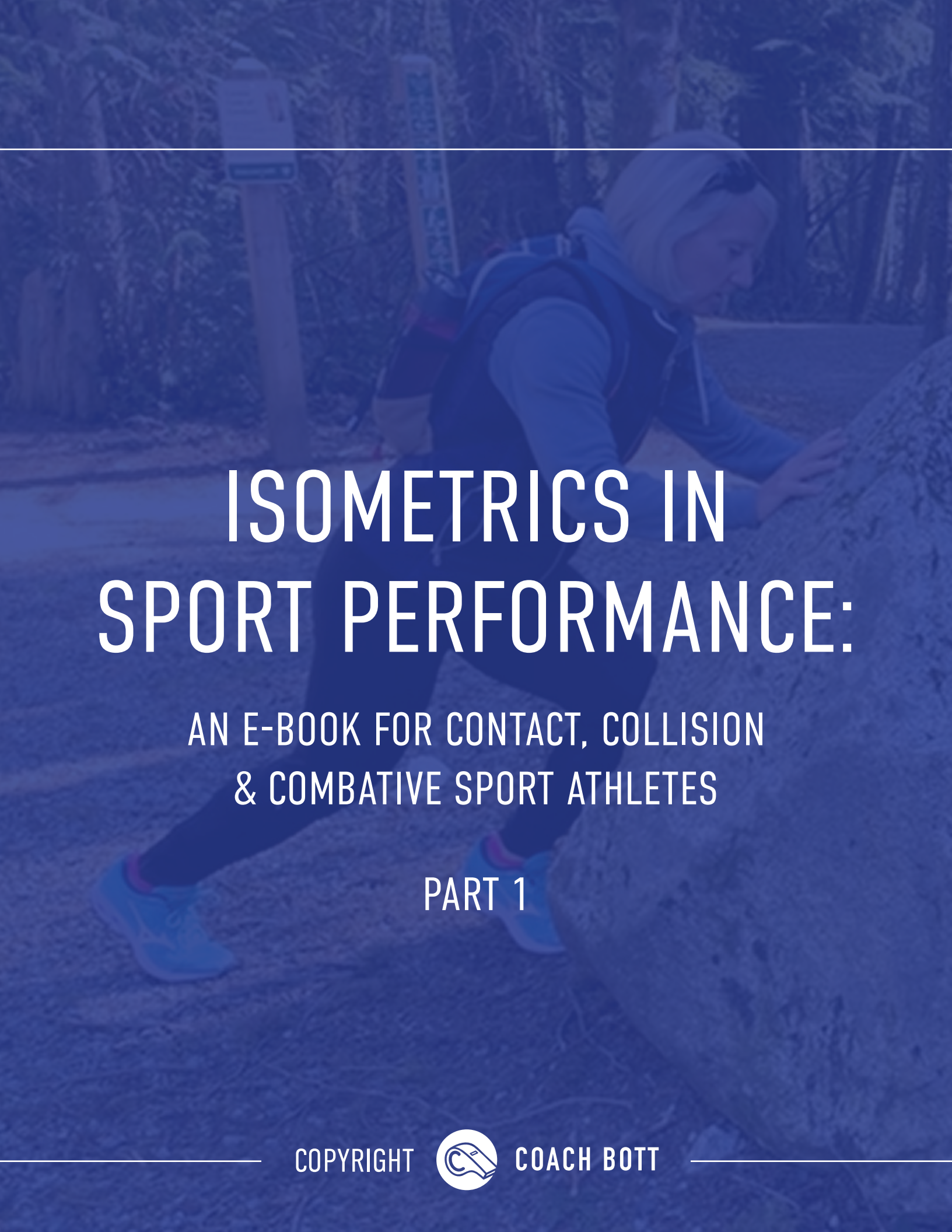

ISOMETRICS IN SPORT PERFORMANCE:

AN E-BOOK FOR CONTACT, COLLISION & COMBATIVE SPORT ATHLETES

PART 1

DISCLAIMER

ABOUT COACH BOTT

Experience

- S&C Coach/ Performance Consultant with over 20 years of experience
- Has trained 3 World Medalists in Freestyle Wrestling and several CFL draft picks
- International speaker, sought after for her practical applications of the sport sciences
- Full time Professor of Exercise Science
- Author of The Wrestler's Edge

