THE BENEFITS OF CONCENTRIC-BIASED TRAINING

by Boston Biomotion

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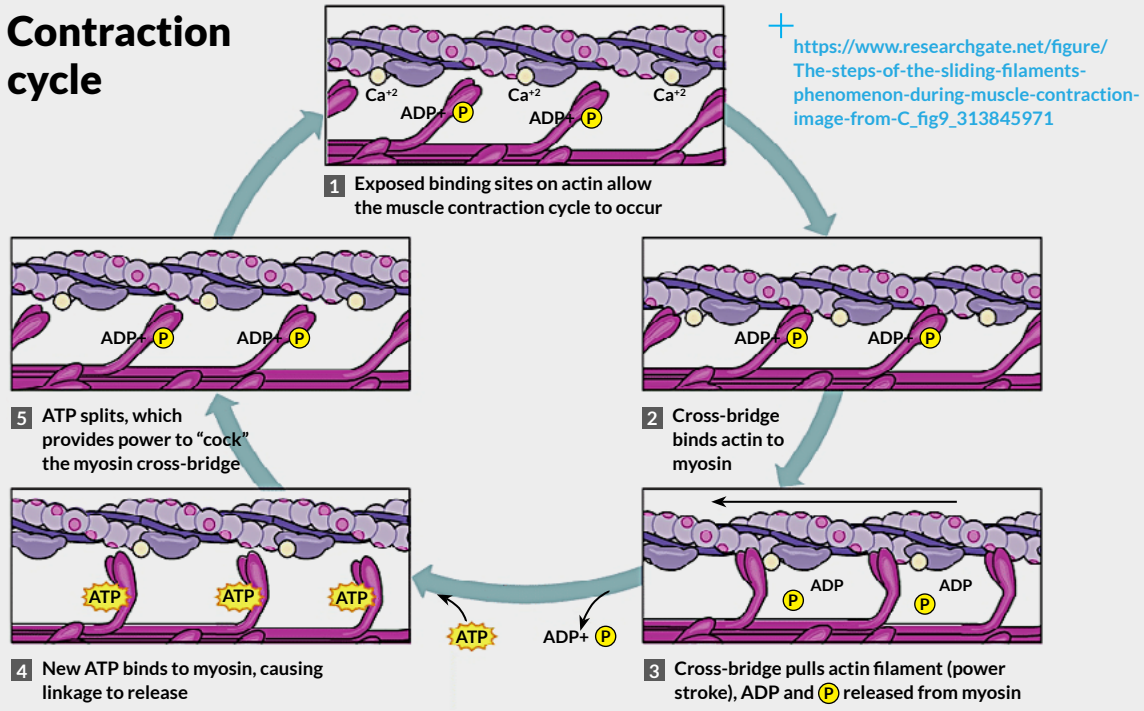
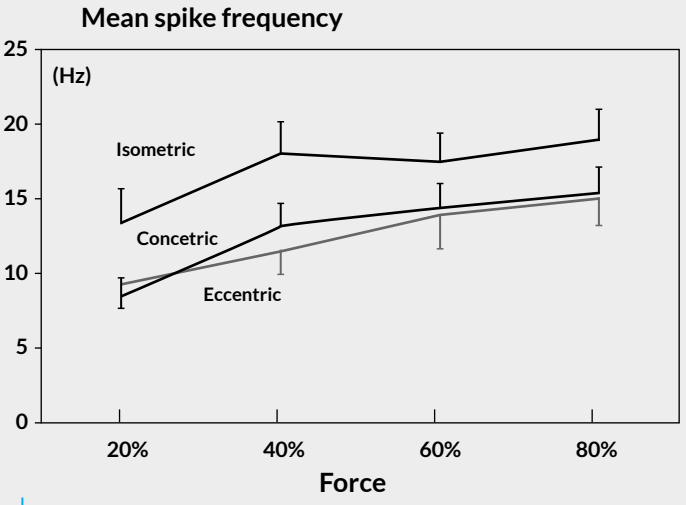
As many in the strength and conditioning world are aware, different training goals are achieved by focusing on the different phases of the muscle shortening cycle. Within the sliding filament model there are three phases of muscle contraction: concentric, isometric, and eccentric. Each of these phases can be targeted by strength and conditioning as well as rehab professionals to create specific adaptations in their athletes[1].
The current exercise science, rehab, and training community have made much of the benefits of eccentric training. Many forget that there are also benefits to focusing on the concentric phase as well. To explore this, we need to know more about what is happening during both the concentric and eccentric phases and how the muscle fibers operate during these phases.



