Zatsiorsky, V.M. (1992). Intensity of strength training facts and theory: Russian and Eastern European approach. National Strength and Conditioning Association Journal, 14 (5). 46-57.

HIGHLIGHTS OF THE ARTICLE

PURPOSE

Describe and explain the training routines employed by elite Russian and Bulgarian weightlifters.

THE STRENGTH AND CONDITIONING OF ELITE ATHLETES

Three primary factors:

- 1. Selection of exercises
- 2. Training load (intensity and volume)
- 3. Training timing (exercise distribution)

INTENSITY

The Means of Measuring Intensity of Training

- 1. Magnitude of resistance (% of 1RM)
- 2. Number of repetitions
- 3. Number of repetitions with maximum resistance
- 4. Workout density (number of sets per one-hour workout)

MAGNITUDE OF RESISTANCE

The training weight is assigned as a percentage of the weight lifted relative to the best performance

The best performance can be derived from one of two events

1. Competition 1 RM (C1RM)

This is the maximum weight lifted by the athlete under stressful conditions and with heightened arousal levels (at competition). This is usually 12% (+/- 2.5) better than maximum weight lifted in training (T1RM). An example is a lifter with a competition best of 200kg and a training best of 180kg. The difference tends to be greater in heavier weight classes.

2. Training 1 RM (T1RM)

This is the maximum weight lifted by the athlete without substantial emotional stress and less arousal (training as opposed to competition).

The Differences Between C1RM and T1RM

After experiencing a C1RM, a lifter will be very tired and sometimes will need up to a week of solid rest and a month of lighter training to return to full form. Weightlifting competitions are much more stressful when compared with other sports in which competitions occur week to week, or several times a week (such as basketball). The primary reason for the elevated stress experienced by weightlifters is the great emotional and physical stress involved in truly experiencing a competition maximum. This compounds the stress caused by the loads alone, and makes it seem much more tiring than training.

In contrast, a T1RM can be lifted at EACH training session. Although the load lifted will vary from day to day, a T1RM can be experienced daily without the substantial stress experienced from a C1RM. The Russians utilized the C1RM for the purpose of programming, which they considered to be more practical than T1RM (which was used by Bulgaria).

NUMBER OF REPETITIONS

Another popular measurement of intensity in exercise is to measure the number of repetitions achieved in one set to failure. This is often done where 1 RM is impossible or nearly impossible to determine (such as with a sit-up for example). The magnitude of resistance is characterized by the ultimate number of reps to failure. This method may be convenient, but there is no fixed relationship between the magnitude of the weight lifted and the number of reps to failure. In other words, there is too much variation from lift to lift and set to set.

NUMBER OF REPETITIONS WITH MAXIMUM RESISTANCE

Another method of measuring intensity is to measure all repetitions achieved with a load equal to or above 90% of C1RM. Such loads are almost always above the T1RM total for most athletes.

TRAINING DENSITY

This measurement examines the number of sets per one-hour workout, and is a more general indicator of intensity.

HOW THE RUSSIANS QUANTIFIED INTENSITY

- 1. Loads below 60 % of C1RM are used for warm ups or restitution (8% of all lifts)
- 2. Main portion of weights lifted is 70 to 80% of C1RM
- 3. Lifts above 90% of C1RM account for only 7% of total lifts
- 4. Average training intensity of Russians is 75% (+/-2%)

HOW THE RUSSIANS ASSIGNED REPETITIONS PER SET

The number of reps assigned for each set varies by the exercise in question.

For the classic lifts (snatch and C&J), the major parts of all sets are performed with 1 to 3 reps, with 2 reps being the average. For lifts in which the motor coordination only partially resembles the coordination required in the snatch and clean (such as squats), more than 93% of sets are done in the 2 to 7 rep range. As the intermuscular coordination of an exercise becomes more SIMPLE, and as the technique varies from the classics, the GREATER THE REPS assigned.

<u>Classic Lifts</u>

High intermuscular coordination, complex, and MAIN event 1 to 3 reps

Squats and pulls

Less intermuscular coordination, less complex, and distanced from the main event 2 to 7 ${\sf reps}$

Hyperextensions and Other Auxiliary Exercises

Least intermuscular coordination, simple, and far distanced from the main event 5 to 10 reps

HOW THE RUSSIANS ASSIGNED REPS AT MAXIMAL RESISTANCE

The attempts described as maximal include those performed at or above 90% of the C1RM on the classic lifts. The Russians assigned a relatively low amount of such reps, with 65% of those falling in the 90 to 92% range of all lifts above 90%. Only 20% fell between 92 and 97% of all lifts above 90%, and even less (15%) of those above 90% were above 97%.

