PERPECTIVES

Fasting during exercise for fitness during feasting?

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Current lifestyle trends are characterized by low levels of physical activity and overconsumption of energy dense foods. This has led to a worldwide increase in the prevalence of obesity. Overweight and obesity are closely linked with a number of metabolic disturbances including the development of insulin resistance. Insulin resistance is defined as a relative impairment in the ability of insulin to exert its effects on glucose and lipid metabolism in target tissues (e.g. skeletal muscle, liver) and is considered one of the best predictors of the future development of type 2 diabetes (Warram et al. 1990). Insulin resistance can be induced experimentally by positive energy balance in humans (Samocha-Bonet et al. 2010) and in rodents (Storlien et al. 1986), and creating a negative energy balance either through dieting or increased physical activity rapidly improves insulin sensitivity and cardiovascular health. Since obesity prevalence continues to skyrocket, it is clear that most pharmaceutical therapeutics are not effective long term strategies for weight loss. Therefore, we need to identify smarter ways of dieting and/or exercising to improve metabolic health in the overweight and obese.

In a recent issue of The Journal of Physiology, Van Proeyen et al. (2010) shed light on the optimal exercise training protocol to improve health when consuming a fatty diet to excess. Here, 20 young men were placed on a high fat, weight gaining diet that consisted of 30% more calories than they required to maintain stable body weight. They were then randomized to exercising either first thing in the morning before breakfast, or exercising after consuming a carbohydrate rich breakfast, 4 times per week for 6 weeks. Both groups were compared to control, which increased energy intake by 30% but did not exercise. Exercise produced comparable increases in measures of fitness (e.g. $V_{O_2\text{max}}$ and time to exhaustion) and mitochondrial content as assessed by citrate synthase activity, regardless of whether it was conducted in the fasting or fed state. Importantly, only exercise performed in the fasting state produced significant improvements in glucose tolerance and GLUT4 protein content as compared to controls, despite consumption of a high fat diet that was designed to induce insulin resistance. This is in contrast to the group that exercised in the fed state, who did not have any detectable change in glucose metabolism. This study therefore suggests that exercising before breakfast provides greater health benefits than exercising after breakfast during caloric overload.

The authors also examined for changes in lipid metabolites within skeletal muscle as potential mechanisms that may contribute to this glucose sensitizing effect. Intramyocellular triacylglycerols (IMTGs) are an inert storage depot of lipid within skeletal muscle that are elevated in obesity. Accumulation of more deleterious lipid derivatives (e.g. fatty acyl CoA, diacylglycerol, ceramides) inhibit the insulin signalling cascade and impair GLUT-4 translocation to the cell surface (Turner & Heilbronn, 2008). Lipid accumulation within muscle may be due either to increased fatty acid delivery to cells, or an impaired capacity to oxidise dietary lipids. There is considerable evidence that a lipid oxidation defect exists in human obesity (Hulver et al. 2003) and another theory that is gaining momentum, suggests that defects in mitochondrial function may contribute to the accumulation of lipids in skeletal muscle (Turner & Heilbronn, 2008). These authors have previously shown that a single bout of exercise in the fasted state produces greater increases in fat oxidation and reductions in intramyocellular triacylglycerols, which may prevent diacylglycerol and ceramide accumulation in skeletal muscle (De Bock et al. 2005). In the present study, analyses were performed at least 48 h after the last exercise bout. There was some evidence that fatty acid turnover may be higher in the fasted group, as significant increases in the mRNA expression of FAT/CD36 and CPT1b were observed. However, functional measures of $\beta$-oxidation in muscle homogenates were not changed and in vivo whole body lipid oxidation was not assessed. Moreover, all groups had significant increases in IMTGs in response to overfeeding. This suggests that high fat overfeeding promotes triacylglycerol storage within muscle, regardless of exercise status. Interestingly, this increase in IMTGs did not coincide with any increases in ceramides or diacylglycerols in this lean healthy population, and it would be of great interest to test whether obese individuals overfed under similar conditions have a different response.

There are several limitations in this study design that should be noted. One major limitation is that only young, physically fit males were tested. This restricts possible interpretation as this population may behave quite differently to overweight or obese individuals. It is also doubtful that an obese individual is physically capable of running or cycling for the 60–90 min duration that was implemented in this study. Thirdly, all individuals were placed on similar increases in energy intake, but controls did not increase energy expenditure through physical activity, meaning that this group was relatively more overfed. Unsurprisingly, this led to greater weight gain in the control group. It should also be noted that the controls did not become glucose intolerant after overfeeding, as has previously been described in some, but not all human overfeeding studies, and this may depend on the macronutrient makeup of the overfeeding diet. Finally, the carbohydrate-fed exercise group also put on more body weight during overfeeding than the fasting exercise group. This may indicate that comparable exercise conducted in the fasting state expends more energy but may be better explained by lower dietary adherence in the 10 patients randomized to this protocol. Nevertheless, this study provides important new evidence that exercise imparts a powerful impetus to improve glucose metabolism and metabolic health, even during high calorie, high fat diets that typically induce insulin resistance. Refining exercise protocols for obese patients, who may habitually consume this type of diet, are now warranted.
References


