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**The interaction between physical activity and nutrition is integral to general health and sports performance**

**David J Stensel**
**Professor of Exercise Metabolism**
**Associate Dean – Research**

**Correspondence: Professor David J Stensel, School of Sport, Exercise and Health Sciences Loughborough University, Leicestershire, UK, LE11 3TU**

The eleven papers published in this *Nutrition Bulletin* Virtual Issue address a range of topics relating to the interaction between nutrition and physical activity/exercise/sports performance. Eight of these articles focus to a greater or lesser extent on sport as distinct from physical activity (Alderton & Chambers 2015; Currell 2014; Egan 2016; James 2012; Leser 2011, 2015; Reid 2013; Shirreffs 2009), two of the papers focus specifically on the issue of physical activity, appetite and energy balance for general health (Blundell 2011; Stensel *et al.* 2016) and one paper focuses on the role of both diet and exercise in modulating postprandial glucose and triacylglycerol responses, which has relevance for cardiovascular/metabolic health (Edinburgh *et al.* 2017).

The first paper published in this series (Shirreffs 2009) concerns hydration in sport and exercise. In this paper, Dr Susan Shirreffs (then at Loughborough University) discusses the need for effective rehydration strategies both during and after exercise. Shirreffs emphasises, in particular, the need for sodium, water and small amounts of carbohydrate in rehydration solutions. It is also noted that electrolyte losses in sweat during exercise are highly variable between individuals making it difficult to design a rehydration drink which matches electrolyte losses for everyone.

A possible alternative to sports drinks for rehydration is milk. The paper by Dr Lewis James (2012) (Loughborough University) explores the role of milk as rehydration solution both during and after exercise. James emphasises that milk may be a suitable drink for sportsmen and women because it contains nutrients in similar amounts to those found in typical carbohydrate-electrolyte sports drinks, but milk also provides protein which is useful for muscle protein synthesis particularly after resistance type exercise. Protein supplementation is a thread running through many of the papers on sport nutrition and there is emphasis on protein intake (and milk in particular) to aid recovery. As a supplement, with exercise training, milk ingestion may enhance lean mass gain and fat mass loss compared with other protein sources or ingestion of carbohydrate. James concludes that milk is a suitable rehydration solution for active individuals (who are not intolerant to lactose and/or dairy) due to its electrolyte and protein content.

Another paper emphasising the role of protein for post exercise rehydration is that by Suzane Leser (2011) (Volac Ltd; European Specialist Sports Nutrition Alliance). In agreement with James, Leser explains that fluids containing some protein in addition to carbohydrate and sodium will lead to more effective restoration of body water and plasma volume. Leser also suggests that the milk proteins – whey and casein – may be particularly important in facilitating post-exercise fluid retention. This, it is argued, will aid plasma volume expansion and thermoregulatory capacity. Also examined in this paper is the 'cell volume' hypothesis, whereby hydrated swollen cells counteract glycogen breakdown and increase whole-body fat breakdown favouring a reduction in body fat stores and sparing protein. According to Leser, protein supplementation may enhance this process.

Another paper focusing on protein is by Dr Brendan Egan (2016) (University College Dublin). Egan stresses that athletes and active adults in general may need more than the reference intake of 0.8 g protein per kg body mass. Egan recommends between 1.2 and 2.0 g/kg/day of protein for highly

active individuals, regardless of whether they are performing resistance or aerobic exercise. Moreover, injured athletes and those on low energy diets may need even higher amounts of protein beyond 2.0 g/kg/day. Egan finds little evidence that high protein intakes cause kidney damage, although he acknowledges that few studies have explored the long-term effects of elevated protein intakes. There is also some concern that a high protein intake (>20% of energy intake from protein) may increase the risk of cancer and type 2 diabetes but it is not clear whether this is due to protein *per se* or because some meats are highly processed.

The paper by Dr Kevin Currell (2014) (English Institute of Sport; Loughborough University) addresses the diet of Olympians. Currell emphasises the role of 'performance nutrition' for three areas: 1) prevention of illness and injury; 2) facilitation of training adaptation; and 3) improvement of competition performance. Currell stresses the role of overall energy and macronutrient intake for ensuring that energy needs are met to prevent fatigue and illness. As with many of the papers, Currell emphasises the importance of carbohydrate and protein to support recovery from exercise. Currell ends his article by touching on nutritional ergogenic aids such as dietary nitrates (obtained, for example, from beetroot juice) which are purported to lower the oxygen cost of exercise. Further research is needed to confirm this intriguing theory.

