OVERLOOKED TRAINING VARIABLES

PART I:

THE SCIENCE OF TEMPO AND TIME UNDER TENSION

By

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TEMPO: ***[***tĕm'pō] relative rapidity or rate of movement; the rate of some repeating.

TENSION: ***[ten-shuh n]*** the act of stretching or straining; the longitudinal deformation of an elastic body that results in its elongation; a force tending to stretch or elongate something.

The next time you are in the gym for a resistance training workout, choose a weight that is approximately 80% of your one rep max in either the bench press or squat. This weight should represent your 10-12 rep max (this may vary as it is dependent on your training age, status, fast twitch/slow twitch fiber distribution, and if you are an anaerobic vs. aerobically trained athlete). After a proper warm-up, perform at set of 10 at your regular repetition tempo (ie: down slow/ up fast, down slow/up slow, or down fast/up fast). Record how you felt during this set, and how much effort it took to achieve the ten repetitions. Next, after a 120 to 180

second rest, perform a set of 10 (with the same weight) with a predetermined tempo of 4 seconds down, and 2 seconds up for each repetition. Make sure to have a spotter usd a stop watch to count for you, as we don't want any cheating. Record how this set felt, and compare it to the first set. This is the science of tempo and time under tension.

The human body is made of different types of muscle fibers. The three general classifications are: (Schantz et al 1983, Tunnemann and Hartmann 2001, Siff 2003)

1. Type I (slow twitch, endurance based)
2. Type IIA (fast twitch, greater endurance but less force produced than IIB)
3. Type IIB (highest threshold fast twitch, less endurance but greater force produced than IIA)).

A complete overview, classification, and analysis of muscle fibers is beyond the scope of this article, a review of any of the following books is recommended: Physiology of Sport and Exercise (Costill/Wilmore), High Threshold Training (Thibedeau), Fitness and Strength Training for All Sports (Hartmann/Tunneman), Poliquin Principles (Poliquin), or Designing Resistance Training Programs (Fleck/Kraemer).

The type, intensity, and duration of training modality influence the recrution of different muscle fibers by the Central Nervous System (Siff 2003, Anderson and Aagaard 2000, Simoneau et al 1985, Campos et al 2002). During long slow distance cardio exercise, there may be a greater recruitment of slow twitch muscle fibers, while during a 3 rep max set of the deadlift there may be a greater recruitment of high threshold fast twitch fibers (Campos et al 2002, Jackson et al 1990). The amount and distribution of slow twitch vs. fast twitch fibers in the body is genetically pre-determined, but different fibers may take on the characteristics of their counterparts (Paddon et al 2001, Simoneau et al 1985, Jackson et al 1990, Staron et al 1990,

Hikida et al 2000). A complete understanding of this concept and the demands of sport should be required before partaking in any strength and conditioning program. After all, if running long distances makes up the majority of training for a shot-putter, the athlete may want to revisit their strength and conditioning protocols or contemplate a change of athletic career.

Tempo is the time it takes to complete each component of a repetition. Repetitions consist of 4 components:

1. The Eccentric Phase: lowering of the weight, lengthening of the muscle fibers, increasing the distance between attachments,
2. The Pause (or lack there of) at the end of the eccentric phase before beginning the concentric phase
3. The Concentric Phase: raising of the weight, shortening of the muscle fibers, decreasing the distance between attachments
4. The Pause (or lack there of) at the end of the concentric phase before beginning another eccentric phase.

Varying the time of each of these different phases can have vastly different effects on the overall results of a repetition, set, or biologic development (Campos et al 2002, Hather et al 1991, Jones et al 1987, Raue et al 2005, Jackson et al 1990). For instance, the body is approximately 110-150% stronger in the eccentric phase (muscle group dependent) than concentric phase. While performing a repetition, if the athlete chooses a longer eccentric phase than concentric phase, then greater hypertrophic or strength gains may be seen (Jones et al 1987, Hather et al 1991). The pauses are just as important. If an athlete chooses a long pause between the end of the eccentric phase and beginning of concentric phase, then there is a decrease in the ability to utilize the myotatic stretch reflex, resulting in decreased elastic "bounce"/energy before attempting the concentric phase of the repetition. This may lead to a decrease in the amount of weight one can handle successfully for the exercise.

