New insights into protein recommendations for promoting muscle hypertrophy

In this article, Lindsay Macnaughton and Dr Oliver Witard critique the latest information regarding athlete-specific protein recommendations for promoting muscle hypertrophy.

Introduction

The field of protein nutrition continues to rapidly evolve. As a result, guidelines on protein recommendations for athletes are regularly being updated and refined. This article focuses on recent developments regarding protein recommendations for promoting muscle hypertrophy. The current guidelines on protein intakes for athletes range from 1.2-1.7 grams per kilogram body mass per day (Rodriguez *et al.,* 2009). However, we believe that guidelines on protein recommendations for promoting muscle hypertrophy are more complex than simply recommending a daily total protein intake (Tipton & Witard, 2007). A primary driver of muscle hypertrophy is the stimulation of muscle protein synthesis (MPS) during exercise recovery. The interplay between several factors - including the source, pattern and timing of dietary protein intake - regulate the postprandial *(after feeding)* stimulation of MPS during exercise recovery that, over time, underpins muscle hypertrophy (Tipton & Witard, 2007). As such, guidelines that consider each factor, or better still the interaction between these factors, will provide a more evidence-based approach to making more precise protein recommendations for athletes.

Protein quantity and pattern

Recent advances in guidelines regarding *how much* dietary protein athletes should consume have moved towards the expression of recommendations on a meal-by-meal, rather than on a total daily, basis. We recently published an article that plotted postprandial rates of myofibrillar MPS (contractile muscle proteins only) after a single, high-intensity bout of lower-limb resistance exercise against quantities of whey protein ranging from 0-40 g (Witard *et al.,* 2014). Postprandial rates of MPS plateaued with 20 g of ingested protein. The fate of the additional protein contained in the 40 g dose was primarily oxidation and/or excretion, rather than the incorporation of ingested amino acids into new contractile muscle protein. Given that a similar dose-response relationship was reported for egg protein (Moore *et al.,* 2009), we have established, that on a meal-by-meal basis, ~20 g of ingested high-quality protein is sufficient for the maximal stimulation of MPS during exercise recovery. In practice, ~750 mL of skimmed milk, 4-5 eggs or 100 g of lean beef are examples of foods containing ~25 g of protein. Since the participant characteristics of both studies (Moore *et al.,* 2009; Witard *et al.,* 2014) were ~80 kg resistance-trained men, when normalised to individual body mass, this *optimal* per meal quantity is equivalent to 0.25-0.30 g/kg of protein (Moore *et al.,* 2014). A logical extension to these data will be to characterise the optimal dose of ingested protein for maximal stimulation of MPS between smaller- (e.g., 50 kg gymnast) and larger- (e.g., 120 kg rugby player) sized athletes.

Having established the optimal dose of protein required in a single meal, recent efforts have focused on understanding the aggregate daytime response of MPS to multiple meals (Areta *et al.,* 2013; Mamerow *et al.,* 2014). These studies revealed that, despite consuming the same daily protein intake, the aggregate daytime stimulation of MPS is dependent on the pattern of protein feeding (Areta *et al.,* 2013; Mamerow *et al.,* 2014). For example, a protein meal pattern that distributed 90 g of protein evenly between breakfast (30 g), lunch (30 g) and dinner (30 g) stimulated a greater 24 h response of MPS compared with a meal pattern that skewed a large proportion of daily protein intake (63/90 g) towards the evening meal, with suboptimal doses of protein contained in breakfast (10 g) and lunch (16 g) meals (Mamerow *et al.,* 2014). Informed by dose-response data described above (Moore *et al.,* 2009; Witard *et al.,* 2014), it can be assumed that when protein was spread evenly between meals, maximal postprandial rates of MPS were stimulated repeatedly at each meal sitting, without a marked stimulation of non-anabolic processes.

