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Brief Review

A Brief Review of Concurrent Activation Potentiation: Theoretical and Practical Constructs

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Abstract. Ebben, W.P. A brief review of concurrent activation potentiation: Theoretical and practical constructs. *J. Strength Cond. Res. 20(4):985–991. 2006.*—Enhancing the acute quality of the resistance training stimulus is the goal of many research and applied professionals. To that end, many methods have been proposed and a variety of training strategies and ergogenic supplements have been investigated. Postactivation potentiation is one phenomenon that has been frequently examined, offering some promise in this regard. Though never previously applied in the strength and conditioning profession, dental research on jaw clenching, studies examining the Jendrassik maneuver and remote voluntary contractions and research on motor overflow together make a compelling case for the existence of a concurrent activation potentiation phenomenon and the acute ergogenic advantage associated with the simultaneous activation of muscles other than the prime mover or synergists. Evidence demonstrates that this advantage is accrued via activation of the H reflex and through cortical overflow. Ultimately, through research and practical application, athletes may be taught to optimize the type, timing, and magnitude of remote muscle actions in order to gain an ergogenic advantage and increase the acute response of the prime movers. This strategy may be especially useful during the most difficult portion of a resistance training repetition and during the most difficult repetitions of a resistance training set.

Key Words. Jendrassik maneuver, remote voluntary contractions, motor overflow, strength

Introduction

When exerting maximal muscular effort, it is somewhat common for people to clench their jaw, to develop muscular tension in the face and neck, to increase core muscle tension via a modified Valsalva maneuver (grunting), and to activate core muscles. These practices often occur during resistance training exercises. Since these practices are commonly invoked, there may be a physiological explanation for this behavior.

An explanation for this behavior can be pieced together from a variety of disciplines and their respective literature, such as that which examines the use of mandibular orthopedic repositioning appliances (MORA), teeth clenching, the Jendrassik maneuver (JM), and the concept of the remote voluntary contraction (RVC), as well as the literature on motor overflow. Though not previously described in the strength and conditioning literature, together this research provides an argument for the potential ergogenic advantage associated with muscle activations remote from, but concurrent with, the activation of a prime mover in many activities or exercises.

Historically, investigators wondered if oral devices such as the MORA, which aligned the temporal mandibular joint, as well as biting, had an affect on strength (13, 26). The potential increases in strength associated with the use of the MORA and biting may best be explained by a substantial body of literature investigating the clinical concepts associated with the JM and motor overflow.

If RVCs offer an ergogenic advantage, an explanation can be found in understanding the JM, which was first described in 1883 and was used as a means of potentiating the tendon reflex in neurologically impaired patients (43). More specifically, the JM is defined as a technique in which patients clench their teeth, hook together their flexed fingers, and attempt to pull their hands apart. The JM increases the strength of reflexes, often measured clinically by assessing deep tendon reflexes (43).

According to Pereon et al. (31), the JM is an example of an RVC, which may include muscle contractions other than those specifically described in the JM, in order to increase the amplitude of reflexes and neural excitability of the lower body. Theoretically, it is possible that JM-like actions, such as contracting muscles not involved as primary movers or synergists, may increase the acute strength expression of the primary movers, and thus the quality of a resistance training stimulus. Another possible explanation for why muscle actions remote from the prime mover may potentiate the prime mover centers around the idea that intercorticol communication, or motor overflow, occurs between different motor areas of the brain, and from one cerebral hemisphere to another. Potentially, athletes can be taught to take advantage of these phenomenon more effectively and systematically than occasionally gripping, grimacing, and grunting.

Ultimately, concepts such as the JM, and the broader description of this phenomenon, RVC, as well as motor overflow, can be described as a potentiation phenomenon. Potentiation is usually described based on its mechanism of action, such as the reflex potentiation (33), and twitch potentiation (30), or by its time course, as is the case with short-term potentiation (18), and postexercise potentiation, or postactivation potentiation (PAP) (39). For purposes of this paper, the term concurrent activation potentiation (CAP) is used since the JM, RVCs, and cortical motor overflow occur at the same time as the activation of the muscles that are the target of the training. Thus, the purpose of this paper is to introduce the concept of CAP, review the research supporting the effectiveness and mechanisms of action of CAP, encourage the systematic investigation into this phenomenon, and suggest practical examples of how CAP may be applied in strength and conditioning settings to potentially increase the quality of the acute training stimulus.

