THE SCIENCE BEHIND

MRM

MRM: a recovery product

Key Points:

- Muscle glycogen is used up as an energy source during exercise. The more strenuous the bout the greater the muscle glycogen use
- Muscle glycogen depletion occurs in those muscles that are employed during the exercise bout
- Muscle glycogen can be replenished after exercise if carbohydrate is ingested in adequate amounts
- Ideally, carbohydrates should be ingested as soon as possible – particularly if further training bouts are to take place within a short time
- A dose of 1.2g/kg body weight is advised within an hour after strenuous exercise, and an overall dose of ~ 8g/kg body weight in 24-h is required
- Addition of protein is beneficial not only to glycogen storage but also to help muscle structural recovery
- A carbohydrate:protein ratio of 3:1 is recommended IF the prior exercise bout is very strenuous, although a lower ratio of 2:1 is suitable after less intense bouts and for those athletes who are concerned with body fat issues
- MRM at a 2:1 ratio is ideal since additional carbohydrate can be eaten if needed
- Eccentric activities result in muscle damage which can inhibit appropriate muscle glycogen restoration

Introduction

The first hour following any form of exercise is the most crucial period to recover glycogen stores as well as to promote protein synthesis in muscle (Koopman, 2007). Classical studies on muscle glycogen synthesis have highlighted the need for early ingestion of carbohydrate to help drive storage (Ivy et al., 1988). The amount of carbohydrate needed after intense exercise was reported to be around 1.2g per kg body mass in the first hour (Ivy et al., 1988). For an 80kg person this would amount to 96g of carbohydrate, and the choice of liquid or solid sources was not important (Reed et al., 1989). Most isotonic sports drinks usually lack sufficient carbohydrate unless a large volume is ingested. Drinks containing amounts of carbohydrate close to 100g have, until recently, been unlikely or too sweet and syrupy.

The role of glutamine in promoting glycogen storage after exercise has been explored and found by some to result in a significant increase in muscle glycogen not only after infusion (Varnier et al., 1995) but also after oral supplementation (Bowtell et al., 1999). Subsequently investigations have been performed on combinations of carbohydrate and protein to examine their effects on glycogen synthesis. The consensus view was that a ratio of 3:1 carbohydrate: protein appeared ideal (Ivy, 2007). The form of protein does not appear to be of great significance, although the faster absorbed whey protein should prove advantageous when rapid recovery is desired. The use of additional protein with carbohydrate is probably to help stimulate insulin levels in blood and hence promote uptake of glucose across a muscle membrane for incorporation into glycogen. Some amino acids are insulinogenic and thereby increase insulin concentrations. These include glutamine and the BCAAs (leucine, isoleucine, and valine).

Of course, stimulation of insulin in recovery is not only beneficial for muscle glycogen synthesis but also protein synthesis. Carbohydrate alone evokes protein synthesis after training due to enhancing insulin levels (Borsheim et al., 2004). The effect, therefore, of protein (and in particular leucine) ingestion in a recovery supplement drives protein synthesis further (Koopman et al., 2005).

MRM is an ideal supplement to aid the recovery process after exercise. The combination of carbohydrate and protein in the correct ratio, as well as the extra amounts of key amino acids glutamine and leucine help to promote storage of carbohydrate and enhance muscle protein synthesis.

Muscle glycogen use and exercise

There are a plethora of investigations that have reported on the decrease of muscle glycogen during exercise bouts since the introduction of the biopsy needle in the late 1960’s. Figure 1 illustrates the combined findings from a host of studies reporting on muscle glycogen depletion at varying exercise intensities.

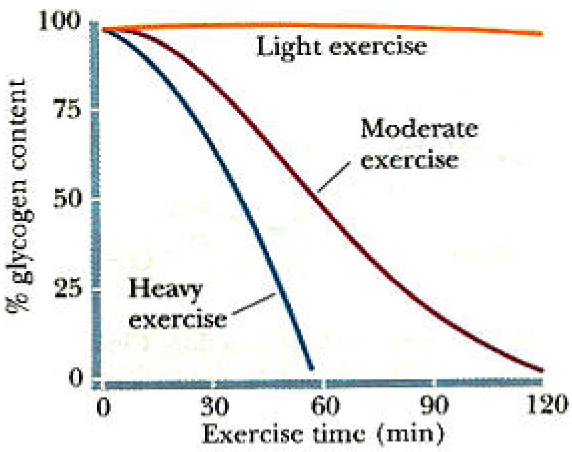

Figure 1. Schematic of muscle glycogen depletion during time after exercise of varying intensity.