Education & Certifications

- Master's Degree in Exercise Science
- RKC Kettlebell Challenge Certified
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PART 1: THE SCIENCE OF ISOMETRICS

Isometrics are a broad topic of interest and has been for many top coaches in the realm of performance enhancement. One drawback of traditional lifting is that the concentric contraction is the limiting factor in the completion of a lift and because of this both the isometric and eccentric actions do not get stressed or overloaded sufficiently (6). Doing lifts slowly to stress the eccentric phase is also not as stressful neurologically as it is metabolically, so other modalities of work are necessary to improve strength, power and thus performance. The use of what we know as isometrics today have been found and utilized by man for over 5000 years, whether it was a Nepalese sherpa, an ancient martial artist, or Buddhist monk - isometrics have been utilised across a broad spectrum. You'll likely be more familiar with Bruce Lee's workouts that famously brought isometrics into the eye of performers today (6).

The word "Isometric" originated from the Greek word isos, which means "the same", and metron which means "size". Thus isometric contractions translate to tensing the muscle without the muscle itself changing length (7).

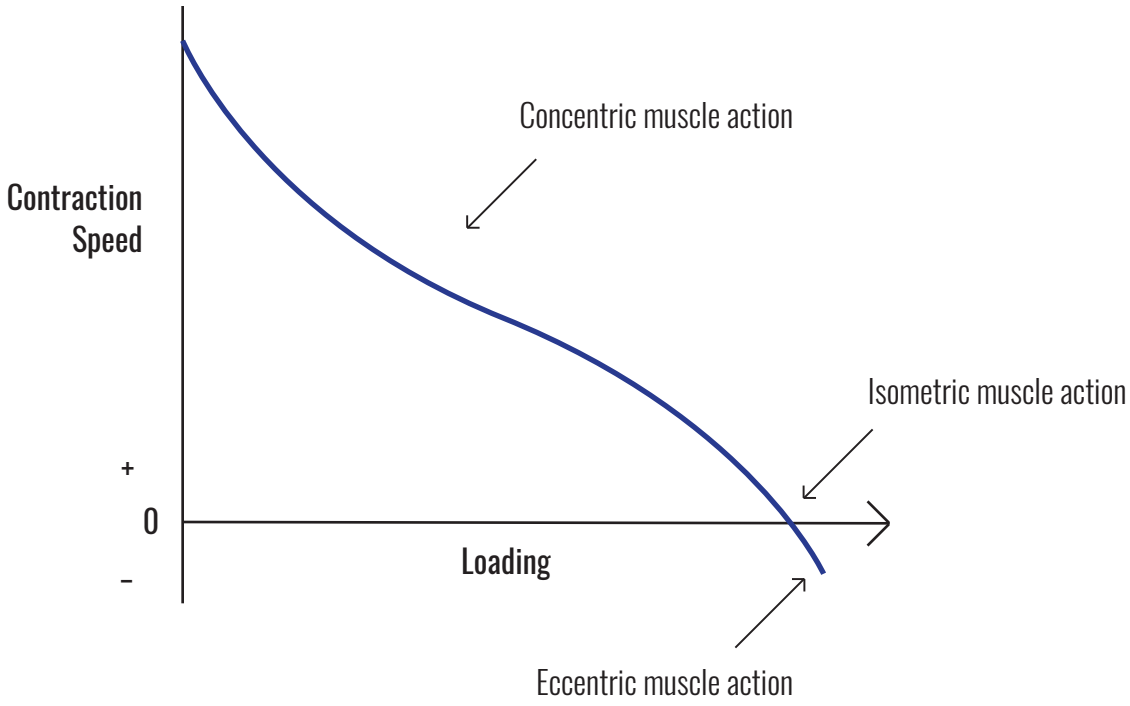
An isometric contraction of the muscle occurs when the tension developed within the muscle is equal to the external load imposed upon the muscle (2) but the limb that attempts to produce the movement remains motionless. Despite the external lack of body movement, inside the muscle, the fibers are working. Thus an isometric contraction may be highlighted by its external appearance of a static position, but the muscle fibers are in fact producing force. Isometrics create a unique, observable phenomena in connective tissues.

Isometrics are everywhere...