Evidence Regarding the Effect of Concurrent Activation Potentiation

Mandibular Orthopedic Repositioning Appliances and Dental Research

Some evidence suggests that the use of the MORA reduces mouth injuries and may provide ergogenic benefits, perhaps due to a placebo effect (26). Other literature reviews on the topic have indicated that of the exercises assessed, isometric strength increased with the use of the MORA (13) or have been critical of the experimental design of studies investigating this issue (14). Upon closer examination, some studies failed to find any ergogenic effect of using the MORA (2, 28, 42), including a study of a variety of strength tests of National Collegiate Athletic Association Division I football players (42). Other studies indicated that the MORA was effective in increasing maximum voluntary contraction of the muscle groups assessed (13, 41). Collectively, these studies do little to answer the question of whether the MORA and biting offer an ergogenic benefit via RVCs. However, questions remain about whether it is useful. The research on the JM is more compelling.

Jendrassik Maneuver Research

Several studies have assessed the effect of the JM, consistently demonstrating a positive relationship between the JM and the outcome variables assessed, including H reflex potentiation (H reflex), T reflex, motor evoked potentials (MEPs), electromyography (EMG), force, rate of force development (RFD), and strength (5, 6, 9, 10, 12, 17, 29, 31, 34, 36, 40, 43). Of these, the H reflex may be the most important mechanism to explain the JM.

Remote voluntary contractions may be useful for increasing the H reflex. The H reflex results from stimulation of sensory fibers with the resulting afferent discharge causing an excitatory potential in the motor neuron pool. Exceeding the potential threshold for a particular motor neuron generates an action potential, and the resulting afferent discharge will cause the muscle fibers innervated by that neuron to be activated. The H reflex is used to assess the excitability of spinal alpha motor neurons, while reflecting transmission efficiency such as presynaptic inhibition in Ia synapses. Acutely, the H reflex increases concurrent with RVC and has been demonstrated to increase by approximately 20% from 1 to 10 minutes following 8 sets of 10 reps of resistance training exercise. Thus, the H reflex demonstrates both CAP and PAP responses (39). Change in the H reflex activity is also one of the chronic neural adaptations to resistance training. Previous research has shown that subjects' H reflex amplitude was increased by approximately 20% after 14 weeks of training, increasing at a rate similar to the rate of strength increase (23–30%) (1). Consequently, it is theoretically possible that a stimulus that increases acute H reflex activity, such as RVCs, has the potential to increase chronic H reflex activity and ultimately improve strength.

The traditional JM has been shown to increase T reflex as well as H reflex responses in test subjects (6, 12). Similarly, variations of the JM, such as attempting to pull apart one's grasped hands as hard as possible, have been previously demonstrated to facilitate the H reflex (5, 43). In addition to hand grasping, other forms of RVC, such as squeezing a tennis ball, resulted in an increased H reflex response in both young and elder subjects (40). Interestingly, even small muscle group contractions associated with mastication increase the H reflex in the pretibial and soleus muscles, which is thought to be developmentally important for stabilization of postural stance. According to one study, jaw closing resulted in no significant difference in H reflex facilitation compared to jaw opening, with the magnitude of the soleus muscle group H reflex response to jaw opening and closing representing 135.4 and 133.8% of resting H reflex activity, respectively (36).

In addition to mastication, previous studies in which subjects performed teeth clenching demonstrated increased H reflex activity (29, 31, 34). More specifically, Miyahara et al. (29) examined subjects who performed voluntary teeth clenching in order to investigate the correlation between motor functions of the jaw and body. Results reveal increased soleus H reflex facilitation, particularly during teeth clenching, with increased H reflex activity correlated with increased masseter EMG. Sugawara et al. (34) assessed H reflex activation to determine excitability at the spinal level, as well as MEP following transcranial magnetic stimulation to assess excitability at the cortical level. Facilitation was observed in both H reflex and MEP. Therefore, 2 neural pathways are presumed, one involving a release of presynaptic inhibition at the spinal level and another involving the unmasking of lateral excitatory projections at the cortical level, suggesting that both processes may be important during the JM. The magnitude of the change in MEP has been investigated and determined to be 170% greater than baseline in response to a JM consisting of a bilateral hand grip (31).