Another, perhaps under-appreciated, opportunity for protein feeding is at bedtime. A recent study demonstrated ingesting a large dose of slow-releasing casein protein immediately prior to bedtime stimulated a greater overnight response of MPS (Res *et al.,* 2012). In practice however, athletes typically report protein intakes of only 6-8 g in pre-bedtime snacks (Erdman *et al.,* 2013). Moreover, descriptive studies reveal that a large proportion of the daily protein quota is typically contained in the evening meal, with significantly smaller quantities of protein contained in breakfast and lunch meals (Tieland *et al.,* 2012). Based on previous discussion, there is clearly room for improvement regarding best practice of daytime protein distribution. Whereas a daily protein intake of 1.6 g/kg offers a useful point of reference (Rodriguez *et al.,* 2009), future guidelines on protein recommendations for athletes should be refined to consider the quantity of protein contained in each meal and how far apart daily meals are spaced. A pictorial illustration of how such refined protein recommendations could provide an adaptive advantage for athletes is displayed in Figure 1.

Protein source and form

The Digestible Indispensable Amino Acid Score (DIAAS) is the latest index to assess the *protein quality* of a protein source. The DIAAS score reflects the essential amino acid profile and digestibility/absorption characteristics of any given protein source. Importantly, these same factors regulate the stimulation of MPS. Essentially, the more rapidly essential amino acids (EAA) - especially leucine - are made available in blood, the more potent the postprandial stimulation of MPS and the higher the quality of the protein source.

Protein source is known to influence the postprandial response of MPS during exercise recovery. Indeed, animal protein sources (i.e., whey) have been shown to stimulate a greater response of MPS compared with plant protein

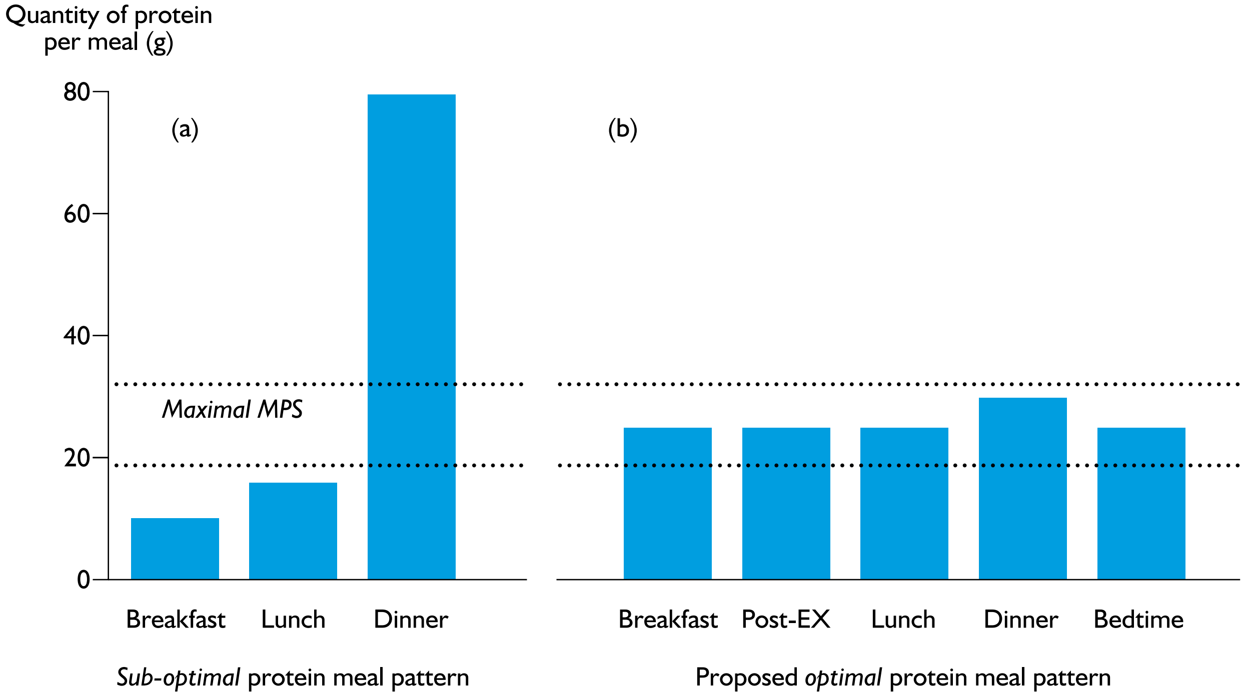

Figure 1. A pictorial example of the proposed relationship between protein meal pattern and the aggregate daily stimulation of muscle protein synthesis: (a) Unbalanced distribution of protein between 3 meals; (b) Balanced distribution of a similar total amount of daily protein between 5 meals. Figure 1b is more likely to provide a greater aggregate daily response of MPS and thus promote muscle hypertrophy.