Isometric muscle contractions occur stabilization and the rapid transfer of energy within a single musculo-tendon structure (2). This occurs commonly in the stretch shortening cycle (SSC) where energy is transferred throughout the muscle. During the SSC, the muscle goes from a lengthening (eccentric) muscle action to a rapid shortening (concentric) muscle action (2). The isometric contraction phase occurs between these two and, in a highly trained athlete, will only be utilized for a brief moment in time (2).

It can be stated that isometrics are required at all times during movement prior to the completion of a concentric muscle action (2). For any limb to complete a motion, the acting muscle must first generate enough force throughout the musculo-tendon unit to overcome the forces acting against it. Thus, during the initial portions of tension development, when the limb is not moving and the external resistance is not moving, the muscle is still producing force.

Isometric strength plays a critical role in executing movement in a synchronized, efficient, and powerful manner as force is transferred through the muscle action phases (2). Together, the isometric (no length change), eccentric (lengthening), and concentric (shortening) muscle actions are utilized within the body in multiple fashions in order to facilitate human movement. Regardless of the exercise/movement being completed, there is always a coupling of eccentric to concentric contraction with an isometric occurring in the middle as the muscle fibers change their direction.



Source: Science Direct.com

TYPES OF ISOMETRICS

The net torque being equal to zero remains a requirement of an isometric contraction, but the manner in which this net force is achieved and then sustained can be differentiated (2). Similar to the other two muscle actions (eccentric and concentric), the external load imposed upon the muscle, the amount of momentum required, the time allowed to perform the movement and the external environment all impact the type of isometric contraction that may occur. Also, due to the innate static character of isometrics (no changes in joint angles), the muscle length at which the isometric is performed will have an influence on the adaptations (2). Isometrics can be performed at any muscle length available to an athlete, from a long-length to short-length position (2).

It is important to note, an isometric contraction requires continuous neural output to a specific target group of muscles for a time that is typically longer than that of the same dynamic movement (2).

YIELDING VS. OVERCOMING ISOMETRICS

Typically the first stage of isometric training involves yielding isometrics (6). 'Yielding isometrics' occur in an attempt to hold a position. This contraction type is normally completed in a sub-maximal effort for an extended period of time while an athlete "'fights" an eccentric contraction (2) and therefore resisting forces that try to move the body out of these positions. Yielding isometrics are associated with postural muscle groups. Efficiency of these muscles are key as their resistance to fatigue is part of the performance picture.

When an athlete holds/ pauses in a position for a period of time with a sub maximal load - this is commonly referred to as a yielding isometric. A simple example would be a pause in a squat. Yielding isometrics have the ability to transfer to eccentric strength possibly through the activation of mTor pathways (mTor is in essence the 'light switch' to muscle building and protein synthesis - it gets turned on) (7). Yielding isometrics can be done sub-maximally for long duration holds (upwards of 2 mins or more) to help remodel and strengthen tendons and connective tissue. More examples of these yielding long duration holds could be split squat & lunges (foot flat or heel elevated) as well as push-up holds. These are generally done towards the end of a session and also have analgesic properties.

Another first stage category of isometrics are 'Overcoming isometrics,' whereby force is developed with the intent to overcome the external force. Typically, the execution of this contraction type results in a maximal, or near-maximal magnitude of force (2). The goal of this isometric contraction, unlike the postural muscles, is to overcome the external force imposed and produce a powerful, locomotive force (2). Thus, this type of isometric contraction can be labeled as overcoming, as the muscle is attempting to produce as much force as possible to overcome the external load imposed upon (2). Not all overcoming isometrics result in motion. For example, someone can press against the supports of a power rack as hard as they can, in an overcoming fashion with no movement occurring.

In the realms of athletic development, overcoming isometrics have tremendous application into recruiting more muscle fibres, increasing the firing rate of those muscle fibres and (as aforementioned) being utilized at specific joint angles to carry over into your sporting endeavors (7).

The reference points with respect to intensity of the above type of isometrics as well as others are ideally derived from force plate data. Measures of absolute isometric force in key positions that exercises are performed in are evaluated quantitatively so a coach has a better understanding of an athlete's true maximum force output. That output is then extrapolated into an external load, accounting for body mass as well to determine accurate loads for athletes (6). For the purpose of this article, we will focus on more general prescription variables. It is important to note, isometrics can be done without force plates, but true maximum effort thus cannot be evaluated.