Studies examining the JM consistently demonstrate its positive effect on the mechanisms by which the JM is facilitated, such as the H reflex and MEP. However, one study specifically measured the outcome of those mechanisms, by assessing grip strength and RFD. Hiroshi et al. (21) conducted a study in which subjects clench their teeth before, as well as before and during, a test of grip strength, resulting in 12.1 and 12.3% improvements, respectively. Furthermore, maximum RFD with teeth clenched before, as well as before and during the test of grip strength, was 8.5 and 15.8% greater, respectively, compared to grip strength when the teeth were not clenched.

Unilateral ankle dorsi flexion significantly increased the H reflex in the flexor carpi radialis of the contralateral side by approximately 22 ± 52%. However, this same study showed that unilateral wrist extension decreased contralateral flexor carpi radialis H reflex by 33 ± 29%, although MEPs increased to as much as 215 ± 85% of control values, suggesting stimulation of the corticospinal tract as well (22). The literature seems to indicate that the JM has a facilitory effect and several researchers have attempted to explain the mechanisms of action of this phenomenon.

Corticol and Motor Overflow Research

The JM literature describes the important role of the H reflex and offers less-clear cortical explanations for the CAP elicited as a result of RVCs. These cortical mechanisms may be explained by theories of motor overflow including the cortical connection theory, the transcallosal facilitation hypothesis, and the transcallosal inhibition theory. These theories are not mutually exclusive and support the idea that there are functional cortical connections. In other words, when one part of the motor cortex is active, as would occur during an RVC, connections to other areas of the motor cortex are affected. While there are many possible explanations for this occurrence, one is functional synergy, such as would be required between the upper and lower body during locomotion. Explanations may also be evolutionary or developmentally based, such as the need to eat while locomoting or to grasp and bite at the same time. Ultimately, the effect of RVCs on prime movers can be explained by understanding the research evaluating the nature of cortical connections.

Cortical Connection Theory

In humans, the MI motor area is responsible for control of muscle force and movement direction. This area contains functional subdivisions of the face, arms, and legs. These divisions are overlapping and interconnected and are plastic in their reorganizational response to pathology and motor learning (11).

In animals, cortical interconnections have been demonstrated between visual and motor areas of the cortex (16) and during hand-eye coordination (27). In monkeys, evidence indicates that the prefrontal area of the brain is connected with a variety of nonmotor and motor areas (3). Huffman and Krubitzer (24) examined cortical connections in marmosets using electrophysiological recordings and anatomical tracing techniques in order to map the functional organization of area 3a. Results reveal an integration of cortical areas within area 3a as well as other motor areas and somatosensory areas with patterns of interconnections between behaviorally relevant body parts. These findings suggest the existence of functional cortical connections for hand-eye reaching tasks and between forelimb and hindlimb, potentially important for functional synergy. Simply stated, in some cases, the movement of one limb is cortically connected to another. Other animal research has advanced the idea of a functional organization of cortical connections, specifically between the motor areas associated with the hindlimb and the contralateral forelimb of rats, and that this connection can be developed through training, further demonstrating the existence of cortical interconnection and its plasticity (32). In addition to cortical interconnections, some evidence also suggests that monkeys have somatopically organized input from MI, located in the putamen where some functional overlap may occur as well (35). Most of the evidence demonstrating cortical connections has been gleaned from animal studies. However, some evidence indicates these interconnections occur in humans as well, as proposed in the literature evaluating motor overflow.

