

Energetics

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Introduction

There are several paths that lead to upregulated protein synthesis in resistance training. It would be naive to focus completely on any one, or to neglect the aspects of any one of the various signaling factors. Many times, a means is thought of as the actual stimulation. Or more simply, a method of applying a stimulation is deemed as an actual path of stimulation. An important marker for the hypertrophic stimulus, lies in the energetic cost of the set, usually in reference to the time span per amount of energy consumed. This is the energetic theory.

Definition

The energetic theory is one in which the energetic cost of the contractions, or sum of contractions, is used as a measurement tool for the upregulation of protein synthesis.(14) Many debate this, usually from a lack of understanding. An opposing point might be, that running or aerobics burn ample energy but are not a good stimulus for hypertrophy. This is true, but is wrongly applied to this theory. The energetic cost is more related to the time factor.(5,9,14,21) ie ATP turnover per time period. A muscle fiber uses ATP to break the contraction bonds, and burns it in proportion to the actual tension on the fiber. (5) This rate is determined by the neurological input frequency and the load on the muscle. Exercise which is of low intensity, calls for slower contractions of the motor unit pools. Thus, total energy for the exercise session might be high, but the rate at which ATP is turned over, is low.

The science of the energetic theory is based upon the action of mTOR (mammalian target of rapamycin). mTOR is a regulator of protein synthesis in a muscle cell, simply, it monitors and adjusts protein metabolism (synthesis/degradation) in response to energy requirements. mTOR is very sensitive to amino acids and insulin. How the process appears to work, is AMP-activated protein kinase (AMPK) blunts mTOR during contraction. By mTOR slowing protein synthesis, more ATP is available for use during the contractions. When contractions cease, mTOR rebounds to a higher level, increasing protein synthesis to a greater than resting levels. The presences of amino acids at this time also seem to be required. It's possible that a high ATP turnover, such as found during heavy or high intensity contractions, blunts mTOR to a maximum or close to maximum level, causing the highest level of rebound afterwards. The rebound level may or may not be proportional, or somehow related to the rate of ATP turnover and/or the time it is blunted. (5,14)

Explanations

The reason aerobics or endurance activities do not cause this effect, is due to the lower levels of tension. High rates of ATP turnover require high frequency contractions (rate coding)and high tensions.(9) The way in which the CNS manipulates activity is by the level of required effort. Recruitment and rate coding increase until recruitment is full, then rate coding will continue to increase until maximized. Depending in the muscle or muscle group in question, full recruitment will occur anywhere from approximately 40% (for smaller muscles such as those of the hand) to possibly 95% (upper thigh musculature) of maximum momentary MVC. Other muscles of the torso usually

fall somewhere inbetween, such as biceps at approx. 70-80% of momentary maximum MVC. (16,17,18,22)

Note: The reason "momentary" maximum MVC is stressed, is to emphasize that the resistance does not have to be that particular percentage of fresh maximum force (percent of 1RM), but that anytime that level of effort is required, recruitment follows these patterns. For example, if your biceps reach full recruitment at 80% of 1RM, and your 1RM is 100lbs, a single rep with 80 pounds will induce full recruitment, as will the last several reps of a set with your 10RM, where fatigue has limited your strength. Anytime your CNS is putting out a "greater than the minimum" level of effort for full recruitment, rate coding is employed afterwards for further force requirements.

Assurance

How do we know that energetics are even a viable marker? First, studies using occlusion have found rapid increases in size and strength, with very low resistance.(6,7) The fatigue induced from the lack of blood flow, causes the muscles to reach full recruitment and high levels of rate coding with very low whole muscle tension. Damage, or micro-trauma is low to non-existent but marked hypertrophy is still evident. Further, what was once thought to be damage from high intensity contractions, is now seen to be more of the remodeling process anyway.(13) The smeared Z lines found in disrupted muscle cells, are much more evident several days after exercise. If damage from the contractions were causing this, they would be seen immediately. Since their prominence is greater days afterwards, it shows the process of recovery has caused this rather than the acute effects of exercise. Why is this important? This effect (smeared Z lines) is sometimes, but not always, in accordance with DOMS. One of the best explanations of DOMS, describes the effects stemming from high intra-cellular calcium concentrations initiating the process, and the time course of the immune system following the time course of the soreness.(15) High peak tension, eccentrics, and many other aspects of training, including high frequency contractions, can increase intra-cellular calcium concentrations through various means.(3) We've all experienced increased levels of DOMS with higher levels of intensity and/or the volume of exercise. Obviously, both of these applications (intensity and volume) are increasing the stimulation of the remodeling process.

A final point is concerning a measurement variable, termed TTI (Tension Time Integral), where the average true tension is computed, (4,5) and is directly proportional to the energetic cost of a contraction. Even tension signaling factors, such as P70sk (70-kDa ribosomal S6 kinase, an important marker for hypertrophy) (9,10) can be tracked by calculating the TTI of the contractions. One can then extrapolate, that ATP turnover (the energetic cost/time) is proportional to the stimulation induced by resistance based contractions. (5,6,7,8,21)

Means To an End

What you're seeking, is protein upregulation. Your means is through an application of external resistance that will induce full recruitment and higher levels of rate coding. These factors have been shown to induce a hypertrophic effect. Whether synthesis levels increase beyond degradation levels depends mostly on genetics, recovery factors and proper nutrient timing.

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