IMPORTANT: Lifts above 90% were based on a COMPETITION MAXIMUM and NOT a training maximum. The Russians believed that the competition maximum was almost always a higher load than training maximum, and therefore any lifts above 90% were considered to be of considerable intensity and either equal to or more difficult than daily maximums (T1RMs). This would help to explain why the Russians did NOT assign a large amount of lifts above 90% of the C1RM in training.

Interestingly, by limiting the number of reps above 90% of C1RM, and concentrating more in the 70 to 85% range, the Russians actually trained in a similar manner to that of the Bulgarians. The Bulgarians utilized weights based off of the T1RM, which is usually a smaller starting point than basing weights off of the C1RM (sometimes by 20kg or more!). By assigning loads of -30 to -20 to -10kg from the T1RM, they are effectively training similar to loads 70 to 85% of C1RM, as their maximum (T1RM) is a lower starting point than that of the Russians.

The two methods end up being similar in training intensity, even though the measurements and programming methodology is different.

BULGARIA

In Bulgaria, loads are assigned using the **T1RM instead of C1RM**. Bulgarian lifters appear to lift more maximal weight per year, however, maximal loads are based on the T1RM, which is usually significantly less than the C1RM. Discrepancies between the Russians and Bulgarians become less apparent as a result.

The difference does not appear in the training, but in the **METHOD OF DETERMINING MAXIMAL WEIGHT.**

Specific Comparisons

1. The Russians use a significantly higher 1RM total than the Bulgarians

2. Many Russian lifts of 70 to 80% would classify as maximal or submaximal in the Bulgarian system (because of the lower max used in Bulgaria)

HOW TO BECOME STRONG: THE MANIFESTATION OF STRENGTH

Two primary factors must be manipulated in order to become strong:

- 1. Changes in the peripheral muscles
- 2. Changes in central nervous system coordination

PERIPHERAL MUSCLE FACTORS FOR STRENGTH

The capacity of a muscle to produce force depends on its cross-sectional area, and in particular, size of muscle fibers. Cross sectional area increases as a result of muscle fiber size increases and NOT by fiber number gain (hypertrophy as opposed to hyperplasia).

Two types of HYPERTROPHY

1.) Sarcoplasmic Hypertrophy

This type of hypertrophy involves increases in the size of the sarcoplasm and non-contractile protein which do NOT contribute directly to the production of muscle force. In other words, filament density in the muscle DECREASES while the cross sectional area of the muscle fibers increases WITHOUT an accompanying increase in muscle force. This is the type of hypertrophy most often seen in body builders.

2.) Myofibrillar Hypertrophy

This type of hypertrophy involves more contractile proteins being synthesized and an increase in filament density in relation to the cross-sectional area of the muscle. An increase in contractile proteins and filament density increases the size of muscle fibers. This leads to increased muscle force production, and is the type of hypertrophy desired by athletes to increase performance.

CATABOLISM AND ANABOLISM

Exercise activates protein catabolism (the breaking down of muscle proteins). During strength exercise, muscle proteins are forcefully converted into more simple substances. This creates conditions for enhanced synthesis of contractile proteins during rest periods (supercompensation)

THEORY BEHIND THE MECHANISMS OF HYPERTROPHY

An increase in protein catabolism is achieved by creating a shortage of energy within the muscle

cell available for protein synthesis during heavy strength exercise. The synthesis of muscle proteins requires a large amount of energy, and during heavy training, nearly ALL energy goes to fuel the contractile elements and muscular work and not to synthesis. As a result, protein degradation increases and amino acid uptake from the blood is also suppressed. The mass of proteins catabolized during exercise EXCEEDS the amount synthesized.

Between training sessions, protein synthesis is INCREASED (supercompensation for the catabolic state during exercise). The uptake of amino acids from the blood into muscles rises above resting levels.

The vital parameters that stimulate hypertrophy are exercise INTENSITY (load and subsequent force applied) and VOLUME (mechanical work/reps).

INTRAMUSCULAR COORDINATION FACTORS FOR INCREASING STRENGTH There are three options for increasing muscle force output by stimulating change within the nervous system

1. Recruitment

Recruitment is defined as the gradation of total muscle force by addition or subtraction of active motor units. Once a motor unit is activated, it is activated in its entirety (all or none), but it first must be recruited. The more faster and larger motor units recruited during a lift, the more muscle force will be exerted.

2. Rate Coding

After a motor unit is recruited and fires, changing the firing RATE of the motor unit will help to change force output (the units are "turned on" faster – remember, there is no "dimmer" switch for motor units, they are all or none!)