PHASES OF MUSCLE CONTRACTION

First off, it is important to know that a sarcomere, which is the smallest contractile unit of a muscle fiber, is essentially an all-or-nothing, 1-way mechanism. The sliding filaments within a muscle fiber can only actively pull in a shortening direction. When this shortening actually occurs, this is called a concentric contraction. The other phases of muscle contraction are dictated by the movement that ends up occuring due to the number of motor units (groups of muscle fibers activated together) activated by the central nervous system. Simply put, when a muscle shortens, enough motor units must be activated to generate sufficient force to overcome the resistance placed on the muscle.
During an isometric contraction, the resistant force and the force generated by the motor units activated are equal. This results in zero movement. In a sustained isometric contraction, the force is matched by cycling motor unit activation to continuously match the force of the resistance. The end result is no movement but the sarcomeres that are activated continue to individually shorten. Remember, that is the only way

a sarcomere can create active force. This is why quivering in the muscle is seen which is the result of continuous cycling of motor unit contractions within the muscle.
During an eccentric contraction, fewer motor units are activated than are required to overcome the force placed upon them by the external resistance, so the muscle lengthens[2]. It is important to realize that during this lengthening contraction, the individual sarcomeres are actually trying to shorten but are lengthening instead. They are literally being pulled apart! There is a place for training each type of contraction within the normal training cycle for an athlete. Adaptations gained from training are specific to training contraction type[3]. Proper training requires optimization of each contraction type to achieve specific athletic qualities.



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BENEFITS OF ECCENTRICS

In general weightlifting terms, the eccentric phase of muscle contraction occurs during the "negative" portion of a lift. This is when the weight is being lowered in a typical weightlifting exercise such as a bench press or bicep curl. During this phase the sliding filaments in the sarcomere are resisting the lengthening force that the muscle is experiencing from the weight and the muscle as a whole is activating fewer motor units than is required to generate enough force to lift the weight. This causes the weight to lower. The rate at which the weight descends is determined by activating a greater (slower) or fewer (faster) number of motor units. Within each sarcomere, the sliding filaments are pulling one way as they are being pulled apart in another. This is why so much muscle protein damage occurs during the eccentric phase. The proteins in the filaments are ripped apart at their binding sites. In addition to this, the surrounding connective tissue also takes on load and can also get damaged[4].
Because of this damage, eccentrics do create a powerful stimulus for muscle growth as the body will then repair these damaged proteins during the recovery phase and will also stimulate synthesis of an increase in the number of contractile units[5]. This results in muscle growth known as hypertrophy which is the addition of more sarcomeres within the muscle.
Eccentric contractions are also an essential and important component in some athletic movements as they are vital to control deceleration forces that occur when competing. The principle of training specificity dictates that an athlete gains most from training the specific qualities of muscle contraction by actually training the specific phase[6]. An athlete must train eccentrically if the athlete wants to improve their ability to produce force eccentrically. If an athlete can't control the deceleration or the deceleration of forces placed upon them, they tend to get injured. Being able to absorb the forces placed upon the athlete is crucial to their health and performance. Eccentric training is necessary to human movement and comes with a multitude of benefits. However, it also come with its own set of consequences.

THE NEGATIVE SIDE OF NEGATIVES (ECCENTRICS)

Since the body experiences the most damage during an eccentric contraction, it takes much longer to recover from a heavy eccentric training session. As a result, eccentric-biased training, particularly at heavy loads, cannot be performed frequently as the muscles need more time to recover. This added strain would place excessive stress on the recovering athlete. Therefore this type of training is particularly impractical during in-season training routines, as proper recovery is crucial between games.

