Evaluating Common Weight Training Concepts Associated With Developing Muscular Strength: Truths or Myths?

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SUMMARY

THIS ARTICLE DESCRIBES SEVERAL STRENGTH TRAINING CONCEPTS AND ASSESSES THOSE USING PERTINENT BIO-MECHANICAL AND PHYSIOLOGICAL PRINCIPLES. BECAUSE MAXIMIZING MUSCULAR STRENGTH IS EXTREMELY IMPORTANT TO THE OUTCOME IN CERTAIN ATHLETIC COMPETITIONS, MUCH OF THE DISCUSSION WILL FOCUS ON ONE SPORT IN PARTICULAR, POWERLIFTING. HOWEVER, ANY SPORT THAT PLACES HIGH DEMAND ON INCREASED STRENGTH LEVELS COULD BENEFIT AS WELL. A CHALLENGE THAT STRENGTH AND CONDITIONING PROFESSIONALS MAY ENCOUNTER WITH REGARDS TO ANY TYPE OF EXERCISE PROGRAM IS DISCERNING WHICH TRAINING METHODS OR CONCEPTS ARE COUNTERPRODUCTIVE (MYTHS) AND WHICH ARE BENEFICIAL (TRUTHS).

INTRODUCTION

The historical significance and origin of a resistance exercise or workout program can provide the strength and conditioning professional with valuable and educational information regarding the effectiveness of a particular training instrument for developing a specific motor skill. For example, the deadlift is believed to have originated during the Roman Empire around 200 B.C. After military battles, young Roman soldiers would go out onto the battlefield and lift their fallen comrades onto carts to be buried later. The young soldiers were literally “lifting the dead.” This was used not only to prepare these soldiers for combat and death but also to increase lower extremity and back strength, which could ultimately mean the difference between living and dying on the battlefield (12). Truth or legend, sports historians struggle to substantiate such claims but interesting stories are born and for all intent and purposes an ideal beginning for this discussion.

Maximum muscular strength is defined as the maximum amount of force a muscle can exert against some form of resistance in a single effort (22). The ability to maximize muscular strength is an essential component for enhancing performance in a variety of sports. However, the arduous task can only be accomplished if the strength and conditioning program meets the specific biomechanical and physiological demands of the sport. To help ensure success, the workout design should be concise but complete, and the exercises should be functional but specific. One way of achieving these objectives is by incorporating synergistic exercises with regards to having the capability of stressing multiple muscle groups simultaneously or sequentially. Meeting these demands can present certain challenges to the strength and conditioning professional because exercises of this nature are limited. Several exercises specific to strength development do meet the criterion, such as, the squat, bench press, and deadlift. Coincidently, these

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are also the 3 lifts used to measure an athlete’s absolute strength level in the sport of powerlifting.

Several strength training concepts are described and explained using pertinent biomechanical and physiological principles. Because maximizing muscular strength is extremely important to the outcome of certain athletic competitions, much of the discussion will focus on one sport that exemplifies that concept, that is, powerlifting. However, any sport that places high demand on increased strength levels could benefit as well. A challenge that strength and conditioning professionals may encounter with regards to any type of exercise program is discerning which training methods or concepts are nonproductive (myths) and which are beneficial (truths).

THE FUNDAMENTALS

Most strength and conditioning professionals would agree that the specificity of training philosophy should be a foundational component of any resistance exercise program. The principle states that the training stimulus should mimic the aspects of performance to improve skill performance. This involves overloading the physiological systems sufficiently to induce an adaptation of those systems (34). Physiological adaptations to training are incredibly specific, and the outcomes of training are directly related to the exercises used as a training stimulus (3,32). The specificity concept refers not only to the physiological systems (i.e., endocrine, neurological, and muscular) but also to the biomechanical factors (i.e., movement patterns, muscle force production, and lifting technique). Once an individual alters one of these areas or deviates away from the norm, training gains can diminish.

To provide the strength and conditioning professional with knowledge concerning specificity, the following sections discuss the importance or insignificance of several training concepts that have been incorporated into a variety of strength development programs in the past.

CURRENT TRAINING METHODS OR STRATEGIES

TRAINING CONCEPT: POWER TRAINING FOR MAXIMIZING STRENGTH

Description. A training strategy commonly found in powerlifting routines emphasizes power development for improving strength performance. It is implied that diminished levels of muscular power can negatively affect the initial portion of the ascent phase of the back squat and bench press, the lift-off portion of the deadlift, and the region of each lift referred to as the sticking point.

Explanation. Distinct and fundamental differences exist between strength and power development, which is explained, in part, by the force-velocity relationship (Figure). A key component for maximizing power output is generating relatively high velocities while lifting (16). Power development can actually be counterproductive for developing maximum strength because of the inverse relationship associated with movement velocity and lifting load (2,7). The relationship illustrates how velocity of muscle contraction is inversely proportional to the load, and thus, large force magnitudes cannot be exerted in very rapid movements (30). The greatest barbell velocities are attained under conditions of low to moderate loading, and the intermediate values of force and velocity depend on the maximal isometric force. For example, average vertical bar (VB) velocity of a 1-repetition maximum (RM) deadlift is 0.3 m/s (peak VB velocity, approximately 2.5 m/s), which would be considered to be relatively slow compared with the 2.0 m/s average VB velocity of a 1RM power clean (peak VB velocity, approximately 6.5 m/s) (17,18).