Motor Overflow

Research on motor overflow demonstrates motor cortical connections in humans with neurodegenerative diseases. Motor overflow can be defined as involuntary activity in the homologous muscles of the contralateral side of the body during voluntary muscle contractions, which can be induced or demonstrated during neurological dysfunction (15). For those with neurological dysfunction, motor overflow includes the involuntary movements that occur as the result of voluntary movements (23). In those with neurodegenerative diseases, the excess movements associated with overflow are obviously unintentional and undesirable. These excess movements are reported to be atypical in the normal population (23). However, previous studies demonstrate motor overflow in healthy controls, although at rates lower than those with neurodegenerative disease (15). For example, normal controls, compared to affected subjects, demonstrated 2.79 ± 1.51 to $8.96 \pm 3.48\%$ compared to 5.67 ± 4.39 to $23.77 \pm 30.20\%$ changes, respectively, in the percent of motor overflow as assessed by a linear variable differential transformer used to assess absolute force in g·weight^{-1}. In other words, movement of the ipsilateral hand resulted in facilitation of the contralateral hand in both affected and normal subjects, although the magnitude was smaller in the normal subjects. Additionally, transcallosal motor overflow has been demonstrated in 12 different relaxed, contralateral, forearm muscles via EMG, caused by movements of the ipsilateral forearm (4). Two theories are proposed to explain the cortical connections associated with motor overflow.

Transcallosal Facilitation/Inhibition Theories

The transcallosal facilitation hypothesis states that activation of a cortical region associated with a voluntary movement activates the contralateral hemisphere and homologous muscle in via interhemispheric connections. This facilitation results in motor overflow unless inhibited (15). The transcallosal inhibition theory indicates that motor overflow occurs as a result of the removal of inhibition within the ipsilateral corticospinal tract and that movements produced by the contralateral hemisphere result in a degree of ipsilateral facilitation from overflow (15). Ultimately, a theoretical explanation of the mechanisms of action of CAP must consider both the potential effects of motor overflow, as well as the theoretical explanations associated with the JM.

POSSIBLE MECHANISMS OF ACTION OF CONCURRENT ACTIVATION POTENTIATION

As previously stated, CAP may work through excitatory cortical projections and motor overflow. Additionally, it is likely the JM and RVC work via their effect on the H reflex, although previous investigations yield limited insight into the specific mechanisms of this reflex facilitation (17). Ultimately, a number of possible mechanisms may explain CAP, including the increase H reflex and MEP response to the JM. Possibilities include increases in the activity of the alpha motor neuron activity, gamma loop, muscle spindle, and descending cortical input, as well as stimulus invoked afferent input resulting in inhibition of the presynaptic inhibition and postsynaptic changes in membrane potential. The literature offers some guidance as to which of these mechanisms may be most important, particularly regarding the H reflex potentiation, which ultimately is manifested in a 3-phase response.

Triphasic Response

Some evidence indicates that the JM reflex facilitation occurs in 3 phases: the first begins before EMG is noticeable in the facilitated muscle, the second phase is characterized by maximal intensity, followed by a progressive decrease, and eventually a third phase of medium intensity occurs that is stable until the end of the contraction (8, 9). The first phase is thought to be due to supraspinal facilitation, whereas the stimulation of afferents of the muscle undergoing the RVC may result in H reflex facilitation that is more significant during the second phase, and finally, the tendon reflex may be more significant during the third phase. Facilitation of the alpha motor neuron is thought to be part of the explanation for the increase in amplitude during the second phase (8), although the role of the alpha motor neuron remains equivocal.

Alpha Motor Neuron/Gamma Loop

Burke et al. (5) suggests that the differences between JM responses of young and older subjects is due to differences in the inhibitory and excitatory influences on alpha motor neurons, proffering a role of the alpha motor neuron in response to the JM. On the other hand, other researchers indicate that the JM does not operate by direct facilitation of the alpha motor neuron, as evidenced in a study of ischemic muscle that resulted in the blocking of the alpha motor neuron, despite the fact that the H reflex was still facilitated (18). Similarly, the gamma loop may have a limited role in the JM as well, as reported by Bussel et al. (6), who determined that the facilitory effect of the JM remains even if Ia afferent nerve fibers are blocked by ischemia and spindle activation cannot affect the alpha motor neurons, thereby concluding that the JM is not routed via the gamma loop.