There is also less neuromuscular stimulation during the eccentric phase. As discussed previously, fewer motor units are activated during eccentrics so therefore there is less central nervous system stimulation[7]. The one exception to this rule is during muscle failure: when a muscle fails, the body is essentially attempting a maximum concentric contraction but is unable to produce enough force to overcome the resistance due to fatigue of the muscle. This results in high muscle activation during the eccentric phase as the body attempts, but is unable to stop the lowering of the weight. Although training to failure can be useful, it is certainly not a method that can be utilized often in training athletes as it is too strenuous, particularly in-season, and difficult to safely execute.

Eccentric training has also been reported in some studies to increase muscle fiber length by increasing the number of sarcomeres in series. This can be a good thing as this can increase the range of motion in which a muscle can produce force. The downside of this is that when the muscle adaptively lengthens, there has been shown to be an associated decrease in the rate of force development in the concentric phase[8]. This decrease in rate of force development may have to do with decrease actin-myosin overlap or a decrease neuromuscular activation or both. There is evidence for both depending on the specific type of eccentric training.

If eccentric training, particularly at high loads, is beneficial for muscle growth but poor for neuromuscular activation and recovery, can we focus training on other phases to help an athlete reach those goals?

CONCENTRIC TRAINING BENEFITS

Concentric-biased training helps athletes reach training goals in ways that eccentric-biased can not. In order to see the benefits of concentric-biased training, we need to dive into what that looks like. There are not many ways this type of training can be achieved currently. Cycling and swimming provide great examples. Both of these sports essentially have little to no eccentric loads—they are very concentrically biased. This is why athletes in these sports can perform for very long periods of time and on back-to-back days (think of the Tour de France) and are still able to recover. They sustain very little mechanical muscle damage with the movements that occur in these sports.

Concentric-biased training can also be used in the weight room. Common movements like barbell deadlifts, high pulls, or high-catch cleans are performed and then the weights are dropped, eliminating the eccentric phase of lower the weight. Sled pushes are another great example of concentric-biased training. These exercise are used to increase training volume, and muscle activation without the mechanical stress and damage that occurs with eccentrics[9].

This lack of mechanical damage is also why these modalities are used during recovery periods. Cycling, for example, is routinely used as a means to enhance lower body recovery between competitions and heavy training days as is swimming and aquatic recovery programs.

But why are these modalities useful for recovery? The reason is because when a muscle is allowed to contract concentrically while eliminating the eccentric load, all the benefits of concentric training occur without the "negatives" of the eccentric training. This allows the athlete to add volume to their program between heavy eccentric bouts. When muscles contract concentrically, there is still substrate utilization. The body still has to produce ATP to make those muscle fibers shorten. This helps the muscle continue to adapt to the metabolic stimulus of muscle contractions. This utilization of energy then requires an increase in nutrient delivery which comes in the form of increased blood flow as well as enzyme adaptations. This may enhance the outcomes of an eccentric-biased session that occurred earlier in the week. This all occurs while still getting maximal neuromuscular stimulus from the central nervous system.

Another benefit from concentric-biased training is the increase in capillary density in the muscle that occurs with this method training method. Studies that directly compare concentric-biased to eccentric-biased training have demonstrated this[10]. The increase in capillary density increases the ability for the muscle to clear metabolic waste products, deliver oxygen to the tissue, and may enhance the ability for a muscle to recover.

