Enhancing Athletic Performance by Predicting Fatigue and Preventing Muscle Failure

Stephen C. Gangemi, DC, DIBAK

Abstract

Preventing muscle fatigue and increasing human performance, whether for the average person or a world-class athlete, is a considerable topic of investigation. Often, muscle fatigue occurs with no clear antecedent, typically sooner than expected, and always sooner than desired. If an individual, or even a specific muscle, is not experiencing any muscle inhibition (weakness) during the examination process, it is very difficult, if not impossible, to determine what may be done to prevent that weakness from occurring once exercise begins. What if there was a way to determine what would fatigue before it actually did? This author submits a way to challenge the body and test to see if prediction is possible, and, if so, determine to what extent prevention is possible or at least significantly delay fatigue onset.

Key Indexing Terms
Glucose, Branched Chain Amino Acids, Bcaas, Protein, Glycogen, Cortisol, Manual Muscle Testing (MMT), Gluconeogenesis

Introduction

Muscle fatigue has been shown to occur for many reasons – depletion of ATP, depletion of glycogen, dehydration, lactic acid accumulation, generalized physical fatigue, cramping, mental fatigue - the list goes on. The quest for athletes to push their physical performance to new levels is understandably under constant scrutiny; more strength and speed is of utmost importance. Dietary considerations are well known to have a major impact on performance, not only before and during exercise, but also immediately after. An increasing amount of research emphasizes post exercise carbohydrate and protein intake is paramount given their impact on performance.

The average 150-pound endurance athlete can store approximately 450g (1800Kcal) of glycogen/glucose while the average 120-pound female can store slightly under 400g (1550Kcal).[1] The intensity and duration of exercise will determine how much glycogen is being depleted, and therefore, how much eventually needs to be replaced. Protein requirements vary for individuals, but they are significantly increased in athletes. The current protein guidelines for endurance athletes are 1.6 to 1.7 g/kg for strength athletes and 1.2 to 1.4 g/kg for endurance athletes.[2] However, some studies suggest higher levels in endurance athletes, up to 15% of caloric expenditure.[3] For a 150lb male endurance athlete burning 4,000 Kcal a day, that would equate to 2.2g/kg of protein. Nitrogen balance is the main factor affecting how much protein any person needs, athlete or not. Nitrogen balance refers to the body's state of either having enough protein available for the body to use or having a lack of protein for the body's use. When protein is broken down and used as energy, whether to repair, rebuild, or fuel the body, nitrogen is released, and an excess accumulation will overburden the body, resulting in ammonia toxicity. An individual with ammonia toxicity will experience physical and mental fatigue – an overall lack of motivation. Ammonia toxicity can be screened by performing the "Ammonia Sniff Test" as developed by Walter H. Schmitt, D.C.

During the recovery phase following any training regime or competition, there is a time considered as the "window of opportunity" where an athlete can recover faster than if he or she was to wait. The window is said to be open for approximately 60 minutes post-exercise and the focus should not be just on hydration, but also on protein and carbohydrate intake particularly. Approximately 100g of carbohydrates and 25g of protein are needed within the first hour after exercise (the actual amount depends on body weight, activity duration and intensity). This ratio of 4:1 is said to nearly double the insulin response, which results in more stored glycogen. Carbohydrate-protein (CHO-PRO) supplementation is more effective to rapidly replenish glycogen levels than just a regular carbohydrate supplementation post-exercise.[4] CHO-PRO supplementation has also been shown to improve exercise endurance during a second bout of exercise performed on the same day.[5] Glycogen stores are quickly replenished in depleted muscles (and to some extent the liver) and amino acids are readily available to repair any tissue damage, particularly those caused by cortisol's influence of converting amino acids (specifically branch chain amino acids) to glucose for fuel through the process of gluconeogenesis.

Amino acids are oxidized as substrate during prolonged exercise and both endurance and resistance training increase skeletal muscle protein synthesis and breakdown in the post-exercise period. During intense exercise workouts lasting longer than three hours, as much as ten percent of energy may come from protein. The branch chain amino acids (BCAAs) leucine, isoleucine, and valine are said to be the most important for recovery than any of the other amino acids. BCAAs make up about one-third of muscle's protein and enhance endurance by conserving glycogen, maintaining muscle mass, power and endurance during exhaustive bouts of exercise. Furthermore, BCAAs have been shown to help maintain immune status and therefore reduce overtraining.[6]

