LEUCINE

- A major driving force for **Muscle Protein Synthesis –**

An article by Professor Don MacLaren, 2016.

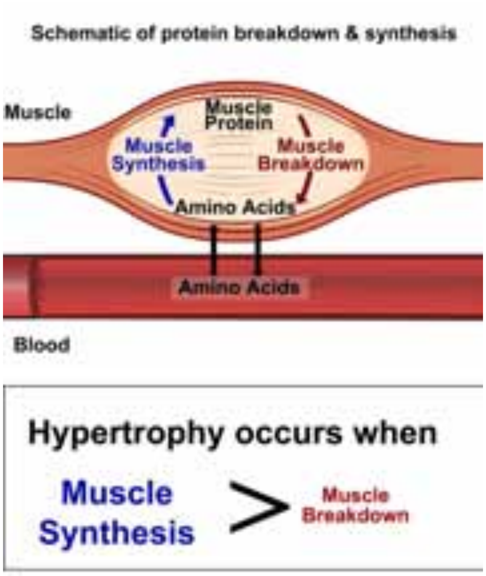
Leucine is one of the 9 essential amino acids that are required to be ingested by the body since the body is incapable of producing it *de novo*. It is also one of the 3 branched chain amino acids (BCAAs) – the others being isoleucine and valine. What is so important about leucine is that there is now sufficient evidence that it is the major amino acid which stimulates protein synthesis not only after exercise but even when consumed without exercise (Morton et al., 2015).

"Repeated bouts of resistance exercise and protein feeding leads to muscle hypertrophy…"

It is important to recognise that exercise stimulates Muscle Protein Synthesis (MPS) in the recovery phase and Muscle Protein Breakdown (MPB) during the exercise bout. If an athlete undertakes an exercise bout in a fasted state (i.e. without some form of protein feeding) there is a greater amount of MPB than MPS in a period of hours after exercise. In effect, there is a net negative protein muscle balance i.e. the muscle is losing mass. Clearly this is not desirable and so feeding protein after exercise is recommended. Indeed, there is good evidence that ingesting protein after exercise not only promotes a greater amount of MPS but also reduces the amount of MPB – hence a more positive net protein muscle balance.

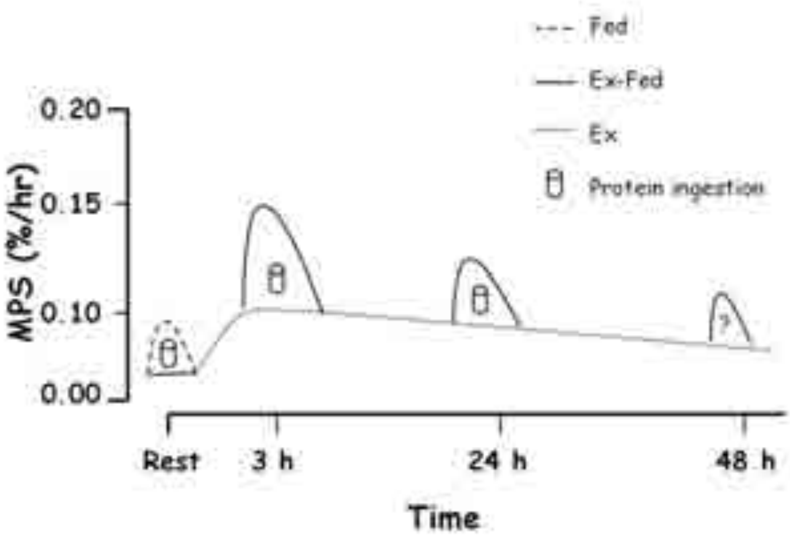
Figure 1 captures the relationship between MPS and MPB. Repeated bouts of resistance exercise and protein feeding leads to muscle hypertrophy (Cermack et al., 2012). Of course if the exercise is more endurance based then greater muscle recovery ensues rather than hypertrophy of the muscle.

Figure 1. Schematic of MPS and MPB



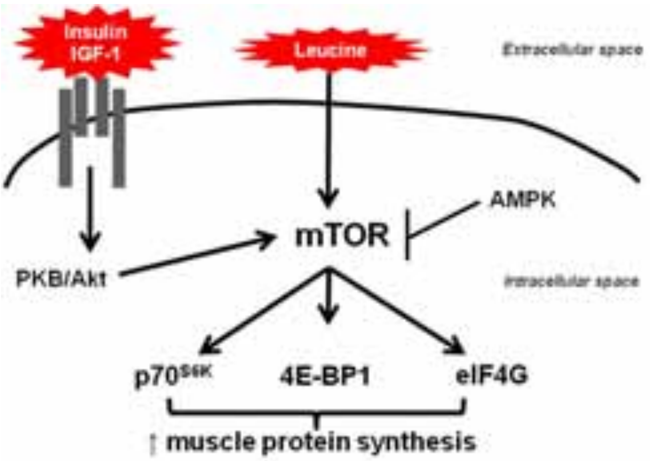
Eating foods containing protein or ingesting protein-containing products promotes an increase in amino acids in the blood and even insulin levels are elevated. The increase in circulating amino acids stimulates MPS and reduces MPB whilst the increase in insulin mainly affects the reduction in MPB. Remember that this happens without exercise i.e. eating/drinking protein stimulates MPS (Phillips, 2014). Figure 2 is a schematic highlighting the facts that (a) feeding alone stimulates MPS (note little 'blip' on left of graph), (b) exercise alone stimulates MPS over 48 hours, and (c) feeding protein with exercise bouts has the greatest benefits on MPS.