Muscle Spindle/Presynaptic and Postsynaptic Changes

Earlier work eliminated the muscle spindle and gamma loop as the JM-induced mechanism of spinal reflex facilitation, leaving presynaptic (inhibition of presynaptic inhibition) and postsynaptic changes in motor neuron membranes potential as a viable explanation (12). According to Dowman and Wolpaw (12), H reflex amplitude facilitation increased, in the absence of an effect on soleus EMG; thus, the H reflex change was not caused by an increase in excitatory input into the soleus motor neuron pool. The researchers suggest a change in a stimulus evoked afferent input at some point proximal to the muscle spindle such as presynaptic inhibition or change in motor neuron pool resistance. Presynaptic modulation of the H reflex has since been confirmed (43), and Hortobagyi et al. (22) report that the muscle spindle and cutaneous afferents are not the likely contributors to the JM-induced increase in H reflex, maintaining that there is likely a cortical and segmental component.

Corticol Control

Soleus H reflex activity seems to be related to teeth clenching force level, possibly due to afferent input from oral motor structures and descending influence from the higher brain (29). This issue was further examined by Chen et al. (7), who used electrical conditioning stimulation delivered to the left index finger, preceding transcranial magnetic stimulation of MEPs of the tibialis anterior and gastrocnemius. In this study, the peripheral volley of electrical conditioning stimulation must have been transmitted supraspinally to facilitate MEPs in the lower limb since facilitation did not occur in patients with thalamic infarction when the stimulus was applied to the affected side. In other words, the transcranial magnetic stimulation was not the source of the source of the facilitation as it was mitigated in the subjects with thalamic infarction. Other researchers found increased MEPs even in the absence of changes or associated with a decrease in the H reflex, stimulated by upper-body contralateral muscle activations (22).

Presently, the evidence suggests that the potentiation effect of the JM is not a result of changes in alpha motor neuron, gamma loop, or muscle spindle activation. The JM effect is most likely due to a combination of cortical influence as well as inhibition of the presynaptic inhibition, mediated by stimulus evoked afferent input, consisted with proposed role of the H reflex, as well as changes in postsynaptic membrane potential.

Evidence Regarding How to Best Optimize the Effects of Concurrent Activation Potentiation

Mastication and Teeth Clenching

Takahashi et al. (36) indicated that both jaw opening and jaw closing are equally effective, suggesting that jaw closing may not be critical, despite a number of JM studies that report that teeth clenching is effective in increasing H reflex activity and strength.

Previous reports indicate that teeth clenching before, as well as before and during, grip strength tests resulted in acute strength improvements (21). In fact, some evidence suggests that teeth clenching alone may be ideal, as shown in a study that demonstrated that maximum voluntary teeth clenching facilitated more soleus H reflex than the combination teeth clenching and maximum voluntary efforts of other parts of the body such as hand clenching (29).

Wrist Extension, Flexion, and Handgrip

While the concept of the RVC descends from the JM, RVCs other than teeth clenching or those specifically prescribed during the JM have also been demonstrated to be effective in eliciting changes in the variables assesses. Previous research has examined RVC in upper-extremity limbs including wrist extension and flexion and handgrip. According to Delwaide and Toulouse (8), contraction of the wrist extensors facilitated reflexes as effectively as the classic JM, which includes teeth clenching. Other research has demonstrated that wrist muscle contractions as well as squeezing a tennis ball facilitate the H reflex response (12, 40) and bilateral handgrips increased MEPs (31). Thus, it appears that RVCs in addition to those associated with mastication and teeth clenching may be useful.

