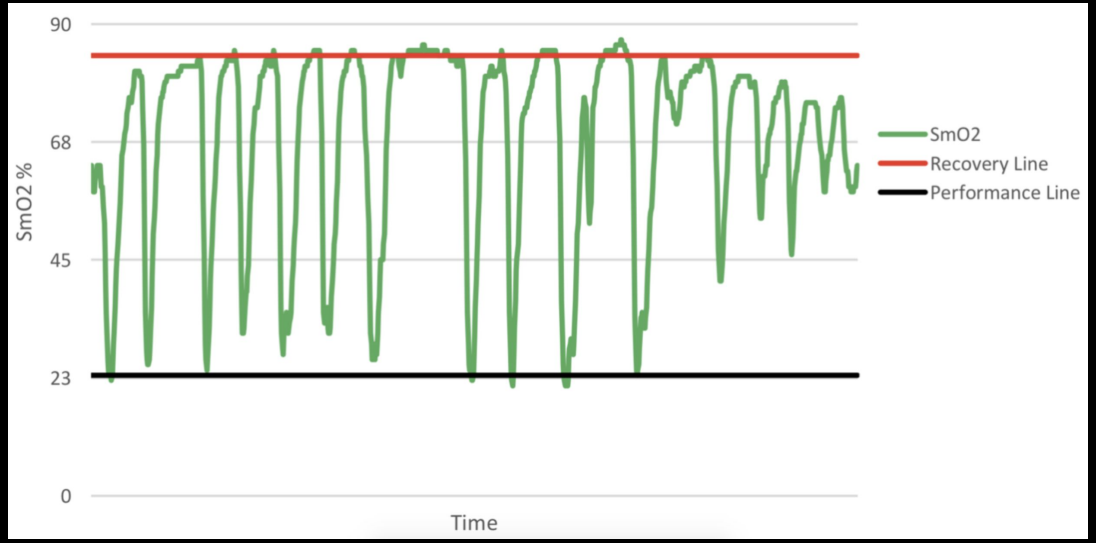
An athlete's response to a "10 reps x4 sets" of back squatting at a moderately challenging intensity. In each set you can see a rapid drop in muscle oxygen saturation down to ~10% SmO2. This indicates increased motor unit recruitment across the set as the athlete approaches failure. Note that they were able to desaturate to the same low point on each set, as well as recover oxygen to baseline during rest.

Based on a recent meta-analysis it appears the most productive sets you can do in a session for a given body part range from 8–14 sets on average.

- Why would 8 sets be the low end maximum productive volume per session on average and 14 the top end cut off?
- Is this a moving target that can be skewed upwards or downwards based on individual factors?
- Is there a practical way to know what the optimal volume is on a given day ?

Using NIRS to Determine Maximum Productive Training Volume (cont.)

My speculation is that the point at which we can no longer utilize oxygen in the tissue is the same point at which the repeated bout effect is occurring and we at a point where additional training volume is no longer effective. As a result, monitoring muscle oxygen saturation in live time may be a viable way of figuring out our maximum productive volume on any given day, which can an add unprecedented layer of precision trying to hit the moving target of ‘optimal’ training volume.



What about rest periods ?

- Impact of rest on ‘productive’ volume
- Efficiency vs. efficacy

Sample Protocols for Auto-regulating volume

Single Variable:

- Fixed: total number of reps in a set, load, and rest
- A-Reg: total # of work sets
- ex) Back Squat; 8 reps @10RM (2 RIR), rest 3 minutes x repeat until you cannot desaturate to the same extent as previous sets, or you cannot reach the same recovery baseline

Multi-Variable:

- Fixed: load
- A-Reg: reps in a set, total number of sets, and rest
- ex) Leg Press @315# - drop O2 down to lowest load possible w/o a plateau, then recover back to baseline.
  *If you cannot drop O2 down to lowest level or recover back to baseline w/i 10% margin of set #1 then stop the workout

Using NIRs to assist with exercise selection

- Muscle recruitment and mechanical tension
- Desaturation of target muscle (gross changes and rate).
- Intramuscular coordination versus technical issues

References

Baudry, S., Sarrazin, S. & Duchateau, (2013). Effects of load magnitude on muscular activity and tissue oxygenation during repeated elbow flexions until failure. J. Eur J Appl Physiology 113: 1895.