The article by Alderton and Chambers (2015) [British Nutrition Foundation (BNF)] provides a short overview of papers presented at BNF's 2014 half-day symposium: 'What's new in sport nutrition?' This symposium covered some fascinating topics including nutrition for elite sport, where Dr Kevin Currell presented three specific case studies highlighting the role of nutrition for preventing illness and injury as well as facilitating training adaptation and performance. Collectively, these studies demonstrated the importance of personalised nutrition. Also covered in this symposium were topics on bone metabolism and the role of vitamin D, the potential role of bovine colostrum (*i.e.* the milk produced by cows in late pregnancy) in reducing the risk of 'exercise-induced immunodepression' and the topical issue of sports nutrition, sleep and performance. The latter talk highlighted the difference between morning 'larks' and evening 'owls' and the question of whether these differing chronotypes require different nutritional strategies. The final talk assessed the importance of carbohydrate for skeletal muscle adaptation to training and in particular muscle fibre, mitochondrial biogenesis and vascularisation. According to this talk, there is potential for enhanced adaptation by training in a glycogen depleted state but the detrimental effects of such a strategy (*e.g.* reduced speed and peak power) mean that it should not be used close to competition.

Touching on many of the previous topics is the paper by Dr Karen Reid (2013) (Performance Food Ltd) on 'performance food' (*i.e*. foods with a functional benefit for sports performance). This paper provides practical dietary strategies for enhancing the functional benefits of food and minimising the reliance on unnecessary dietary supplements. The paper explores the goals of sports nutrition, nutrition for recovery, nutrition and immune health, and a potential role for antioxidants and probiotic drinks for boosting immunity and fighting illness and infection. There is also mention of dietary nitrates in this paper and evidence is provided to support the theory that these will lower the oxygen cost of submaximal exercise and extend endurance capacity.

A second article by Dr Suzane Leser (2015) (Volac Ltd; European Specialist Sports Nutrition Alliance) discusses the possibility of increased regulation of sports nutrition products. The nutritional needs of athletes differ from those of the general population and sometimes these needs conflict. Leser highlights two examples in particular –the need for increased sodium and simple sugar intake in athletes both of which contrast with public health recommendations to reduce salt and free sugar intake (PHE 2016). Recounting the recent history of European food regulations, Leser argues that 'Initially, the industry was in danger of legislation that was so specific it was restrictive (whereas) now … the industry is in danger of legislation that is so general it does not recognise the specific

needs of sports people'. Thus, Leser contends that sport nutrition remains in 'regulatory limbo' and there is still uncertainty over the best regulatory environment for sports foods which also offers sufficient consumer protection.

In contrast to the above papers, the articles by Professor John Blundell (2011) (University of Leeds) and my colleagues and I at Loughborough University (Stensel *et al.* 2016) address an issue central to the role of exercise in maintaining a healthy energy balance and body composition, which is the relationship between exercise and appetite control. Here both Blundell and Stensel *et al.* argue that physical activity can assist in effective appetite regulation and make an important contribution to energy balance (in contrast to the scepticism sometimes expressed in the popular and scientific press, where it has been claimed that exercise can contribute to weight gain by increasing appetite). Both papers also emphasise that there is individual variation in the way people respond to exercise and that exercise/physical activity improves health in a variety of ways even in the absence of weight/fat loss. Blundell concludes: 'physical activity offers many benefits; the challenge is to implement our action plans'.

Finally, the paper by Edinburgh and colleagues (2017) discusses strategies to improve postprandial glucose and lipid metabolism. This is important because repeated elevations in blood glucose after meals can lead to insulin insensitivity and type 2 diabetes while exaggerated postprandial lipaemia is a risk factor for cardiovascular disease. Edinburgh *et al.* discuss how diet composition (carbohydrate, fat, protein and fibre intake) and acute bouts of exercise influence postprandial blood glucose and triacylglycerol responses, and highlight the need to understand more about how exercise and diet interact to determine these effects.

Collectively, these eleven papers emphasise that physical activity and nutrition are integrally related and it is impossible to consider one without attention to the other; whether from the perspective of general health or sports performance both are crucial for the attainment of an optimal state. Important areas of research for the future include the factors underlying individual differences in responses to diet and exercise, the synergistic or antagonistic effects of the ingestion of two or more nutrients concurrently on sport/exercise performance, as well as the interaction between diet and exercise for optimising body composition and metabolic health.

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