3. Synchronization

This involves the activation of motor units in a more or less synchronous way

Slow Motor Units (or Slow Twitch)

SMUs are specialized for prolonged usage at slow velocities. They consist of small, low threshold motor neurons with low discharge frequencies, and low conduction velocities. They are highly adapted to lengthy aerobic activity.

Fast Motor Units (fast twitch)

FMUs are specialized for brief periods of activity involving large power outputs, high velocities, and high rates of force development (RFD). They consist of large, high threshold motor neurons with high discharge frequencies, and high conduction velocities. They are highly adapted to explosive or anaerobic activity.

All or None Principle

A motor unit is either active or inactive at any given moment. There is no "dimmer" switch, as the motor unit is either "on" or "off". Changes in muscle force can occur through changes in the rate of "on" and "off" or firing rate (rate coding). A slow firing rate will produce less force than a fast rate. In this way, the level of force is controlled by how fast or how slow a motor unit fires.

Comparisons between SMU and FMU

The maximal shortening velocity of FMU is almost four times greater than that of SMU. The force per unit area between SMU and FMU is relatively similar, however, the FMUs have a larger cross sectional area and therefore produce more force per ENTIRE motor unit (a small segment of the same size of SMU and FMU would produce the same, it is just that FMU has much more size and a greater total amount of force).

RECRUITMENT SPECIFICS

During voluntary contraction, the orderly pattern of recruitment is controlled by the SIZE of motor neurons (the Size Principle). The smaller motor neurons with the LOWEST threshold are recruited first. Demands for larger forces are met by the recruitment of an increasingly forceful motor unit. The motor units with the highest threshold (which possess the largest and fastest twitch contractions) are recruited last (if at all). SMU are ALWAYS activated in muscles which contain both SMU and FMU, regardless of the magnitude of tension and velocity required. Full FMU recruitment is difficult to achieve (if at all for untrained individuals). Increased recruitment and activation of FMU are typically more often seen in strength trained individuals. In addition, specific muscle motions have different recruitment patterns. For some motions, a motor unit may have a low threshold, while for others it may be high. If the object of interest in training is full development of muscle and not athletic performance (body builders, hypertrophy), one must exercise a muscle in all its possible ranges of motion (to vary recruitment order to ensure that at least one motion recruits all motor units).

RECRUITMENT VS. RATE CODING: DEPENDS ON MUSCLE SIZE

In small muscles, most motor units are recruited at the level of force less than 50 percent of max force. Therefore, rate coding plays the MAJOR role in the further development of force up to maximum. In contrast, larger muscles rely more on recruitment. The activation of additional motor units appears to be the MAIN mechanism of increasing force development up to 80% of max force. From 90% to 100% of maximum force, rate coding plays the exclusive role of increasing force.

SYNCHRONIZATION

Normally, motor units work ASYNCHRONOUSLY to produce smooth and accurate movement. In elite athletes, motor units are activated synchronously during maximal voluntary efforts.

THE REQUIREMENTS FOR THE DEVELOPMENT OF MAXIMUM FORCE

- 1. Maximum recruitment of SMU and FMU
- 2. High rate coding
- 3. Synchronicity of motor unit activation
- 4. High level of arousal (such as seen in a C1RM attempt)

VARIED RESISTANCE AND HYPERTROPHY

When exercising with varying levels of resistance, differences exist in both metabolic reactions and neural coordination.

Metabolic Reactions

The crucial factor in determining the balance between protein catabolism and anabolism is the AMOUNT OF ENERGY available for protein synthesis during exercise. If the resistance is small, there will still be enough energy for synthesis. However, if the resistance is heavy enough, there will be a transfer of energy from synthesis to the contractile elements and to the production of muscle work. The rate of protein breakdown will increase. As the weight gets heavier, more protein degradation occurs, but less mechanical work will be accomplished (less reps and sets). Protein breakdown is also a function of the **mechanical work done** in addition to total weight lifted. Increases in mechanical work causes a demand for more energy for said work, and less for synthesis.

Ways To Increase Protein Degradation For Hypertrophy:

- 1. Increase weight up to a point
- 2. Increase mechanical work up to a point.

The "point" being described is on a continuum. As the resistance is increased, less reps can be performed. The optimal zone for protein degradation occurs when a near maximal weight is lifted

for a near maximal amount of repetitions. Too high of weight will lessen the mechanical work, while too high of mechanical work will require less weight. A trainer must find a way to maximize BOTH methods.

