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**The interaction between nutrition and exercise for promoting health and performance**

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# **Abstract**

The theme of The Nutrition Society Spring Conference 2017 was on the interaction between nutrition and exercise for promoting healthy ageing, maintaining cognitive function and improving the metabolic health of the population. The importance of this theme is highlighted by the public health issues surrounding obesity, diabetes and the age-related loss of skeletal muscle mass (sarcopenia). The opening symposium provided a historical perspective of both invasive and non-invasive methodologies for measuring exercise energetics and energy balance. Data derived from these techniques underpin current understanding regarding the metabolic response to nutrition and exercise. Further symposia examined the importance of skeletal muscle for healthy ageing in older men and postmenopausal women. From a nutritional perspective, the potential for animal- versus plant-based protein sources to offset the age-related decline in muscle mass was discussed. The day concluded by discussing the link(s) between nutrition, exercise and brain function. Day 2 commenced with examples of applied equine research illustrating the link between nutrition/exercise and insulin resistance to those of a human model. The final symposium examined the combined role of nutrition and exercise in reducing risk of type 2 diabetes and dyslipidaemia. The overall conclusion from the meeting was that the interaction between diet and physical activity confers greater benefits to human health and performance than either component alone.

Not since 2010 has The Nutrition Society organised a conference with an exercise theme. In the intervening period, the exercise literature has continued to expand with numerous research groups, worldwide, focussed on understanding the powerful, but complex, interaction between nutrition and exercise for promoting human health and performance across the lifespan. Hosted by The University of Stirling, the theme of the Nutrition Society Spring conference 2017 attracted 114 scientists, nutrition educators, healthcare professionals, clinicians and students from the UK, Europe, North America and South America. Over the two days, experts and delegates discussed the role of nutrition and exercise as non-pharmacological interventions for promoting healthy ageing, preserving cognitive function and reducing the risk of type 2 diabetes. These topics were addressed across three symposia, two plenary lectures, 24 original communications and finally a roundtable discussion.

The topic of symposium 1 — ‘Exercise energetics and energy balance’ — provided a historical perspective of key invasive and non-invasive methodologies for measuring exercise energetics and energy balance, both at the tissue (muscle) and whole-body level and within both laboratory and field settings. The first speaker, Professor Lawrence Spriet (University of Guelph, Canada), covered the reintroduction (by Jonas Bergstrom in the 1960’s<sup>(1)</sup>) and continued application of the percutaneous needle muscle biopsy technique as a powerful tool for measuring both substrates utilised and metabolites produced by skeletal muscle in response to various exercise and nutritional stimuli. The muscle biopsy technique was described as having a significant impact on current scientific knowledge regarding the role of nutrition in regulating fuel selection during exercise and manipulating muscle adaptation to exercise training.

Next, Professor Klaas Westerterp (Maastricht University, The Netherlands), presented data exploring the valuable contribution of the doubly-labelled water technique for measuring energy expenditure in free-living individuals. Introduced in 1949 and developed over the following 30 years, the doubly-labelled water method remains the gold standard tool for assessing energy expenditure in humans under free-living conditions<sup>[2]</sup>. In terms of application, this method allows scientists to precisely determine energy requirements for the maintenance of energy balance and thus helps inform nutritional guidelines for improving health and performance. The complex nature of utilising doubly-labelled water methodology also was discussed, highlighting the challenges presented in accounting for background isotope enrichment and accurately measuring higher rates of energy turnover in specific populations (e.g. Professional cyclists competing in the Tour de France). Finally, the impact of restricting caloric intake on energy balance was discussed, emphasizing the remarkable ability of the body to maintain homeostasis with the effect of resetting to a lower resting metabolic rate.

The final topic of the symposia involved a transition into discussing the control of substrate utilization and the influence that exercise and nutritional interventions can play in this process. Dr Francis Stephens (University of Exeter, UK) detailed the impact of carnitine supplementation on fat and carbohydrate utilization during exercise. Evidence demonstrating the role of carnitine in fatty-acyl transport

into mitochondria and as a buffer in the face of excess acetyl-CoA accumulation was discussed. The methods and impact of manipulating intracellular carnitine availability by dietary means was presented with the conclusion that such a nutritional strategy can enhance fat catabolism at rest and increase the flux rate of pyruvate dehydrogenase complex with the concomitant reduction in lactate accumulation<sup>[3]</sup>.