The BCAAs are catabolized by the glucose-alanine cycle, resulting in a net increase in glucose for anaerobic muscle contraction. The non-essential amino acid, alanine, is formed after glucose is converted to pyruvate in the liver, kidneys and muscle tissue. This cycle also serves to help prevent the buildup of toxic ammonia molecules, as previously mentioned in this paper. This is primarily a cortisol stimulated pathway, resulting in gluconeogenesis.[7]

Of the three BCAAs, leucine is thought to be the most important as it is essential to amplify the signal for protein synthesis at the level of peptide initiation. Studies have shown that feeding amino acids or leucine soon after exercise suggest that post-exercise consumption of amino acids stimulates recovery of muscle protein synthesis via translation regulations.[8]

Discussion

Manual muscle testing (MMT) is based on a change in muscle function. Whether a facilitated (strong) muscle becomes inhibited (weak) or a weak muscle becomes strong, the physician is using this testing method as part of the neurological exam to aid in diagnosing processes gone awry in the patient's body. However, this review proposes there may exist times when MMT is not entirely sufficient in detecting a change in the muscle function. In other words, it is impossible for a physician to determine if a truly strong muscle is "even more strong" or an already weak muscle is "even more weak." Yes, there are varying degrees of inhibition and facilitation, but often a weak muscle will only respond favorably (by strengthening) if there are some positive or beneficial stimuli introduced. For example, this may be a need for a nutrient or correction of some physical or emotional problem.

Likewise, a strong muscle will often only weaken if there are some negative stimuli introduced. A dietary sensitivity (such as a food allergy) or an injury to a muscle would cause this to occur.

Additionally, muscles are going to respond more favorably to what they are most depleted in. In other words, if there is a need for supplement X, supplement Y, and supplement Z, typically not all three supplements are going to test positive during the same examination procedure. Often the most depleted nutrient will be needed first, even if the others are at unfavorable levels.

However, what if one was to take an already inhibited muscle and challenge it so it is functionally even more inhibited, even though this cannot be measured via MMT? This can be done by introducing some negative stimuli such as a food offender or by directly causing further stress to the muscle. The muscle is theoretically weaker, even though the MMT appears to be the same, and subsequent testing can be performed to see what negates the further muscle inhibition that was introduced.

For instance, consider a patient with bilateral weakness in both their gluteus maximus muscles. Having him/her perform some exercise to further inhibit those muscles, such as deep squats, or even an exercise like plyometric box jumps, is going to make the glut max muscles even more fatigued. The extra inhibition is going to stress the muscles out enough, which in turn will change how they will respond to testing – particularly oral nutrient testing – for the muscle in distress.

This is an important consideration for a couple reasons. First, most athletes do not present under such distress. Sometimes they may, say after an exhausting period of physical activity, but most recover quickly enough that by the time they get into the office, those muscles which were inhibited are already on their way to recovering. In essence, the athlete is pulling stored glycogen, and especially protein sources, to recover as quickly as they can. Second, the muscle is going to respond differently to any testing if it is stressed out more and tested immediately after, even though it is already weak in both cases. An athlete with weak glutes provides another example. Having him/her perform ten or more deep knee bend jumps is going to further inhibit those muscles and change how they test and what might strengthen them. By having the athlete perform this type of testing, the physician can see two things he or she would otherwise miss. First, the physician will be able to determine what will aid in faster recovery in the weak muscle, not only locally but systemically. The physician will then be able to advise the athlete in regards to dietary changes to prevent the condition from occurring again. The physician is then able to fundamentally predict what is going to happen when muscles are further stressed even though it cannot be measured via MMT. This allows for the significant delay and even the possible prevention of muscle fatigue.

This author has determined that the two major factors contributing to fatigue and poor performance are glycogen depletion and insufficient protein/BCAA supplementation. Once the body depletes glycogen it will need to make glucose from other sources (this is called gluconeogenesis). The most common source comes from breaking down protein (muscle) into amino acids for fuel. Note that this response is due to the glycogen depletion. If the glycogen levels were adequate, then the body would not shift to using protein as fuel. However, even though both glycogen levels and protein levels are insufficient, the body is more concerned about getting the protein levels back up so muscle tissue is spared. But again, this would never occur if glycogen levels were at an optimum.