Intensity and Duration

Evidence is limited regarding the intensity of RVCs and its effect on the degree of potentiation. Typically, JM and RVC are performed forcefully or maximally. Hortobagyi et al. (22) reported that MEPs increased to 176 ± 57 and $215 \pm 85\%$ at RVCs of 50 and 75% of maximum voluntary contraction, respectively, possibly indicating that RVCs with higher intensity muscle activations are preferable. According to Hays (20), the duration of the RVC, such as handgrip, shows a nonsignificant trend toward decreased facilitation with no facilitation occurring at more than 6 seconds after initiation of the RVC. More specifically, the total reflex time of the patella tendon reflex was 107.89 milliseconds after a 1-second RVC compared with 108.67- and 110.79-millisecond reflex times after 3–4 and 6 seconds of RVC, respectively. While these data examine the patella tendon reflex, the important aspects of the time course of the H reflex and muscle response may be similar, suggesting the RVCs may be optimal if they are brief and cyclical as opposed to lasting longer than 6 seconds. Therefore, it may be best if the RVCs are invoked cyclically during the challenging portion of the resistance training set and repetition.

Contralateral Effects and Relaxation of the Homonymous Muscle

The facilitation associated with the JM and RVCs may be manifested in ways other than upper-body muscle contractions causing facilitation of lower-body muscle. Other possibilities include RVC of the jaw muscles that facilitate upper-limb muscles, RVCs of the contralateral arm resulting in facilitation of the ipsilateral arm (22), and RVCs of lower-body muscles facilitating the contralateral arm. In addition to the facilitation resulting from contralateral RVCs, full relaxation of other homonymous muscles has been reported to be important as well (37).

Upper-Body Facilitation

In addition to the literature that has examined the effect of upper body RVCs on lower-body muscles, some evidence indicates that RVCs of muscles in the face or the lower body facilitate muscle activity in the arm. For example, Sugawara and Kasai (34) showed that remote facilitation invoked with the JM (voluntary teeth clenching) is a dependable method increasing H reflex and MEPs of flexor carpi radialis. Similarly, Hortobagyi et al. (22) showed that ankle dorsiflexion facilitated the contralateral H reflex in the right flexor carpi radialis.

Muscle-Specific Responses

Ultimately, a variety of RVCs may be useful, including upper-body RVCs to facilitate muscles in the lower body, lower-body RVCs to facilitate muscles in the upper body, and RVCs of the face and jaw muscle in order to facilitate muscles in either the upper or lower body. However, some RVCs may be more effective for some lower-body muscle groups than others. Toulouse and Delwaide (38) evaluated a variety of lower-limb reflexes and found that quadriceps tendon reflex is facilitated more than the soleus or biceps femoris. This finding exists, despite the fact that H reflex responses are often studied and demonstrated to be effective in the soleus, presumably because this reflex is relatively easy to assess for the soleus muscle group. Other research suggests differences in muscle response potential depend on the muscles involved in the RVCs. For example, lower-limb reflexes are facilitated more by thenar muscles and wrist extensor RVC than deltoid muscle and wrist flexor RVC (38). Research in the area of muscle-specific responses is limited, although existing data suggest possible optimal combinations of RVCs.

Effect of Age on Concurrent Activation Potentiation

Previous research is consistent regarding the role of the JM on H reflex activity with respect to aging, suggesting that sensitivity to the JM decreases with age (5, 19, 40). Tsuruike et al. (40) found differences in JM-induced H reflex increases between young and elder subjects during simple and complex postural tasks. According to Burke et al. (5), there may be a 33% reduction in JM-induced reflex facilitation in older adults compared to younger subjects. Thus, training that attempts to take advantage of RVCs may be optimal for younger athletes.

Time Course of Concurrent Activation Potentiation

Research suggests that the JM manifests in a triphasic response with its H reflex effect occurring before noticeable EMG activity. This fact, as well as previous reports that teeth clenching before, as well as before and during, grip strength tests resulted in improvements, suggests that it may be useful for RVCs to begin prior to the performance of the resistance training exercise for the muscle group that is the target of the facilitation (21). However, there may be an optimal window of opportunity for facilitation since the H reflex is strongest during the second phase of the RVC, at the point where noticeable EMG begins in the target muscle that is being facilitated (8). Additionally, the timing of instruction of the JM may be an important determinant of the enhancement associated with the maneuver (25).