The topic of symposium 2 was the ‘Maintenance of muscle mass for healthy ageing.’ Muscle loss with advancing age — termed sarcopenia — is most commonly associated with reduced strength, an increased risk of falls and a decline in functional abilities (e.g. performing tasks of daily living such as grocery shopping, climbing the stairs, standing from a seated position, etc.). Perhaps less well appreciated is the wider role of skeletal muscle in health and disease, including cancer survivorship, obesity, osteoporosis and recovery from critical illness<sup>[4]</sup>. This symposium, opened by Professor Kevin Tipton (University of Stirling, UK), made explicit reference to the powerful concept of ‘physical activity as medicine’ as fundamental to increasing the ‘health-span’ of our ageing population<sup>[5]</sup>. Rather than biological ageing *per se*, recent evidence suggests that physical inactivity is a stronger predictor of muscle loss, and the associated risk of morbidity, commonly experienced with advanced age<sup>[6]</sup>. Professor Tipton advocated a ‘use it or lose it’ philosophy, offering practical, evidence-based, physical activity guidelines to facilitate the maintenance of muscle mass for healthy ageing. Next, Dr Stefan Gorissen (McMaster University, Canada) focussed on the importance of dietary protein intake for healthy ageing<sup>[7]</sup>. Dr Gorissen addressed a ‘hot topic’ in protein nutrition by comparing the anabolic potential of animal and plant-based protein sources for preserving muscle mass in older adults<sup>[8]</sup>. Interestingly, the rate of muscle loss with advancing age is typically greater in women compared with men, primarily due to hormonal changes that occur during the menopause. This symposium concluded with a lecture by Dr Mette Hansen (Aarhus University, Denmark) summarising findings from recent studies investigating the effectiveness of estrogen replacement therapy as a novel strategy alongside protein feeding and exercise to delay the onset of sarcopenia in post-menopausal women<sup>[9]</sup>.

Day 1 closed with a plenary lecture from Professor Romain Meeusen (University of Brussels, Belgium) that discussed the synergy between nutrition, exercise and brain function. Professor Meeusen suggested that the positive influence of exercise on cognitive function may be mediated by an increase in brain-derived neurotrophic factor. This lecture then critically evaluated the evidence behind the efficacy of several dietary components, namely polyphenols, flavonols and carbohydrate mouth rinsing, for improving cognition<sup>[10]</sup>. These findings were applied to both clinical populations in terms of delaying the progression of age related health disorders and to athletic populations with regards to reducing the impact of central fatigue on endurance performance.

Day 2 commenced with the 2<sup>nd</sup> plenary lecture of the conference from Professor Pat Harris (Waltham Centre for Pet Nutrition, UK) that addressed the debilitating issue of laminitis in horses and the potential link with insulin resistance. The role of diet, macronutrient intake and physical activity in the

process of developing laminitis were discussed both as a cause and potential cure. The comparative links between diet and obesity were clearly illustrated by the effects of changing the diets of horses from rich to poor bioavailability of starch on markers of adipose tissue storage<sup>[11]</sup>. Further examples illustrated the complex nature of classifying metabolic disorders and their root cause(s) with the conclusion that whilst it was possible to identify certain breeds of horse and pony that are susceptible to the condition there is a large degree of inherent variability in laminitis susceptibility.

Continuing with the theme of ‘Nutrition and exercise interactions for metabolic health’, Professor Emma Stevenson (Newcastle University, UK) opened symposium 3 by discussing the role of diet and exercise in postprandial glycaemic control. The merit of constant glucose monitoring of interstitial fluid was illustrated in the 24 hour excursions of glucose as a consequence of being in both a post-prandial and post-absorptive state. Furthermore, it was established that post-prandial glucose monitoring is an excellent variable for predicting HbA1C and cardiovascular events. While the beneficial effects of exercise on blood glucose control are understood<sup>[12]</sup>, Professor Stevenson presented data illustrating that cessation of daily exercise results in a decay in insulin sensitivity over a 5-10 day period that strengthens the case for increased daily activity as an essential component of normal daily living.

The final two presentations of the conference focused on the interplay between dietary fat intake, exercise and metabolism. Utilizing a post-prandial model, Dr. Jason Gill (University of Glasgow) emphasized the beneficial effects of a single bout of exercise on reducing the post-prandial excursion in plasma lipid concentration after a high-fat meal. The impact of prior exercise on reducing the plasma concentration of lipids, increasing the concentration of high-density lipids and increasing the size of low density lipids also was discussed<sup>[13]</sup>. Professor Jorn Helge (University of Copenhagen) discussed the role of bioactive lipids in relation to insulin resistance. This lecture used examples from athletic populations to introduce the argument that limited evidence exists to suggest that the accumulation of excess intramuscular triglyceride leads to insulin resistance. Other discussion points included the variability in ceramide concentrations in response to changes in diet and caloric intake and how these changes are thought to relate to changes in intracellular signaling<sup>[14,15]</sup>. Finally, Professor Helge highlighted that while exercise training increased intracellular ceramide concentration it did so at the same time as improving insulin sensitivity, thus raising questions concerning the role of alternative phospholipids.

The scientific programme concluded with a roundtable discussion that highlighted the importance of participating in physical activity on a daily basis throughout the lifespan and how best to communicate this message to the general population. A second topic of discussion concerned the relative importance of nutrient timing in relation to exercise compared with total nutrient intake *per se* for promoting various aspects of health and performance. Finally, the ongoing debate concerning what constitutes an essential nutrient was discussed.

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