Figure 2. Muscle Protein Synthesis over time after feeding protein alone, exercise alone, and a combination of exercise and feeding protein (after Phillips, 2014).



So we know that feeding protein after resistance exercise stimulates MPS due to the presence of circulating amino acids. Furthermore it is only really the essential amino acids that are important (Tipton et al., 1999) and that leucine in particular is the trigger for the stimulation of synthesis (Wilkinson et al., 2013). The question arises as to how and why leucine stimulates MPS. Figure 3 highlights, rather simplistically, how leucine affects a muscle cell – once inside a muscle cell, leucine stimulates the so-called mTOR pathway, which in turn leads to stimulation of MPS. Therefore mTOR is, in effect, a signalling molecule within a cell that can be activated and so sets in motion a raft of changes resulting in an increase in MPS.

Figure 3. Schematic of Leucine activation of MPS via the mTOR pathway.



Part of the evidence for the importance of leucine in stimulating MPS is that protein-containing foods with a high leucine content have a more pronounced effect than those low in leucine. Indeed, a recent study showed that when a small amount of protein, which would only likely stimulate MPS by 25% of maximal rate, was made maximally effective with the addition of leucine (Churchwood-Venne et al., 2012). This study provided 25g whey protein vs 6.25g whey + 5g leucine. The additional leucine led to the restoration of MPS.

“Leucine is the key amino acid that triggers Muscle Protein Synthesis”

Much of the evidence regarding protein, leucine and MPS has led to the proposal of a leucine ‘trigger’ hypothesis as illustrated in figure 4. This concept revolves around the idea that leucine is the key amino acid that triggers a rise in MPS. Consequently, protein sources high in leucine are likely more effective than those with a low leucine content. Additionally, any leucine-containing product which is easily digested and absorbed would result in a quicker peak in blood leucine and hence trigger MPS.

Figure 4. The ‘leucine trigger’ concept

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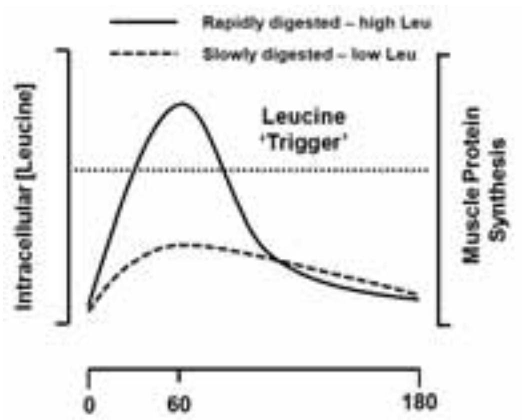
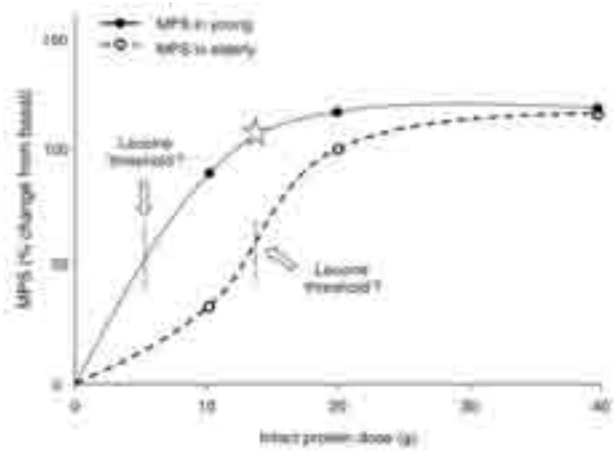


A further consideration that needs mentioning is that for older athletes there is a higher need for protein and leucine in order to stimulate MPS. Figure 5 highlights the idea that the leucine threshold (or trigger) is substantially higher for the elderly than the young. Indeed, whereas the likely maximal dose for protein after training or for a meal is 25g for a young individual, the requirement for an elderly person is 40g. This translates that the leucine requirement for a young person is about 5g per serving (obviously need more for heavier individuals) to around 10g for an elderly person

Figure 5. The Leucine threshold (or trigger) for young and elderly.



Key Points –

- MPS is stimulated by exercise and by eating protein foods
- MPB occurs during and for some time after exercise as well as during fasting
- MPB can be reduced by feeding protein
- Leucine is the key amino acid that triggers an increase in MPS
- A dose of around 5g of leucine after exercise or in ‘meals’ is desirable to stimulate MPS
- A higher dose of leucine (around 10g per time) may be beneficial for elderly athletes
- Adding leucine to protein drinks can ensure the maximal rates of MPS and reduced rates of MPB happen

References

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