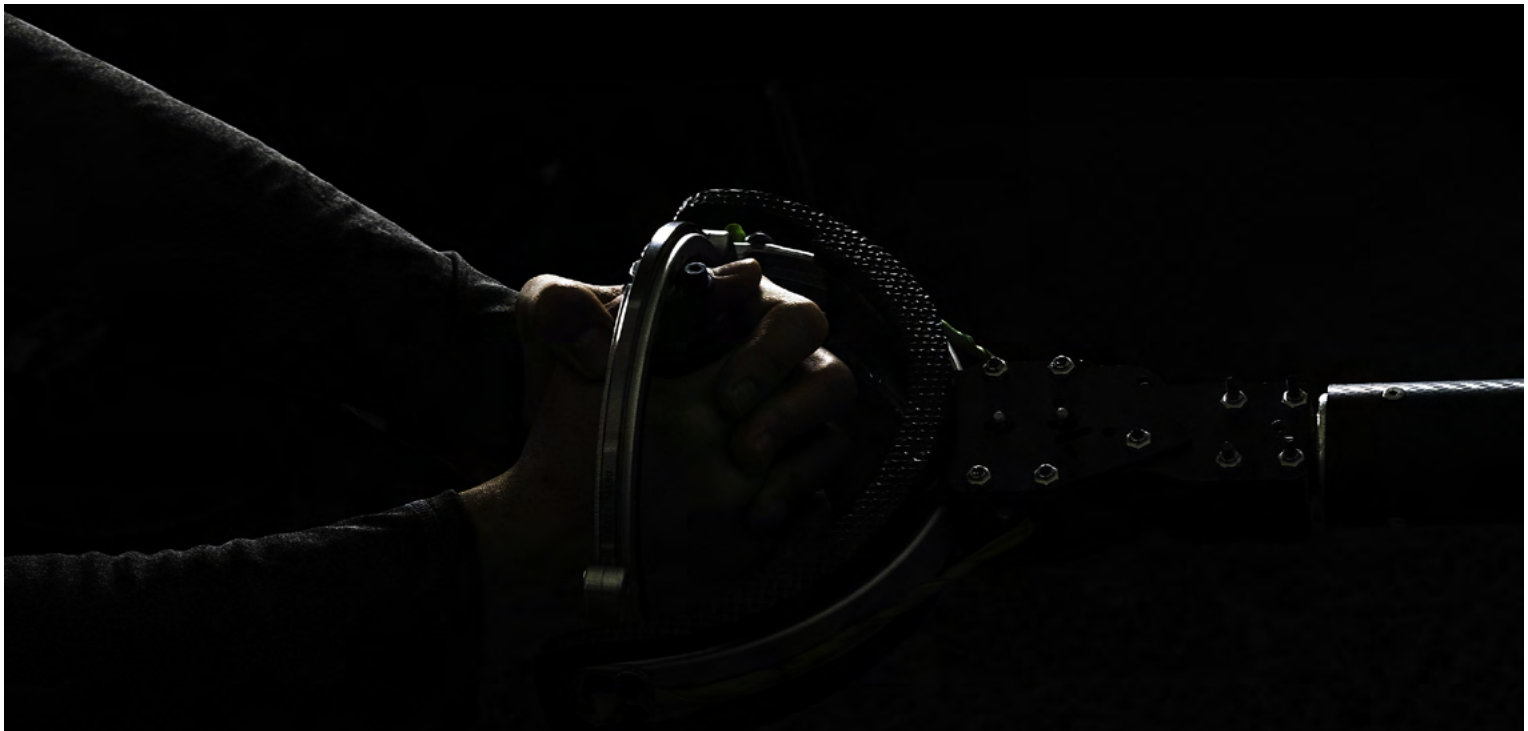
There is also evidence that concentric-biased training can stimulate muscle hypertrophy on its own[11]. A 16-week study using concentric-biased training showed an increase in muscle

hypertrophy by as much as 11% in some groups[12]. Concentric-biased training is likely not as powerful of a stimulus as eccentric-biased training is, but it still produces gains in muscle size without causing the damage that eccentrics can produce[13]. This also makes concentric-biased training useful for individuals recovering from injury. Eccentrics are in fact discouraged during the acute phase of healing for most injuries as they produce too much strain on the tissues attempting to heal. In this case, high-repetition, low-load, concentric-biased exercises can be utilized to both stimulate muscle growth and healing. The increase in capillary density as mentioned previously plays a crucial role in the healing process as it allows for more blood delivery to the injured area.