PRACTICAL APPLICATIONS

The literature indicates that RVCs of upper-body muscles may potentiate lower-body muscles. The data can presently be conceptualized according to two theoretical constructs. One suggests that mastication or jaw muscle activation may potentiate lower-body muscles, and the other suggests that mastication or jaw muscle activation combined with gripping, and possibly the activations of core and upper-body muscles, may potentiate lower-body muscles. Therefore, a variety of lower-body exercises may be enhanced by mastication or a clenched jaw and maximal bilateral handgrip. This may be accomplished by simple practices such as chewing gum, wearing and biting down on a mouth guard during resistance training, and forcefully gripping the barbell, dumbbells, or machine handles, all prior to the onset and during the concentric phase of the resistance training exercise, and perhaps applied during the later reps of a set when completion of the reps becomes more difficult.

Speculation remains as to whether the benefit is proportional to the quantity of muscle groups involved, although anecdotal practices suggest that comprehensive RVC is useful. During the squat, for example, an athlete may bite down on a mouth guard, maximally grip the barbell, and forcefully pull the barbell into the trapezius, during the challenging portion of the concentric range of motion. Theoretically, it is also likely that the activation of core stabilizers and a modified Valsalva maneuver may also accomplish some of the same benefits of the RVC described above.

According to the evidence, RVCs may also affect the contralateral side. Thus, when performing unilateral training, it may be useful to use a handgrip dynamometer, or grip a bar, dumbbell, foam roll, or other implement in the hand contralateral to the muscle group that is to be trained. From the standpoint of functional training for balance, it may not be desirable to grip stationary objects. Interestingly, according to this construct, one may train for grip strength in one hand and perform another strength training exercise while using the other. Some examples may include performing unilateral dumbbell biceps curls or overhead press while gripping with the contralateral hand. An example for the lower body may include performing the single leg stiff leg dead lift while forcefully gripping the dumbbell in the contralateral hand. For bilateral upper-body exercises, it is possible that exercisers are already systematically taking advantage of the RVC phenomenon with the right side potentiating the left and vice versa.

In addition to upper-body RVCs affecting lower-body muscles and the possible role of contralateral RVCs, muscle actions of the lower-body may potentiate muscles of the upper-body. Thus, ground-based exercises that require stabilization and activation of lower-body muscles may offer RVCs that are useful during the performance of upper-body exercises, when performed in the standing position. Additionally, isometrically activating muscles of the lower body such as the posterior compartment of the lower leg or those that make up the quadriceps group may be useful for potentiating muscles during upper-body exercise such a lateral pull-down, the bench press, and lateral raises, to name a few. Anecdotal observations even suggest that walking, while performing exercises such as curls and lateral raises, may offer an ergogenic advantage, although it would be important to determine if it is for inertial reasons, the activation of vibration, pressure, and proprioception afferents, and their effect on the perception of pain due to the release of opioids in the substantia gelatinosa, or if it is due to the effect of the lower-body RVCs.

SUMMARY

One of the important challenges of strength and conditioning research is to find nonchemical and economically viable ergogenic advantages for developing athlete strength. In this regard, the concept of CAP offers promise, particularly in light of the JM and RVC literature and the enhanced acute H reflex response to RVCs. Furthermore, chronic changes in the H reflex seem to closely parallel changes in strength.

Anecdotally, one can begin to evaluate the effects of CAP on their own or with athletes and observe the results, thus increasing the practical applied knowledge of this mechanism of training. This can be done via some of the recommendation already provided and the creative application of this concept to a variety of exercises and by performing variations of RVCs and observing which may be useful. Additionally, the effect of RVCs may be noticed by alternating reps with and without RVC during the performance of a variety of exercises.

Acute studies that evaluate the effect of CAP, assessing motor unit activation, strength, force, and rate of force development, should be conducted to empirically determine if CAP is useful and, if so, to identify the optimal types and combinations of RVCs. It may be important to determine whether or not it works equally well for upper- and lower-body muscles, if there is an optimal type of RVC or combinations of RVCs, if lower-body RVCs affect upper-body, the effect of contralateral RVCs, to determine if CAP affects muscle groups in a similar fashion, and to assess if there are age and gender differences in the effect of CAP. If CAP offers an acute training advantage, eventually training studies would be useful to determine if CAP can play a significant role in enhancing chronic adaptations.

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