Powerlifting is not considered a power sport; however, several individuals in the sport of powerlifting promote the implementation of a power training program developed by a former U.S.S.R. weightlifting coach Prilepin (37). The Prilepin chart, which has proven to be a successful strategy for improving muscular power, was developed specifically for the sport of weightlifting. In the sport of weightlifting, force and velocity of execution depends on the load; therefore, selection of the appropriate load is vital for developing the required muscle quality (e.g., strength, endurance, or power). The influence of maximal isometric strength on dynamic force and velocity is greater in high-load slow movements often observed in powerlifting; therefore, a correlation between maximal velocity and maximal strength has not been shown to exist (36).

The ability to generate maximum strength and the ability to produce power are different motor abilities, so it is inappropriate to assume that greater lifting velocity (power) coupled with moderate loads will necessarily enhance strength development (23). These biomechanical concepts suggest placing less emphasis on exercises focusing on lifting speed in sports that demand high strength levels, such as the sport of powerlifting.

TRAINING CONCEPT: ACCELERATION/STRENGTH TRAINING

Description. A popular mode of training commonly found in powerlifting programs is termed “acceleration/strength training.” Advocates explain that the simplicity of the training method lies in understanding that force equals mass × acceleration. Because mass is constant throughout the lift, force is proportional to acceleration. The mode of training is represented by the equation \( F = ma \). Simply put, if a lifter increases lifting speed, muscle force increases proportionally.

Explanation. The concept of acceleration/strength training is the appropriate phraseology, but these terms, acceleration and speed, are often interchanged by individuals not familiar with biomechanics that often leads to an incorrect interpretation. In this particular instance, the mathematical formulation of the Newton’s second law can be presented as \( a = \frac{F}{m} \) instead of the more familiar \( F = ma \).
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causes an object to accelerate. Two points of interest need to be clarified before the relevance of the training method can be validated.

First, force magnitude is not the product (effect) of vertical barbell velocity; conversely, movement response (acceleration) is the effect of an applied force (cause). Second, an inverse relationship actually exists between lifting speed (velocity) and muscle force production (11). These aspects assume that the individual is exerting maximum effort when lifting a resistive load, either sub-maximal or maximal. For example, an individual lifting a submaximal load at a relatively high velocity while performing a resistive exercise movement compared with the same individual lifting the same submaximal load at a relatively low velocity generates greater muscular force.

As the athlete progresses from moderate loads to lifting heavier resistances, the velocity of the movement decreases. According to the force-velocity relationship, under this circumstance, an individual is capable of generating greater muscle force when lifting high resistive loads compared with lighter loads lifted at a relatively high velocity. The correct interpretation describing the source of human motion states that the resultant acceleration is directly proportional to the magnitude of applied force, thus the greater the force magnitude, the greater the acceleration (2,22). For many years, the basic physical principles of motion have been misinterpreted by some proponents of the accelerated/strength training concept relative to the sport of powerlifting. Training programs designed using a periodization model that progressively increases intensity over a predetermined time frame would be more appropriate for maximizing strength development.

From a coaching standpoint, it is not unusual for a coach or strength and conditioning specialists to use a verbal cue, implementing the term velocity to advocate force production to encourage an athlete to put forth more effort. However, when the strength professional designs an exercise program for maximizing strength, the correct interpretation of the relationship between force and acceleration should be strictly adhered to.

**TRAINING CONCEPT: SPEED TRAINING FOR STRENGTH**

**Description.** It has been speculated that lifting a moderate weight at a high rate of speed is equivalent to large force magnitudes. The claim is that athletes do not need to lift heavy weights in training to lift heavy weights in competition. In other words, an individual performing a squat repetition at a high rate of speed while lifting a load of 400 lb could translate that effort into a large increase in a maximum squat on the day of the competition.

**Explanation.** The principle is a derivative of the previous concept with a focus on the force-producing characteristics of skeletal muscle and the etiology of musculoskeletal injury. The training concept is a misinterpretation of Newton’s second law, and in this case, the misunderstanding makes the training method both ineffective and extremely dangerous. Muscle force magnitude is influenced by motor unit recruitment, firing frequency, and total number of myosin-actin cross-bridge formations (10,15). Lifting a moderate resistance rapidly while performing a traditional strength exercise (e.g., squat, bench press, or deadlift) provides limited benefits for maximizing muscular strength in those exercises. Maximizing strength requires periodic use of heavy loads in training because if the neuromuscular system is progressively overloaded within tolerable limits, it adapts by increasing cross-sectional area, myofibril quantity, mass, motor unit recruitment, and synchronization that improves the motor function (muscular strength) (33).