Concentric-biased training is also extremely beneficial for high-intensity training. When developing athletic movement, power is the primary goal. Explosiveness, or the rate of power production, is a component of power that needs to be trained in order to increase the athlete's ability to rapidly produce power. This will enable the athlete to get to the ball or get off the line faster, and respond more quickly. This ability to produce a rapid contraction and therefore stiffness is crucial to injury prevention in both contact and non-contact injuries. This depends on what is known as the muscle's rate of force development which depends on the number, rate, size, and fiber type of motor units activated. To train this, you need to achieve maximal concentric motor unit activation to achieve maximal motor unit firing as quickly as possible. This is where concentric-biased training, sprint training, plyometrics, and high-speed training have come into play during traditional athletic development programs.

What this all means is that concentric-biased training can be used to optimize gains from other training methods. It can be used as a crucial piece of the training program puzzle that fills the gaps in the overall training program design. We can use this method to optimize and compliment the gains made from eccentric and isometric focused training. Eccentrics can stimulate hypertrophy, muscle length, and connective tissue stiffness to a greater degree, so concentrics can then be used to optimize and compliment this training by improving the neuromuscular stimulation, rate of force development, blood flow, and metabolic efficiency without losing the gains made from eccentrics. The unique ability to increase training volume to compliment the overall training program is the greatest benefit to concentric-biased training and gives athletes and users of this training type an edge over the competition.

Boston Biomotion's revolutionary Proteus System for training and rehabilitation provides the first-ever concentric-biased 3-dimensional resistance (like aquatic therapy on land).



THE NEW SOLUTION

Boston Biomotion's Proteus System is a new training device that can be used to achieve all of the goals of concentric-biased training while giving the user real-time feedback on their performance. The collinear resistance provided by Proteus gives the user the same type of resistance that would be experienced with moving through a fluid[14]. This type of resistance, which is fundamentally different than cable machines and free weights, is uniquely constant throughout the ROM which increases muscle stimulation[15]. Early pilot studies have shown an increase in EMG activity when compared to traditional isotonic resistance. This type of resistance allows the user to perform a workout to achieve maximum benefit of the concentric phase, without the deleterious effects of the eccentric phase. Eccentric training can also be utilized on the device, particularly at high speeds, but its unique ability to maximally train the concentric phase sets it apart from other training modalities.

A major benefit of the Proteus system is also in its ability to train almost any movement, on any part of the body with three degrees of freedom. As indicated earlier, concentric-biased training is difficult to perform in the current gym setting and is limited to cycling, swimming, sled pushes, and barbell lifts with drops. The ability to train other, more complex and functional movements that simulate real-world athletic movements is unique to this system.

The feedback provided by the Proteus software allows athletes and coaches to see real-time metrics of performance and trainability. Power output, explosiveness, and optimal load calculation are just a few of the features that this system can provide that is not available with traditional training equipment. The combination of the unique abilities and state-of-the-art features of the Proteus system allow coaches, athletes, and rehab professionals to fully achieve the benefits of concentric-biased training.

Although eccentrics are necessary for developing athletes, their drawbacks of increased mechanical damage and increased recovery time make them impractical for in-season training. Concentric-biased training with Boston Biomotion's Proteus System can give athletes an edge in training neuromuscular activation, strength, power, and explosiveness with more complex movements and with shorter recovery times. It can be used both in-season to monitor and maximize recovery as well as in the off-season to maximize athletic development.

Traditional resistance only pulling straight down with gravity.

Collinear Resistance enabling seamless resistance along the path of the actual movement.

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ABOUT BOSTON BIOMOTION

Boston Biomotion's Proteus System is an innovative resistance training and performance measurement system that provides the first-ever 3D resistance (like aquatic therapy on land) combined with an intelligent software platform for athletes, trainers, physical therapists, sports medicine and doctors, that includes an array of training and recovery protocols to automatically capture and track strength and muscle performance data in 3D space and time, with powerful insights unique to The Proteus System only.

Boston Biomotion's Proteus System provides innovative training and rehabilitation solutions through intelligent software, powerful analytics, and concentric-biased 3-dimensional resistance.

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