sources (i.e., soy). For example, a whey protein beverage stimulated a greater response of MPS compared with a beverage containing an isonitrogenous quantity (~20 g) of soy (Tang *et al.,* 2009). The same authors also demonstrated whey elicited a superior response of MPS compared with casein protein (Tang *et al.,* 2009). The higher leucine content of whey compared with soy protein and the more rapid digestion/ absorption properties of whey compared with casein protein distinguishes whey as the highest quality protein. From a practical standpoint, to allow for or *rescue* the lower postprandial stimulation of MPS elicited by plant-based protein sources, vegetarian athletes with a training goal of muscle hypertrophy may be advised to consume 25-30 g of protein at each meal sitting.

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Interesting recent work suggests protein form is a factor that regulates the postprandial availability of amino acids in the blood. A more favourable blood amino acid profile for stimulating MPS was reported when ~20 g of protein was sourced from a liquid skimmed milk form compared with solid foods such as beef steak or eggs (Burke *et al.,* 2012). Given that a rise in blood EAA availability - or more specifically a spike in blood leucine appearance - drives the postprandial stimulation of MPS, this observation implies that liquid-based supplement forms of protein may confer an advantage over solid-based food forms of protein for promoting muscle hypertrophy. However, as a note of caution, before such a claim can be fully substantiated, a systematic comparison of the postprandial response of MPS between supplement and food forms of protein is clearly necessary.

Protein timing

Athletes may choose to consume protein before, during and/or after training. Of these three options, the general consensus is that protein ingestion after exercise most profoundly stimulates MPS during exercise recovery. As such, defining the *window of anabolic opportunity* after exercise therefore has received most attention with regards to optimising muscle hypertrophy. We (Witard & Tipton, 2012) have previously argued that the often-purported 45-60 min post-exercise *window of anabolic opportunity* is less critical than is often communicated by lay literature (Ivy & Portman, 2007). This argument is supported by data demonstrating an enhanced post-exercise stimulation of MPS when amino acid ingestion is delayed by 3 h (Rasmussen *et al.*, 2000), or even 24 h, after exercise (Burd *et al.*, 2011). Hence, this *window of anabolic opportunity* clearly persists beyond a 1 h period after exercise.

Alternatively, the counter argument can be made that protein should be ingested as soon after training as possible. This argument is supported by the observation that a greater stimulation of MPS during recovery is achieved when protein is ingested immediately after exercise (Churchward-Venne *et al.,* 2012). Thus, from a practical standpoint, the immediate post-exercise ingestion of protein may confer an adaptive advantage to the athlete. Moreover, protein plays an important role in the bigger picture of exercise recovery by ameliorating symptoms of muscle soreness from *muscle damaging* exercise (Jackman *et al.,* 2010). Thus, whereas a crucial *window of anabolic opportunity* cannot be defined at present, it makes sense to advise athletes that protein provision should begin soon after exercise to promote recovery and facilitate adaptation.

Closing remark

Future guidelines on protein recommendations for athletes should be refined to consider *how much* protein is contained in each meal, the *source* of protein contained in each meal and protein meal *pattern* for promoting muscle hypertrophy. ■

Practical recommendations

P Post-exercise protein ingestion is a potent stimulus for increasing the stimulation of MPS.

R Rescue an inferior response of MPS with plant-based protein ingestion by increasing the dose of protein contained in each meal to 25-30 g of protein.

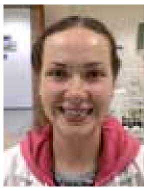
O Optimise protein intake on a meal-by-meal basis by consuming 0.25-0.30 g/kg body mass.

T Twenty-25 grams of protein after resistance exercise is sufficient for the maximal stimulation of MPS in ~80 kg athletes.

E Even distribution of protein (20-25 g) is the recommended meal pattern for maximal daytime stimulation of MPS.

I Include a protein feed at bedtime to increase the overnight stimulation of MPS.

N New research is necessary to characterise the optimal dose of protein that larger (>80 kg) and smaller (<80 kg) athletes should consume in a single meal to maximise the postprandial response of MPS.



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