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The reduced effect of serotonin on oxygen consumption during muscle contraction in the autoperfused rat hindlimb

Abstract

Serotonin (5-HT) has been shown to reduce skeletal muscle oxygen consumption (VO₂) during resting conditions in a variety of animal models. It is thought to act through redistribution of blood flow within skeletal muscle directing flow away from muscle tissue (nutritive bed) towards less metabolically active tissue, adipose and septum (non-nutritive bed) by selective vasoconstriction. The aim of this study was to test whether the effects of 5-HT (previously observed under resting conditions) are reproducible during the increased metabolic demand of muscle contraction.

Keywords

rat, autoperfused, contraction, muscle, during, consumption, oxygen, serotonin, effect, hindlimb, reduced

Disciplines

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The reduced effect of serotonin on oxygen consumption during muscle contraction in the autoperfused rat hindlimb.

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Serotonin (5-HT) has been shown to reduce skeletal muscle oxygen consumption ($\dot{V}O_2$) during resting conditions in a variety of animal models. It is thought to act through redistribution of blood flow within skeletal muscle directing flow away from muscle tissue (nutritive bed) towards less metabolically active tissue, adipose and septum (non-nutritive bed) by selective vasoconstriction. The aim of this study was to test whether the effects of 5-HT (previously observed under resting conditions) are reproducible during the increased metabolic demand of muscle contraction.

Male Wistar rats were anaesthetised with sodium pentobarbital (6mg/100g i.p.). The right femoral artery was cannulated to supply blood to the left femoral artery (perfused) at a constant flow (basal $1\text{ml}\cdot\text{min}^{-1}$, contraction $2\text{ml}\cdot\text{min}^{-1}$) via a pump. Perfused hindlimb pressure was recorded distal to the pump and passive venous return occurred from the left femoral vein to the right external jugular vein. Systemic blood pressure was recorded from the left common carotid artery. Polyethylene cannulae were filled with heparinized 0.9% saline containing 6% w/v dextran70. The left sciatic nerve was isolated and stimulated (5Hz) to produce twitch contraction in the gastrocnemius muscle bundle and tension development recorded. 5-HT ($12.5\mu\text{M} - 100\mu\text{M}$) was prepared with saline and 0.01% ascorbic acid, and injected into the arterial loop. Blood was sampled from the venous and arterial loops and $\dot{V}O_2$ determined using the Fick equation.

In this model, basal $\dot{V}O_2$ was $0.33 \pm 0.02 \mu\text{mol}\cdot\text{min}^{-1}\cdot\text{gww}^{-1}$ ($n = 72$) when perfused at $1\text{ml}\cdot\text{min}^{-1}$ and reduced to $0.19 \pm 0.02 \mu\text{mol}\cdot\text{min}^{-1}\cdot\text{gww}^{-1}$ ($n = 20$) at $2\text{ml}\cdot\text{min}^{-1}$ but was increased to $0.57 \pm 0.08 \mu\text{mol}\cdot\text{min}^{-1}\cdot\text{gww}^{-1}$ ($n = 21$) during muscle contraction. 5-HT significantly decreased $\dot{V}O_2$ at all doses and although 5-HT decreased the $\dot{V}O_2$ during muscle contraction this was only significant only at $25\mu\text{M}$. At rest 5-HT ($25\mu\text{M}$) produced a maximal 67% ($n = 6$) decrease in $\dot{V}O_2$ compared with a 46% ($n = 6$) maximal reduction during contraction. During contraction 5-HT ($100\mu\text{M}$) produced a 36% less reduction in $\dot{V}O_2$ compared with its effects at rest.

It was found that 5-HT reduces $\dot{V}O_2$ in both resting and contracting skeletal muscle however muscle contraction diminished this effect. The reduced effect of 5-HT on $\dot{V}O_2$ during twitch maybe due to local effects of the twitch (such as vasoactive metabolites) on oxygen demand, hence overriding the exogenous vasoconstriction of the nutritive pathway.