

'Microbes in sport' – The potential role of the gut microbiota in athlete health and performance

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INTRODUCTION

The human intestinal tract is home to approximately 100 trillion microbes with the majority of these residing in the colon. Most microbes in the human intestinal tract are bacteria but archaea, fungi, protozoans and a large population of viruses are also present.¹ These microbes have a vast array of functions including vitamin production, fibre digestion, interacting with the immune system^{2,3} and they contribute significantly to health and disease.

Previously, it was only possible to study the human gut microbiota (GM; microbiota refers to the assemblage of microorganisms present in a defined environment) after first culturing the microbes on agar plates. Gut microbes have an extremely specific set of growth conditions in vivo that are difficult to recreate in a lab environment. Advancement in DNA sequencing technology has made it possible to study the genetic material of the microbes present and negates the need for culture.² Increased understanding of the role of GM has led to innovative methods to alter gut microbe composition and subsequently GM function. Many factors have been shown to influence the microbiota including antibiotic medication, diet and exercise.⁴ The majority of research investigating links between exercise (+/- diet) and the microbiota has involved animal subjects, yielding inconsistent results.³

A small number of human studies have examined the role of exercise in GM composition. A single study to date has focused on elite sport (international rugby union), with athletes demonstrating greater microbial diversity (a positive indicator of gut health) compared with control subjects. This microbial diversity

positively correlated with higher protein intake (dietary factor) and higher creatine kinase levels (physical activity factor) in athletes relative to controls.⁴

THE GUT MICROBIOTA AND GENERAL ATHLETE HEALTH

There are many routes through which the GM can impact on athlete health. An undesirable GM composition has been associated with local inflammatory change leading to gut wall permeability that may permit increased systemic migration of bacterial material. This in turn, may lead to systemic immune and metabolic dysfunctions. These processes are implicated in many chronic diseases.⁵ From an immunology perspective, compromise of GM and subsequent immunopathology has also been associated with atopic and allergic conditions such as asthma. Allergic conditions are common in athletes whose airways are often exposed to environmental factors such as cold air or chlorine during aquatic sports.⁵ Allergic conditions increase the risk of upper respiratory tract infections. It has been shown that probiotic supplementation can reduce the incidence and severity of upper respiratory tract infections in some athletes.⁵

Gastrointestinal complaints are common in the spectrum of conditions associated with 'relative energy deficiency in sport' and the 'female athlete triad'. In this low energy state, multiple body systems may experience compromise, including metabolic and hormonal functions. Changes in GM composition are likely to occur following a period of relative energy deficiency. If relevant GM changes could be demonstrated, this could prove a useful biomarker of energy deficiency and provide a target for therapeutic intervention. Notably, GM alterations have also been observed following prolonged periods of physical or psychological stress in conditions such as chronic fatigue syndrome and post-traumatic stress disorder.⁶ Furthermore, changes to the hypothalamic-pituitary axis are influenced by GM.⁵ This hormonal axis has also been implicated in the overtraining syndrome. Investigation of GM in athletes in states of overtraining or non-functional

over-reaching may aid understanding of these conditions.

THE GUT MICROBIOTA AND MUSCULOSKELETAL HEALTH

Changes to GM have been investigated in chronic musculoskeletal conditions. Multiple studies suggest a relationship between GM and inflammatory conditions such as rheumatoid arthritis, spondyloarthropathies and gout.⁷ Bacterial DNA of oral and gut origin has been found in blood serum and joint fluid in these conditions, suggesting a compromised gut barrier is a contributing factor. Low-grade inflammation, gut dysbiosis and bacterial DNA are also present in degenerative musculoskeletal conditions such as osteoarthritis⁷ and rotator cuff tendon degeneration. Chronic tendinopathy is more prevalent in persons with metabolic dysfunctions including type 2 diabetes and dyslipidaemia. Changes to GM are present in metabolic dysfunctions⁵ and investigation of GM in chronic tendinopathy may provide valuable insights.

Ensuring optimal bone health in athletes is important to reduce injury risk and to aid recovery. GM has a proposed regulatory effect on bone mass by altering the skeletal immune system, influencing hormonal regulation of bone metabolism and by production of bacterial metabolites that act as cellular messengers to the bone.⁸ GM analysis may provide a biomarker for bone health and target for therapeutic manipulation in cases of acute fracture, stress fracture and osteoporosis.

POTENTIAL ROLE OF THE GUT MICROBIOTA IN ATHLETIC PERFORMANCE

The optimisation of GM for athlete health and injury treatment will produce indirect benefits to athletic performance. Research investigating performance benefits from alterations in the GM is beginning to emerge. Changes to GM can positively alter body composition through a number of mechanisms.⁹ Further research in this area would be of value for many competitive sports. One study¹⁰ has also demonstrated that variations in GM affect endurance performance in the rodent model. This was proposed to occur through the action of GM on antioxidant enzyme systems. While research on the potential of GM in sports medicine is in its infancy, there is definite potential to positively impact athlete health, injury and ultimately performance, as greater understanding of the complex microbe-human relationship is developed.

Competing Interests None declared.

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