Tempo of an exercise prescription is designated by 4 numbers. For example:

4020

Each number represents a different phase of one single repetition. Broken down into it's separate components this tempo reads:

4 (4 second eccentric phase/lowering the weight)

0 (0 second pause at the bottom of the eccentric motion before beginning the concentric phase; this is where the myotatic reflex occurs)

2 (2 second concentric phase/ raising the weight)

0 (0 second pause at the top of the concentric motion before beginning another eccentric phase)

Manipulating the tempo, leads to variations in the amount of time the working muscles are under tension, known as time under tension. Varying time under tension will influence recruitment of different muscle fibers. With regards to hypertrophic adaptations (muscle growth) Wilson (2003) states, "tests have compared fiber recrution in athletes when they lifted in the 5-15 second range, to the 30-70 second range and found that the latter incorporated much more muscle fibers than the former. At a lower second range your muscle would fail due to rapid ATP shortage, and this rapid shortage of energy does not allow your muscles enough time to be stimulated enough to grow. Essentially, the lower the total time that the muscle fibers are required to produce force is shorter in low rep sets than in higher rep sets. Simply put, a hard set that lasts 30-70 seconds delivers more growth stimulus to the muscle cells than a hard set that lasts below this because in a shorter set, failure may occur due to reasons other than muscle fiber fatigue (Wilson 2003)."

Higher velocity power movements such as Olympic lifts, have very short time under tension and rely more on neural activation and intra/inter muscular efficiency adaptations for

increasing strength and power (Raue et al 2005, Poliquin 2006, Anderson and Aagaard 2000). Slower lifts requiring greater time under tension rely more on increases in cross sectional area of muscle fibers (hypertrophy) for gains in strength and power (Maughan et al 1984, Anderson and Aagaard 2000, Luthi et al 1986). So which is better? The answer is both, but in the right dosages during the right phases of a training cycle. According to Kurz, "loads in the range of 70-75% of one's maximum, allowing up to twelve repetitions, increase muscle cross section, and thus, the mass of the athlete. Loads equal or higher than 80% of one's maximum, permitting maximally 4-6 repetitions, increase strength without increasing mass (Kurz 1991)." This statement should also include the time under tension per set. ***Poliquin recommends no more than 20 seconds of time under tension for relative strength training, no more than 40 seconds of time under tension for functional hypertrophy, and no more than 60-70 seconds for general hypertrophy*** (or beach muscle!).

****The time under tension is calculated by multiplying the amount of repetitions by the overall tempo per rep (ie: 10 reps X 4020 tempo = 10X6 = 60 seconds (general hypertrophy).

How is this concept then applied? Below are some examples of methods to manipulate time under tension.

Changing tempo and repetition count to reflect goal of training

A. **5010 tempo** (5s eccentric, 0 pause, 1s concentric, 0 pause) for 10 repetitions. As the time under tension equals 60s (6X10), this method can be used for athletes looking to increase muscle mass/lean body weight, while maintaining/minimizing losses in power due to the explosive concentric (1s or less) phase of the movement.
B. **4210 tempo** (4s eccentric, 2s pause at bottom, 1s concentric, and 0s pause at top) for 6 reps. With time under tension equaling 42 seconds, this can be classified as borderline functional hypertrophy/general hypertrophy. An athlete looking to increase functional strength without assistance from the stretch reflex (2s pause at bottom) may find this tempo to be effective.

C. **3010 tempo** (3s eccentric, 0s pause at bottom, 1s concentric, and 0s pause at top) for 5 reps. This is considered a relative strength protocol with 20s of time under tension (4x5). This tempo would be effective for an athlete looking to gain strength without increasing cross sectional area (muscle mass). Relative strength tempos are effective for weight class athletes such as wrestlers, boxers, and weightlifters.
D. **21X0 tempo** (2s eccentric, 1 second pause, X (explosive), and 0 second pause at top) for 3 reps. This may represent the tempo seen in Olympic lift variations, explosive squats or bench press utilizing chains for accommodated resistance, and various med ball throwing exercises.

Increasing the time under tension and recruitment of IIB muscle fibers.