In contrast, sports requiring greater muscle power could potentially benefit from a training method that emphasizes lifting speed. It is extremely important to select the appropriate exercises for maximizing the training effects and follow a suitable periodized model using proper load progression. A comparable choice of exercises for sports requiring high levels of muscle power would be jump squats, bench press throws using a medicine ball, and power cleans. These closed-chain exercises involving a projectile component typically incorporate a reduced load, which allows the lifter to produce higher movement velocities, which is
a primary component that defines power output—force and speed. Excessive and abrupt loading of the musculoskeletal system, as depicted by the concept suggesting that an athlete can increase a lifting load by 75% to 100% without an appropriate time frame for progressive overload, could lead to musculoskeletal injuries (9). A traumatic injury can result from a single overload exceeding a tissue’s maximum tolerance (6,27). To optimize the effect of the training, the load imposed on tissues should be kept within a certain range of the maximum allowable load (25,28). Too low a load provides no training effect, whereas too high of a load can lead to injuries (21). The rate with which the various musculoskeletal tissues of the human body adapt to a higher load varies widely between tissues. A well-designed multweek exercise program that incorporates the progressive overload principle provides the musculoskeletal system an appropriate amount of time for adaptation to the imposed stresses (24).

TRAINING CONCEPT: PLYOMETRIC TRAINING IMPROVES MUSCLE STRENGTH

Description. Many coaches and athletes believe that plyometrics are an essential training method for improving strength and powerlifting performance because it affects lifting speed.

Explanation. Plyometric training is implemented into a weightlifting program to enhance speed and power. The Eastern Europeans first used plyometrics in the 1970s to develop greater power in their Olympic athletes (8,20). They based their programs on scientific evidence that stretching muscles before contracting them initiates the stretch reflex of muscle to enhance the power of contraction. When a quick stretch is detected in the muscles, an involuntary protective response occurs to prevent overstretching and injury (5). This response is known as the “stretch reflex.” The stretch reflex increases the activity in the muscles undergoing the stretch or eccentric muscle action, allowing it to act much more forcefully. The result is a powerful braking effect and the potential for a powerful concentric muscle action (4).

When a concentric contraction of a particular agonist muscle group occurs immediately after an eccentric contraction, the force generated can be dramatically increased by storing some of the energy in the elastic components of the muscle (31). To maximize the utilization of the stored energy, the subsequent contraction must occur very quickly (35). This entire process is called the stretch shortening cycle (SSC) and is the underlying mechanism of plyometric training (5). Strength athletes who typically lift near-maximum weights in training and competition produce relatively slow movements (16,26). The transition (amortization) between the eccentric and concentric phases observed during the performance of high resistive strength exercises is relatively long in duration, which reduces the stretch-shortening principle effect (1). Even though, the contribution of the SSC is decreased when extremely heavy loads are lifted as compared with fast explosive movements incorporating lighter weights or body weight exercises, the magnitude of elastic energy used is measurable but highly dependent on the elapsed time between the eccentric and concentric contraction phases (27,29,37).

TRAINING CONCEPT: SQUATS ARE EQUALLY AS EFFECTIVE AS DEADLIFTS

Description. Several individuals in powerlifting suggest that squat exercises are a direct replacement for the deadlift because the movement pattern is similar and the same muscle groups are involved in both exercises.

Explanation. It has been shown the squat and deadlifting using heavy loads are quite different in regards to movement patterns, muscle recruitment order, and selection (13,14,19). The squat exercise demonstrates a kinetic link movement pattern referred to as “simultaneous,” which is defined by joint angle changes of the lower extremities occurring in a relatively equal manner (13,19). Conversely, the deadlift follows a sequential kinetic link pattern indicating prominent joint movements at 3 distinct phases: knee extension to lift-off, hip extension to knee passing, and knee extension to lockout (19). Because of the movement pattern variation and lifting mechanics (bar placement and grip strength) between the squat and deadlift, muscle force–producing factors (muscle recruitment and selection, length-tension relationship, and muscle angle of pull) are different, thus minimizing the crossover effect between the lifts (19).

PRACTICAL APPLICATIONS

Today, strength and conditioning professionals are inundated with new training concepts and programs. It is often difficult for the coach to determine which information is beneficial and which could be detrimental to performance (29). These professionals who are responsible for working with athletes need valid and reliable facts that they can utilize in structuring practical and effective training programs. It is the obligation of the scientific community within the profession to provide the frontline professional with this information. The adoption of training techniques without proper evaluation has beset the sport science community for decades. It is only through research that we can keep from making the same mistakes in the future. This article provides insight into several training applications used explicitly for improving muscular strength in a variety of sports from a biomechanical and physiological viewpoint.

Strength and conditioning professionals interested in training athletes competing in strength-based sports, such as powerlifting, should focus on the principle of specificity. First, eliminate training strategies that do not contribute to the desired motor skill, that is, muscle strength, muscle power, or muscle endurance. Finally, keep it simple, if the objective is to produce an athlete capable of lifting heavy weights, the athlete needs to lift heavy weights.
and follow a well-designed periodized training program.

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REFERENCES