Clinically, this can be verified. If the physician asks the patient to further stress a muscle that is already weakened, and they are depleted in either glycogen, protein, or typically both, the muscle will then strengthen during oral nutrient testing of some high quality protein source (such as denatured whey protein) or BCAAs. Testing of the protein or BCAAs against the weak muscle without further stressing it often shows no change (no need for supplementation) unless the patient/athlete is severely depleted. In the experience of this author, this is very uncommon. However, positive testing for more protein is more common than one may imagine if the weak muscles are stressed, and in essence, made “more weak.”

Correcting this problem can be simple or complex depending on each individual patient. The immediate need for more protein in the diet is most important. This will get the patient out of any crisis mode. Second, glycogen stores should be assessed, which can be done by looking at the patient’s diet as well as training regime. Third, the training/exercise program should be assessed, with particular attention given to aerobic/anaerobic systems.

Procedure

1. Identify a muscle that is inhibited (weak) and responds to autogenic facilitation (muscle turns on with spindle cell activation)

2. Perform oral nutrient testing using a protein source (preferably denatured, non-hydrolyzed whey protein), BCAAs, and some complex carbohydrate source such as maltodextrin
    a. If any of the three above test positive, investigate the need for such supplementation accordingly
    b. If none tests positive, continue to 3.

3. Have the patient further stress the muscle that is weak to the point where they are at least 80% fatigued. This is easy for some muscles, such as a pectoralis muscle (they can perform multiple push-ups), or rectus/glutes (they can perform deep squats or jumps), but more difficult for others. If you are using a muscle such as a latissimus dorsi and can't have the patient perform an exercise such as pull-ups, you will either need to find a different muscle or use another muscle as an indicator. For example, you can perhaps find an acupuncture meridian alarm point which the patient can therapy localize to and weaken a muscle that can be tested.

4. Immediately after the patient stresses out the weak muscle, test them again on the three substances – the [whey] protein, BCAAs, and the carbohydrate source
    a. A positive test indicates glycogen depletion and the body's shift towards protein as fuel is strengthening on the protein and/or BCAAs. *Note, this author has yet to find a patient strengthen on the carbohydrate during this part of the testing, even though they are theoretically glycogen depleted.
        i. Assess the patient's diet – specifically protein intake (perhaps aim for approximately 2g of protein per kilogram of body weight) and carbohydrate intake
        ii. Assess the patient's exercise intensity and frequency. This can be done by looking at their training log as well as administering specific testing procedures set forth by this author in a previous paper, to assess aerobic, anaerobic, and creatine phosphate pathways.[9]
    b. A negative test is no change in the muscle test, as it was before the muscle was stressed.

** Interesting side-note: Often during a positive test, the doctor will find that if they ask the patient to perform *any* strenuous, power-induced exercise to failure, the *strong* muscle they are stressing will weaken. In other words, if the patient strengthens on protein or BCAAs after the weak muscle is stressed, have him or her perform an exercise such as deep knee jumps to the point of complete failure. (These muscles should have been tested to be strong.) The muscles related to that exercise (specifically the rectus and glutes in this example) will be completely inhibited, but will strengthen on the protein or BCAA substance already discovered to benefit some other inhibited muscle.

CONCLUSION

The beauty of employing MMT in the examination of patients is that the physician can specifically identify a problem that an individual may be having and correct that problem through various means. Challenge procedures are often needed to further stress out the patient's nervous system, as often a problem the patient is having may be hiding under many adaptations they have developed or their problem may only show itself under a particular stress. Such is the case when testing and determining the best treatment process for athletes, particularly those involved in endurance events and those at the elite level.

The common way of muscle testing to see a change from negative to positive (weak to strong) or vice-versa is not necessarily going to reveal problems in certain individuals. In athletes who are only experiencing a problem when under a particular amount of stress, that stress must be replicated to some degree in the office setting in order to find a correction and treatment protocol. However, when glycogen levels are depleted and the body is literally using muscle (protein/amino-acids) for fuel, compensations have occurred to such degrees that "smoking out" the problem is often difficult, if not impossible. Challenging a muscle, or group of muscles, to the point of fatiguing them beyond their current state while there is no discernable change in the MMT, and then testing based on that understanding, is a significant new direction in evaluating and treating a patient. Fatigue that is going to occur, but has not yet done so, can be identified and performance can be significantly increased.

The implications which may come forth through this type of testing are not just limited to athletes. Challenging a patient with a substance and seeing no change in the MMT outcome does not necessarily mean there is not a change. Absence of proof is not proof of absence. All it can mean is that there is no change, which can be observed through current methods. If a secondary testing procedure is utilized after the assumed negative response is employed, the doctor can see that a change did occur, identified by the MMT response.

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