It appears that overcoming isometrics can be used in high frequency. Due to the net movement at the joint angle being zero, the damage in connective tissue is minimal to negligible. And, like with yielding isometrics, overcoming isometrics can be performed at specific joint angles. Whether you have access to formal training equipment or not, there is the feasibility for overcoming isometrics all around. The objective is to apply force rapidly up to maximal output momentarily before resting. High arousal and motivation required to reach maximal values.

The critical difference between yielding and overcoming isometrics is the goal of the movement itself. The goal of yielding isometrics is to maintain position, while the goal of overcoming isometric contractions is to 'try to' produce movement. Yielding Iso-Holds can therefore become a great segway between the unsuccessful braking work and the Overcoming Iso-Pushes (6). "Recent evidence suggests that Yielding and Overcoming isometric exercises utilize different neural strategies and provide a different mechanical and metabolic stress to each other (6)"

It is important to become strong and proficient during isometric exercises as they provide a platform to better handle high ground reaction forces later in a training program.

DURATION OF ISOMETRIC CONTRACTIONS

The most common isometric is found in a rapid and brief occurrence, as seen in the SSC utilized in every dynamic movement. The athlete who can rapidly develop isometric force (of short duration) and therefore begin concentric contraction sooner may be at an advantage from a physical performance standpoint when it comes to change of direction speed.

However, long-duration isometrics (aka extreme isometrics) are also utilized in a physical preparation prescription. For example, in a sport such as wrestling, two athletes may "grapple" with each other in a static position for an extended period of time. Although there is no "movement" in these grappling scenarios, athletes are still producing submaximal forces to create a net force of zero.

Being able to sustain an isometric contraction of a specific magnitude for a certain duration of time can be critical for a successful performance in sport. The need for duration of isometric contraction varies widely from sport to sport and from different positions in sport. Thus, the sport demands must be analyzed and prescriptions can ensue from that analysis.

THE PHYSIOLOGY OF ISOMETRICS

During an isometric repetition, the sustained contraction leads to local muscular occlusion where blood circulation is thus hindered. This temporary loss in circulation of blood signals the body's sensory organs to respond and increase the output. Thus, the blood pressure rises and a greater demand is placed on the heart muscle (cardiac) response (2). This increased blood pressure can lead to positive adaptations to the blood vessels as well as the cardiac system barring the participant is young and healthy enough to stress their cardiovascular system in this manner.

Since blood flow is directly restricted within the muscle completing the contraction, metabolite clearance cannot occur to the same extent as it would during a whole-body dynamic effort. Therefore, even at low percentages of voluntary threshold (low muscular efforts), high order motor units will start to be recruited as the lack of oxygen does not allow for metabolites to be cleared as easily and greater demand is placed on the glycolytic energy system. Essentially, it is plausible that an increase in fiber recruitment can be occurring with isometrics, in accordance with the Henman's Ramp Principle (2).

The nerve endings within the contracting muscle will also signal that the pH is rapidly decreased in the muscle, or the muscle is becoming more acidic. This is, in part, due to the reduction in blood flow, and thus, the ability to clear out the accumulated metabolites. This decrease in pH, or increased acidity, leads to an increased breathing rate. However, with this signal for increased breathing coming from a muscle completing an isometric contraction, the increased intake of oxygen will not necessarily be capable of reaching the specific muscle.

This stress creates a unique situation in which the muscle enduring the isometric contraction will remain in an acidic state, while the remainder of the body (the muscles not experiencing the isometric stimulus) may enter an alkalosis state (2) (5). An increase in pH (alkalosis), also leads to a dysfunctional reduction in carbon dioxide, as the body is breathing out this gas with every exhale (4). With carbon dioxide playing an important role in the dissociation of oxygen from hemoglobin (Bohr effect), the body may further experience reduced oxygen state.

For these physiological reasons explained, it seems that **maximally** occluded sustained isometrics (maximum efforts) would be quite difficult to maintain for an extended period of time and thus the need to vary intensity is a must.

**Not all isometrics lead to complete occlusion of the muscle, which explains why various intensities of isometrics can be held for extended periods of time.*

After a repetition, when the isometric contraction has been completed for the programmed amount of time, blood flushes out of the local muscle, with the metabolites being cleared as well. The nerve signals from the muscle are reduced, and breathing is rapidly normalized. The accumulated metabolites enter nearby oxidative muscle fibers, where they can be utilized as an energy substrate, while others enter the circulatory system where other chemoreceptors exist. The systemic chemoreceptors located throughout the circulatory system then send nerve signals to the body, again requesting for an increase in ventilation (breathing).