Specifically

1RM loads High protein degradation Low mechanical work Low total amount of degraded protein

5-10RM loads

Average protein degradation Average mechanical work High total amount of degraded protein

Greater than 25RM loads

Low protein degradation High mechanical work Low total amount of degraded protein

Thus the optimum range for stimulating hypertrophy seems to lie in the 5 to 10 rep range. AGAIN, this is optimum for hypertrophy, which as an indirect influence on performance (increasing cross-sectional area of muscles to increase force output). Another equally important factor are the neural or coordination factors in increasing force output.

COORDINATION AND NEURAL FACTORS FOR MAXIMUM FORCE

When lifting maximum weight, the maximum number of motor units are activated. The fastest FMUs are recruited, and their discharge frequency is at its highest. Their activity also becomes synchronous as well.

When lifting SUB maximal weight, and intermediate number of motor units are activated, the fastest FMUs are NOT recruited and the discharge frequency of the motor neurons is submaximal. **Moderate resistances are not an effective training stimulus for training neural and coordination factors for strength development**. Optimal intramuscular coordination is realized when weights equal to or above T1RM are used in workouts.

Again, it is important to stress the system we seek to train here: the **neuromuscular system**. For peripheral (muscular) adaptations such as hypertrophy, intermediate loads combined with maximum mechanical work are ideal. When it comes to stimulating change at the neural level, maximum loads are required. For highly trained people, weights of 60 to 85% of T1RM not lifted to failure will not stimulate neuromuscular adaptation.

THREE DIFFERENT METHODS OF STRENGTH TRAINING Maximum muscular tension can be attained in one of three methods

1. Maximal efforts Lifting against a maximal load (T1RM or C1RM)

2. Repeated efforts Lifting a non-maximal load to failure

3. Dynamic efforts Non fatiguing load lifted with the highest attainable speed

The limitations of utilizing maximum effort training are threefold

1. High risk of injury

To avoid injury, proper technique must be stressed

Limited hypertrophy production
Only a minor amount of mechanical work is performed

3. Burn out

Performing only this style of training tends to shorten the athlete's career, and can lead to overtraining if employed improperly. Also, if the loads are calculated from the C1RM instead of the T1RM, burn out is much more likely. This helps to explain why Bulgaria utilizes the T1RM for training calculations instead of the C1RM. It also shows why Russia does not program many lifts above 90% of C1RM as well.

BOTH countries use maximal efforts training. Russia employs it less frequently than Bulgaria.

SUBMAXIMAL EFFORTS AND REPEATED EFFORTS

Repeated efforts training involves lifting near maximal or maximal loads to failure, while submaximal efforts training involves the use of intermediate loads. The primary goal of this style of training is to stimulate hypertrophy.

If the method of repeated efforts is used, a concerted effort MUST be made to lift to FAILURE. Only the final lifts in which a maximal number of motor units are recruited are actually useful for performance gains. If an athlete can lift a barbell 12 times but only lifts 10, the exercise is not accomplishing as much stimulation as it should.

These methods stimulate more hypertrophy than the maximal efforts method, and have a lower rate of injury associated with them. However, neural and coordination factors are not trained with this type of method. This training trains "muscles not movements", which is incomplete for weightlifters, who must have BOTH.

CONCLUSIONS

To improve neuromuscular coordination (motor recruitment, rating coding, and synchronization), use the MAXIMAL EFFORTS method

To stimulate hypertrophy, use the methods of REPEATED EFFORTS (or submax efforts)

Weightlifters need to train both the muscles of the periphery as well as the nervous system (the movements). Gains in muscular force due to hypertrophy cannot be properly utilized if the neuromuscular system is inefficient in producing the movements. Likewise, the neuromuscular system can be finely tuned to produce perfect motor unit activity to lift a load, but if the muscle fibers stimulated by the neurons are not large enough or strong enough, the weight lifted may not be enough.

Zatsiorsky seems to recommend that the training of the Russian lifters, which involves training stimulus for BOTH the muscles and the nervous system (by applying BOTH hypertrophic/repeated efforts training along with neuromuscular/maximal efforts training) as being superior to maximal efforts alone training.

However, Spassov disputes such claims. Spassov readily admits that maximal efforts training has a higher rate of injury associated with it, and it shortens athletic careers. But he feels that it is the ONLY way to achieve ultra-high performance. Lifters from his country have shown to be quite formidable. Spassov also has a valid point about the problems associated with the Russian's use of percentages. Zatsiorsky points out that the Bulgarians may only APPEAR to work with higher loads than the Russians, but this may be only due to the fact that the Bulgarians employ the T1RM to calculate loads as opposed to the C1RM that the Russians use. The use of a lower max more often is quite equivalent to the use of a higher max less often.

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