Student Article:
Exercise Has A Beneficial Effect On The Microbiome And Overall Health In Rodents

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ABSTRACT

While the bacterial composition of the gut microbiome in mice is more complex than that of humans, it is important to consider animal models in this area of research. The mouse microbiome, dominated by beneficial and detrimental bacteria, e.g. Firmicutes and Bacteroides, consists of far more Bacteroides, Clostridium, and other strains not found in humans. The mouse microbiome is able to be tested in a controlled environment through quantitative PCR analysis, which is beneficial to studying the various bacteria in the microbiome and is able to determine the sensitivity and specificity of different diseases that are potentially linked to the microbiota as well as the DNA copy number.[5] This review article will discuss three research studies that evaluate whether starting continuous physical activity at a young age would: 1) show an increase in the amount of good bacteria (e.g. Bacteroidetes, Actinobacteria, and Tenericutes), 2) whether exercise can modify the microbiome in mice despite consuming fed a high-fat or low-fat diet, and 3) whether using automatic exercise wheels for one hour per day vs. continuous exercise would impact the mouse microbiome.

INTRODUCTION

The gut microbiome is as fascinating as it is complex. Intestinal bacteria have been at the forefront of research for its role in digestion and overall health. The most abundant species of intestinal bacteria are gram-negative Bacteroidetes, which have been positively associated with weight loss, and spore-producing gram-positive Firmicutes, which have been associated with obesity (see Table 1). While the bacterial composition of the gut microbiome in mice is more complex than that of humans, it is important to consider animal models in this area of research. The mouse microbiome is significantly different from the human microbiome due to different dietary needs and intake.[1] Additionally, there are significant similarities in phyla and anatomy to the human microbiome to warrant studying the intestinal bacteria composition in mice.[1] Therefore, to understand the impact of physical activity on the mouse microbiome, it is important to examine the research previously conducted in murine models and assess potential health benefits and future research needs.

STUDIES

Researchers are just beginning to scratch the surface of the impact that physical exercise has on the microbiome in humans because the plethora of studies performed have been in murine models. Mika et al (2015) investigated whether starting continuous physical activity at a young age would show an increase in the amount of good bacteria (Bacteroidetes, Actinobacteria, and Tenericutes) after six weeks (see Table 1).[2] The study compared 20 young rats to 20 adult rats with the only difference being random assignment to a cage containing an exercise wheel. Rats assigned to the exercise wheel were allowed to run voluntarily every day for six weeks. Running distances were calculated appropriately. The researchers discovered the young rats assigned to a wheel continued to increase their running distance compared to the adult rats that decreased their distance over time. Furthermore, the young rats in the exercise group had two times more modified bacterial genera in their fecal samples.[2]

Evans et al (2014) hypothesized that exercise would modify the microbiome in mice whether they consumed a high-fat or low-fat diet, thereby preventing the microbiota from being damaged by consumption of a diet high in fat.[3] The mice (n=48) were equally assigned to four groups, similar to the aforementioned study of assignment to a wheel or no wheel, with the addition of either a low-fat (10% calories from fat) or high- fat (60% calories from fat; 35.9% of mono-unsaturated, 32% of poly-unsaturated, and 32% of saturated fats) diet, pre-weighed to determine how much food was consumed within a 24 hour period.[3] Fecal samples were collected three times during the 12 week diet and during the unlimited exercise regimen. After sequencing 16S rRNA, encoding genes were extracted from the fecal samples, and the researchers found a significant increase in Bacteroidetes and a decrease in Firmicutes in both exercise groups regardless of the fat content

Beneficial bacteria	Detrimental bacteria
Bacteroidetes (all studies)	Firmicutes (all studies)
Actinobacteria (Evans)	Clostridium (Nguyen)
Tenericutes (Evans)	Proteobacteria (Evans)
	Verrucomicrobia (Evans)
	Streptococus (Kang)

Table 1

in their diet. However, the post hoc test revealed a significant difference between the sedentary mice on a high-fat diet and the exercise group consuming a diet that was low in fat. The amount of Actinobacteria was significantly increased in sedentary mice consuming a diet low in fat, but these bacteria decreased after exercise and almost dropped to zero in the wheel-assigned mice that consumed a diet high in fat. Yet there was a trend for higher levels of Proteobacteria in the mice consuming a high-fat diet without exercise. Two additional phyla tested, Tenericutes and Verrucomicrobia, were not affected by diet or exercise. Exercise did decrease the ratio of Bacteroidetes to Firmicutes when using quantitative PCR analysis regardless of diet, but there was a trend towards an increase in the ratio when physical activity increased. Other families of bacteria were also affected by diet and exercise, but mice consuming a diet high in fat while exercising had the most diverse gut bacteria. The researchers point out that physically active mice consumed more fat than sedentary mice, resulting in an increase level in Bacteriodetes.[3]

A study by Kang et al (2014) conducted a similar study to Evans et al (2014) with the exception of using automatic exercise wheels for one hour per day vs. continuous exercise.[4] After testing fecal samples for 16 weeks, they found an abundance of Streptococci in mice consuming a high-fat diet (60% calories from fat) that was undetectable after exercise and also found a significant change in Bacteroidetes and Firmicutes; however, Tenericutes levels decreased with exercise and diet, unlike the previous study.[4]

DISCUSSION

The benefits observed in adolescent mice exposed to continuous exercise within the Mika et al study (2015), i.e. increased changes in the gut microbiota and a significant increase in lean body mass, suggest that beginning an exercise regimen early in life may be health-promoting. However, that is not to say that an exercise regimen is all that is needed to attain optimal health. A poor diet can still have deleterious effects on the microbiome even with regular exercise. Kang et al (2014) examined the relationship between dietary fat intake and exercise suggesting that while exercise may correlate with a significantly altered gut microbiome, the benefits of exercise do not necessarily outweigh those related to intake of a low-fat diet. Exercise alone cannot reverse the changes that are made to the microbiota while consuming a diet that is high in fat, since it will also cause a major shift in Bacteroidetes and Firmicutes.[3] However, it is interesting that despite using similar methods, Kang et al (2014) and Evans et al (2014) found that their techniques affected different types of bacteria, with the exception of Bacteroidetes and Firmicutes. This suggests that even small differences in diet composition and exercise regimen may result in changes to the microbiome. In addition, the author of this review article believes that regular exercise is crucial to maintain the health of the gut microbiome due to its ability to create more short chain fatty acids after physical activity. Expanding the amount of fatty acids increases control over the movement of the intestines, regulates the creation of new cells, improves the function of the immune system, and lowers cholesterol levels in the blood.[6] The majority of these studies relied on 16S rDNA sequencing and quantitative PCR analysis to sequence bacterial DNA from fecal contents.[1]

CONCLUSION

In conclusion, it is premature to assert that exercise causes a change in certain types of human bacteria or even the human microbiome, given that these studies focused on small samples in murine models. It appears there may be a correlation between exercise and changes in the murine microbiome which also contributes to potential health benefits for obesity such as weight loss and decreased blood glucose levels. Although the murine and human microbiomes are different, they still share a similar phyla and digestive system. Moderate exercise and reduction of saturated fat intake lower systemic inflammation and risk of potentially life-threatening diseases and may support gut health by altering the microbiome.[6]

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