Cipryan L, Tschakert G, Hofmann P. Acute and post-exercise physiological responses to high-intensity interval training in endurance and sprint athletes. J Sports Sci Med. (2017) 16:219–2

Damas F, Libardi CA, Ugrinowitsch C. The development of skeletal muscle hypertrophy through resistance training: the role of muscle damage and muscle protein synthesis. European Journal of Applied Physiology. 2018;118:485–500.

D. G. Allen, G. D. Lamb, and H. (2008). Fatigue-independent alterations in muscle activation and effort perception during forearm exercise: role of local oxygen delivery. Westerblad Journal of Applied Physiology

Drouin P.J., Tschakovs M.E. (2019). The oxygen-conformer response and its contribution to task failure in exhaustive exercise Journal of Applied Physiology 2019 126:3, 796-796

Henselmans, M. “Is there a maximum productive training volume per session.” Retrieved from *https://mennohenselmans.com/maximum-productive-training-volume-per-session/*

Jenkins, Nathaniel & Housh, Terry & Cochrane, Kristen & Bergstrom, Haley & Hill, Ethan & Smith, Cory & Buckner, Samuel & Cramer, Joel & Schmidt, Richard & Johnson, Glen. (2015). Neuromuscular adaptations after 2- and 4-weeks of 80% versus 30% 1RM resistance training to failure. The Journal of Strength and Conditioning Research. In Press. 10.1519/JSC.0000000000001308.

Kamga, C., Krishnamurthy, S., & Shiva, S. (2012). Myoglobin and mitochondria: a relationship bound by oxygen and nitric oxide. Nitric oxide : biology and chemistry*,* 26*(4), 251–258. doi:10.1016/j.niox.2012.03.005*

References

Lasevicius T, Ugrinowitsch C, Schoenfeld BJ, Roschel H, Tavares LD, De Souza EO, Tricoli V. Effects of different intensities of resistance training with equated volume load on muscle strength and hypertrophy. Eur J Sport Sci. 2018;18(6):772–780.

Nyakyiruj., Cas J. Fuchs., Trommelen j., (2019). Blood Flow Restriction Only Increases Myofibrillar Protein Synthesis with Exercise. J Sports Sci Med.

P. J. Drouin, Z. I. N. Kohoko, O. K. Mew, M. J. T. Lynn, A. M. Fenuta, and M. E. Tschakovsky. (2019). Fatigue-independent alterations in muscle activation and effort perception during forearm exercise: role of local oxygen delivery Journal of Applied Physiology

Schoenfeld B. J. The mechanisms of muscle hypertrophy and their application to resistance training. Journal of Strength and Conditioning Research. 2010;24(10):2857–2872.

Schoenfeld, B.J., Peterson, M.D., Ogborn, D.I., Contreras, B., & Sonmez, G.T. (2015). Effects of Low- vs. High-Load Resistance Training on Muscle Strength and Hypertrophy in Well-Trained Men. Journal of strength and conditioning research, 29 10, 2954–63 .

Schoenfeld B. J., Pope Z. K., Benik F. M., Hester G. M., Sellers J., Nooner J. L., et al. . (2016). Longer interset rest periods enhance muscle strength and hypertrophy in resistance-trained men. J. Strength Cond. Res. 30, 1805–1812. 10.1519/JSC.0000000000001272

Robert H. Fitts. (2008). The cross-bridge cycle and skeletal muscle fatigue Journal of Applied Physiology 104:2, 551-558

Yasuda, Tomohiro & Fukumura, Kazuya & Iida, Haruko & Nakajima, Toshiaki. (2014). Effect of low-load resistance exercise with and without blood flow restriction to volitional fatigue on muscle swelling. European journal of applied physiology. 115. 10.1007/s00421-014-3073-9.