In an early study reported on football players in Sweden, Agnevik (1970) showed that muscle glycogen was almost totally depleted after a match (Figure 2). In fact, most of the muscle glycogen use happened in the first half when the distance covered was reported to be higher than the second half.

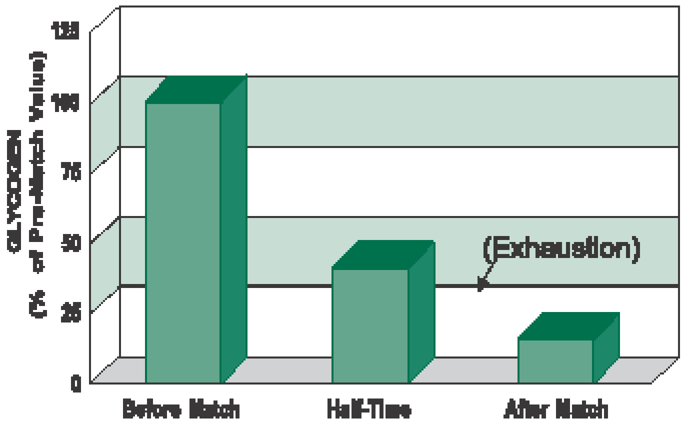

Figure 2. Muscle glycogen and football (after Agnevik, 1970)

More recently, Krustrup et al., (2011) has shown that playing football significantly impacts on levels of muscle glycogen in different muscle fibre types (Figure 3). The metabolic demands of playing football are mirrored in many team sports and so the likelihood of similar use of appropriate muscle glycogen stores is evident.

For those athletes who engage in activities in which there are episodes of uphill, downhill, or level running, the use of muscle glycogen in the muscles principally employed during such episodes does vary (Figure 4). Note that some so-called small leg muscle groups such as the gastrocnemius are significantly used in uphill (and downhill) running as exemplified by the muscle glycogen use.

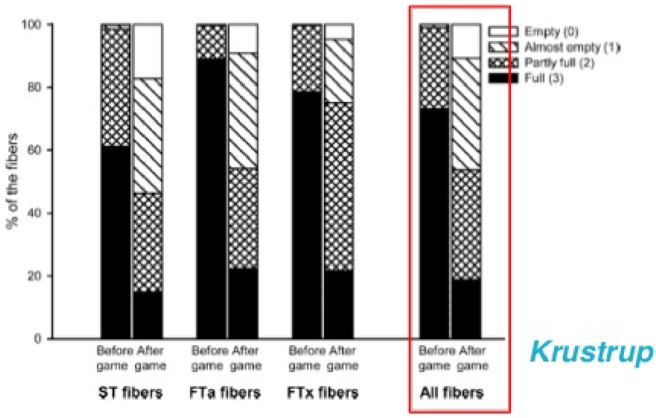

Figure 3. Glycogen depletion in types of muscle fibre before and after football (Krustrup et al., 2011)

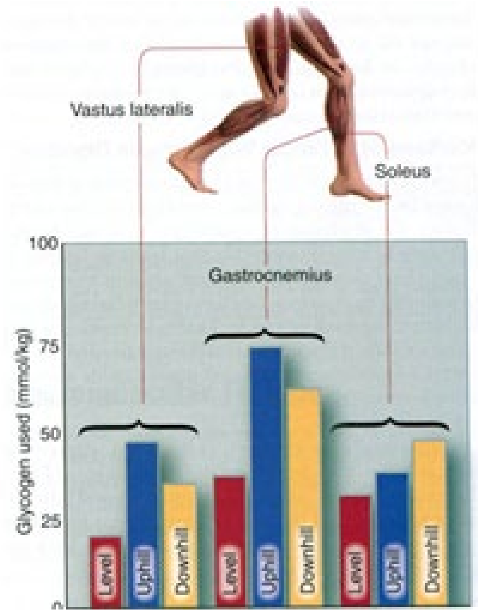

Figure 4. Muscle glycogen use in key leg muscle groups as a consequence of running uphill, downhill or on the 'flat'.

So we can realise that muscle glycogen is used in most energy requiring bouts of exercise. The greater the intensity of exercise the more muscle glycogen is used. The question is, how can muscle glycogen be replenished, and how quickly?

Muscle glycogen replenishment.