When an athlete performs a set of 10 repetitions in the gym, what exactly is happening to the body/central nervous system during the entire set? With regards to muscle fiber recruitment, is the 10^{th} repetition the same as the 1^{st}? Kurz explains "the physiological mechanism of work with less than maximal weights differ from work with maximum and sub maximum weights. As fatigue sets in, the picture changes. As the tension in one motor unit drops, more and more motor units join in the work and in the last movements (repetitions), the number of working motor units is maximal. This is followed by an increase in the frequency and change in the synchronization of nervous impulses sent to the muscle. (As the fatigue sets in, more and more motor units join in the effort and also require stronger stimulation to do the work.) The movement that could be done easily at first, now is difficult. The physiological picture becomes similar to that of maximal load (weight), but the athlete is still using submaximal resistance. The last repetitions are especially important here because they involve maximal tensions (Kurz 1991)."

In essence, during a set of 10 reps, perhaps repetitions 8, 9, and 10 are the only repetitions to create activation of the desired type IIB high threshold muscle fibers. That would mean that reps 1-7 were primarily type I and type IIA fiber dominant. So how does

an athlete influence activation of the high threshold IIB fibers without doing so many "warm up" repetitions? 1, 2, or 3 rep max efforts will do the trick, but there is limited time under tension for IIB fibers in these rep ranges each of these, maximal. A more effective method is the use of drop sets.

Drop sets allow the recruitment of high threshold muscle fibers and greater time under tension for these fibers. Drop sets also allow for a greater average load to be used over a set, when compared to traditional weight training methods (Poliquin 2006). To illustrate how a drop set affects time under tension of high threshold muscle fibers, the 2 rep max squat will be used as an example. The athlete performs their two rep max in the squat, recruiting high threshold muscle fibers. Normally, the set would be done, and the time under tension for the high threshold muscle fibers would be limited to the time it took to complete the repetitions. But during the drop set method, the set would continue. Upon completion of the 2nd repetition, the athlete's spotters reduce the weight by 5-10 percent, and the athlete performs another repetition or two (if possible). Upon completion of the rep(s), the spotters reduce the weight by another 5-10 percent, and the athlete performs yet another repetition or two. This may continue for 2-7 additional reps beyond the initial 2 repetitions, allowing recruitment of high threshold muscle fibers for each additional repetition. This allows the IIB fibers greater time under tension. The drop set method is highly effective if done properly, but also very taxing on the Central Nervous System. A strong training base, correction of structural imbalances, technical mastery, and proper general physical preparation must be addressed prior to incorporation of this advanced technique.

Another method of increasing time under tension is through the use of isometric pauses throughout various points of the range of motion. Each pause will increase the time under tension, allowing for greater recruitment of high threshold muscle fibers (O'shea and O'shea 1988, Cornelius et al 1987, Shea 2004). Isometric pauses can be done at any point in the movement (preferably at sticking points), as long as tension is maintained on the working musculature.

An example of isometric pause training can be illustrated in a 6 repetition set of the bench press. To influence gains in functional hypertrophy, each repetition should take an average of 6 seconds. **Below a tempo variations focusing on isometric contractions.**

A. **21X3 tempo** (2 second eccentric, pause for 1 second at the chest (not resting on the chest), explosive concentric phase, then pause for 3 seconds at the end of the concentric phase, maintaining tension on the muscle).
B. **22X2 tempo** (2s eccentric, 2s pause at bottom, explosive concentric, and 2s pause at top).
C. **20(2 at bottom 3rd, 2s at 1/2, 2s at top 3rd)0** This method includes a 2 second eccentric, 0 pause at the bottom, a 2s pause at the bottom 3rd of the concentric movement, a 2s pause at the ½ way point of the concentric movement, and a 2s pause at the top 3rd of the concentric movement.

The purpose of this article was to highlight the importance of two often overlooked components of strength training, tempo and time under tension. With a better understanding of each of these components, strength and conditioning can be directed toward specific goals, including hypertrophic adaptations, increases in both maximal and relative strength, and increases in rate of force development. Greater knowledge of these aspects of training allows one to focus on other overlooked components, one of which is manipulation of rest intervals, the subject of Part II of this series.

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