

Special Contribution

# The Female Athlete Triad: effects of estrogen deficiency on skeletal muscle in female

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## ABSTRACT

The Female Athlete Triad, an interrelationship of low energy availability, menstrual dysfunction, and low bone mineral density, is prevalent in sports activities. Because estrogens have a pivotal role in an extensive range of physiological functions regulating cellular homeostasis and energy metabolism, estrogen insufficiency caused by menstrual dysfunction leads to systemic health problems including metabolic dysfunction. We investigated the effect of prolonged estrogen insufficiency on skeletal muscle in young ovariectomized (OVX) female mice. Estrogen insufficiency resulted in muscle atrophy, reduced muscle force generation and a shift to a faster fiber type distribution. Population expansion of muscle stem cells, called satellite cells, was significantly reduced in OVX mice. Indeed, muscle regeneration was markedly impaired by a decrease of estrogen levels. Together, these results suggest that estrogens are essential for comprehensively maintaining muscle function with its insufficiency affecting muscle force and regeneration in young female mice. Here, we review recent progress in our understanding of the roles of estrogens in muscle function, and discuss nutritional interventions to prevent and treat the Female Athlete Triad.

**Keywords:** the Female Athlete Triad, estrogens, skeletal muscle, satellite cells