One of the primary aims after exercise is to increase blood insulin levels. This stimulates muscle glucose transport, activates muscle glycogen synthesis, stimulates amino acid transport, and also stimulates muscle protein synthesis. So if muscle glycogen resynthesis is to happen, carbohydrate must be ingested after exercise in order to raise blood insulin and stimulate the glucose transporters on the muscle cell membrane to promote uptake of glucose into the muscle. Indeed, the classical studies on muscle glycogen restoration after exercise clearly demonstrated that immediate ingestion of carbohydrate as opposed to a delay of 2-h enhanced muscle glycogen stores in the first 4 hours (Ivy et al., 1988). On the other hand, when muscle glycogen levels were examined at 8 or 24-h post exercise, the 2-h delay in feeding had no significant impact (Parkin et al., 1997). Figure 5 highlights these findings.

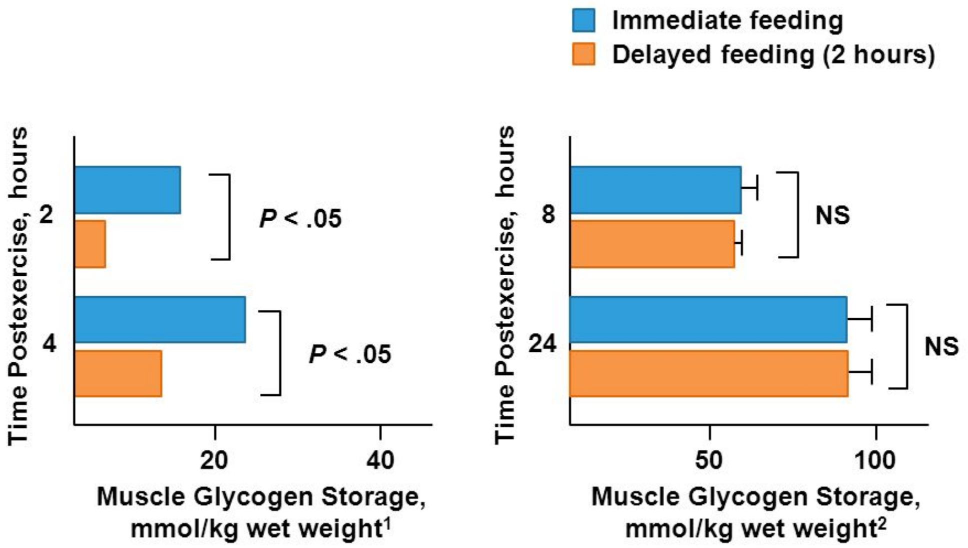

Figure 5. Timing of carbohydrate ingestion (i.e. immediately or after 2-h) in relation to muscle glycogen resynthesis over 2, 4, 8, and 24-h (after Ivy et al., 1988; Parkin et al., 1997)

In further study by Ivy et al. (1998), their findings demonstrated that the dose of carbohydrate required to maximally stimulate muscle glycogen resynthesis was 1.2g per kg body weight – higher doses had no greater impact. In fact, Ivy et al. also demonstrated that the form of carbohydrate (i.e. drink, eat, or infuse) made no difference. So the key points from these studies was that (a) ingest carbohydrate as soon as possible after exercise, (b) ingest an amount of around 1.2g/kg body weight, and (c) drink or eat the carbohydrate.

Prior to these key findings, Costill et al., (1981) had undertaken a study using middle distance runners who ran for 10 miles on a treadmill at 80% VO_{2max} on 3 separate occasions. After each run which they were given varying amounts of carbohydrate (375g; 525g; 650g) to see if they could replenish the stores in a 24-h period. Figure 6 highlights the fact that only after the highest dose of carbohydrate was there complete replenishment. This carbohydrate intake represented an amount corresponding to approximately 8g per kg body weight in a 24-h period. So it appears that full muscle glycogen replenishment can be achieved as long as high amounts of carbohydrate are ingested.

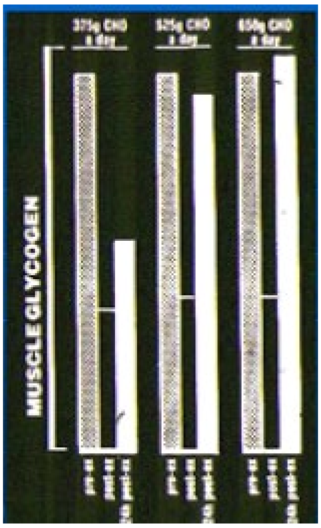

Figure 6. Muscle glycogen use and replenishment after a 10 mile run with varying amounts of carbohydrate (Costill et al., 1981).