**Thus, the creation of a hypoxic environment could be a reason why isometrics can be useful for creating muscle hypertrophy, when we consider the research around occlusion training.*

The post-contraction, increased breathing rate will counteract the waves of metabolites that were stored, and now released, from the muscle. This increased ventilation may potentially cause a secondary level of excess carbon dioxide exhalation to occur. However, this is entirely dependent upon the number of muscles utilized in an isometric contraction as well as the total amount of metabolites produced, which seems to be influenced by both the intensity and duration of each isometric contraction.

**Thus, this information might impact rest intervals between max isometric efforts.*

It is also of interest to note, when performing an isometric contraction, the catecholamine response is much larger when compared to isotonic exercises, even when a greater total muscular demand is required of the isotonic exercises.

**Thus, sustained isometric contractions for long durations may provide a unique training and hormonal stimulus when compared to other forms of muscular contraction.*

UNIQUE ADAPTATIONS TO ISOMETRIC TRAINING

STRUCTURAL ADAPTATIONS

As Supertraining (4) states “Static (isometric) training produces the following changes: the sarcoplasmic content of many muscle fibers increases, myofibrils collect into fascicles, nuclei become rounder, motor end-plates expand transversely relative to the muscle fibers, capillaries meander more markedly, and the layers of endomysium and perimysium thicken.”

Specific to the length at which the muscle is exposed to; more pronounced when isometric contraction is completed in an elongated muscular state where there is a stretch-stress to the sarcomeres (2). Also, specific structural remodeling does not appear to be specific to the length at which the muscle is stressed isometrically and that at several lengths, fascicle length of the muscle was increased (2). Evidence suggests that alterations in fascicle length is associated with injury prevention protocols (2). Isometrics have also been shown to increase tendon stiffness, attributed to architectural realignment of fibers within the tendons (2). Tendon stiffness has been shown to increase with the length of time the isometric contraction is held (5) and also serves to rapidly transfer force through the SSC and can aid in efficient and powerful energy transfer (2). Thus, the training of tendons is imperative in this programming.

METABOLIC ADAPTATIONS

Isometrics can be prescribed to improve the metabolic functions of tissues as well. During isometrics the ability of the muscle to clear metabolites can become limited as compared to a more dynamic muscle contraction. And, as the duration of the isometrics increases, metabolites accumulate. It is a plausible claim that throughout a progressive isometric program, local muscular endurance and the ability to both tolerate and buffer the growing acidic environment would be improved with training over time. Through the use of long duration isometrics at low intensities, the ability of the muscle tissue to improve its strength at different, desired lengths, while continuing to allow oxygenated blood flow to the muscle. These long-duration, yielding exercises can include lengthened and shortened muscle states, based on the requirements of the athlete and/or their sport (2).

The use of moderate duration, moderate intensities can also lead to specific metabolic adaptations within the tissue where a coach is able to create a form of occlusion within the muscle. Reducing the blood flow to a muscle immediately reduces the ability of the aerobic system. Not only is the muscle driven into an anaerobic state (which has its own slew of beneficial adaptations when utilized appropriately), the increased training load utilized will further enhance the strength of the muscle tissue in the various tissue lengths utilized in training. This allows for a non-maximal effort, while still requiring a high-level of recruitment and adaptation at the prescribed muscle length (2). This may improve the athlete's ability to tolerate an unfavorable metabolic environment or better mimic this environment. Yielding isometric contractions can be completed in either a lengthened or shortened muscle position for a length of time to stress the anaerobic system.

**This occlusion within the muscle could also explain why longer duration (yielding) isometrics can stimulate maximal strength gains. Occlusion training research has found intensities as low as 30% 1RM can stimulate strength gains when done in an occluded/hypoxic environment.*

NERVOUS SYSTEM ADAPTATIONS

The motor cortex area of the brain specific to the utilized muscle fires at a greater amplitude post-glute isometric training (3), or an athlete has an increased ability to learn to utilize the trained muscle group in movement after this training method is implemented (2).