However, a ‘fly in the ointment’ so to speak can be observed in Figure 7, which clearly demonstrates that only about 80% of muscle glycogen is replenished in elite Italian football players 3 days after a football match. What seems to be the problem? The answer lies in the fact that the study by Costill et al (1981) – and incidentally studies using laboratory-based cycling – was performed on a level treadmill. The activity in such modes of exercise is essentially concentric, whereas that engaged when playing team sports such as football has significant components of eccentric activity. Eccentric activity causes significant muscle damage, and so it appears that when engaged in those bouts of activity there is an issue with the ability to load muscle glycogen (hence the findings seen in Figure 7).

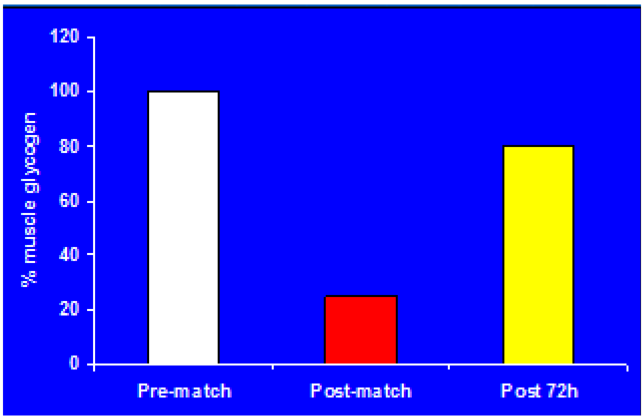

Figure 7. Muscle glycogen use and restoration following a football match.

It would therefore appear that there is an inability to substantially restore muscle glycogen after team games – at least within a window of 3 days or so. The problem does not exist if there is a 7 day recovery period.

A consequence of these findings has been the exploration of using additional nutrients to see if they can help enhance muscle glycogen replenishment. One such area of study has been the use of adding protein to the carbohydrate. Ivy and his colleagues (2002) undertook such an investigation whereby participants depleted muscle glycogen by cycling on an ergometer and then either consumed a high (108g) of carbohydrate or a low (80g) of carbohydrate or a mixture of low carbohydrate + protein (80 + 28g) immediately and then after 2 ½ hours later. A muscle biopsy was the taken at 4-h. Figure 8 shows that the combination of carbohydrate and protein had the greatest benefits in terms of muscle glycogen restoration over a 4-h period.

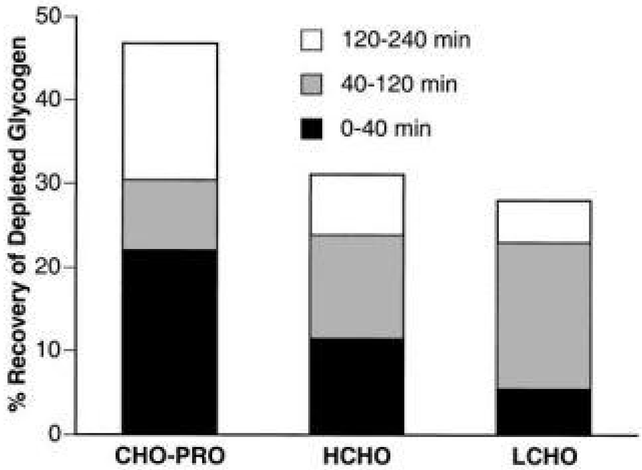

Figure 8. Muscle glycogen resynthesis after exercise with the addition of protein (after Ivy et al., 2002).

The rationale for the use of protein is due to the fact that some amino acids (notably leucine) are insulinogenic i.e. they stimulate insulin secretion and so promote glycogen storage as well as protein synthesis. In a subsequent study (Ivy et al., 2007) concluded that a ratio of carbohydrate to protein of 3:1 was ideal. This resulted in many subsequent recovery products containing such a mix. The problem with these relatively high amounts of carbohydrate in relation to protein is that concerning the prospect of these high amounts of carbohydrate being converted and stored as fat when the muscle is incapable of loading up carbohydrate adequately. Furthermore, not all exercise bouts lead to large depletions of muscle glycogen.

In this context, MRM has been designed to contain a carbohydrate to protein ratio of 2:1. Our rationale in devising this product is that if the activity is prolonged and severe, and results in great muscle glycogen depletion, then athletes should be encouraged to eat more carbohydrate from food items – and this can be achieved in a typical post-training/match meal.

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