Unlike the isotonic exercises, isometric exercises caused greater cortical inhibition within the brain. This cortical inhibition was associated with a reduction in pain for 45 minutes (13,14). As a coach, such findings should jump off the page. 45 minutes often sounds like the length of most training sessions in the weight room. Thus, isometrics might be a useful tool to help not only build up tendon qualities (mentioned above), but also inhibit some of the pain in the structures you are trying to build up. Theoretically, if isometrics are properly applied in a warm up setting, either on the field or in the weight room, then pain may be reduced and therefore the inhibition caused by the pain may no longer hinder performance. Thus, isometrics allow one to dull the pain for an acute period, such as a training session or a game (2).

**This pain reduction quality could be beneficial for post-training to alleviate any discomfort from the session as part of a cooldown process.*

Isometrics are the foundation of rate of force development (RFD) and can assist an athlete in the initial phases of a dynamic movement where they are overcoming inertia. This 'pre-activation' may increase the initial muscle stiffness and thereby improve the ability of the tendons to be stretched and recoiled to assist in RFD. This is essentially the load and explode portion of the stretch-shortening cycle. By training with isometric programming, the ability of an athlete to produce high-force, pre-activation may be increased.

As an athlete produces rapid, high-velocity movements, they must be capable of rapidly reversing the direction of those required limbs. Without a high level of isometric strength, an athlete will be relatively slow in this ability and will not be capable of producing the highest level of performance (2).

KEY: Without the foundational and specific range of motion strength developed in many of these isometric protocols the dynamic training may not achieve the highest effect level, thus not allowing optimal performance.

SUMMARIZED BENEFITS OF ISOMETRIC TRAINING

1. Accessibility: Although certain sport specific applications of isometrics require specialized equipment such as power racks, generally you can do with such mundane things such as a wall, a rope, a stick, a doorway, a chair, or towel.

2. Specificity: The ability to train any muscles at very precise angles. Isometrics can allow an individual to develop force in positions that the body would not otherwise be able to dynamically produce a contraction in. The athlete can progress to producing dynamic strength in this position and therefore, better develop stability and control (5).

3. Time efficiency: 10 minutes per day is often sufficient and can replace a traditional WL session (5).

4. Maintains speed-strength: The ability to maintain high levels of speed-strength during important competitions due to the fact that isometrics expend a lot less time and energy than lifting weights (5).

5. Coach friendly: A more controlled, less dynamic setting may be a useful way of "re-educating" maximal intent (2). With no dynamic movement, a coach can easily control body position and teach appropriate technique for an athlete as they progress towards dynamic movement.

6. Potentiation: Pairs well with explosive exercises through post-activation potentiation.

7. Tendon stiffness: Improves tendon stiffness which is beneficial for sprinting, jumping, and injury reduction.

8. Motor learning: Create 'plasticity' in the brain to allow for learning of exercises and patterns.

9. Keeps freshness high: Quick recovery time of 6-8 hours meaning that you can perform on the same day as a practice, or perform high intensity training sessions multiple times per week. Also, traditional training is also highly fatiguing with high levels of mechanical work performed. It often results in mechanical damage (particularly with eccentric exercise) which causes soreness and requires time for recovery and therefore can negatively affect ensuing training and/or competition. On the flip side isometric training seems to require less recovery time (6).

10. Improves reactivity: Can improve athletes reactive ability (make them more spring like).

11. Overcoming inertia: Can help improve ability to overcome inertia (helpful for accelerating your body).

12. Fast twitch friendly: Can target high threshold motor units that wouldn't be possible through high rep training.

13. Rapid force production: Can train the ability to create force rapidly, which is important in sport, better than high rep/volume training.

14. Hypertrophy: Can stimulate muscle hypertrophy with minimal soreness.

POTENTIAL DISADVANTAGES OF ISOMETRICS

- They are contra-indicated to people with high blood pressure and heart problems.
- Your muscles could lose their elasticity if used too frequently (4).
- It is easy to lose your sense of exertion. Bogdasarov recommends varying the intensity of isometric contractions to address this problem, for instance an easy set followed by an all-out set (1).
- Prof. Alexey Medvedev (1986) urges caution in applying isometric exercises to children and teenagers (1).
- He also warns that strength development plateaus after six to eight weeks of isometric training (1).
- They are hard to monitor effort - requires a motivated & reasonably knowledgeable athlete and/or good coaching.
- They are difficult to progress over time.
- They can become monotonous.

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