

This document only includes an excerpt of the corresponding thesis or dissertation. To request a digital scan of the full text, please contact the Ruth Lilly Medical Library's Interlibrary Loan Department (rlmlill@iu.edu).

THE ROLES OF O_2 , H^+ , AND K^+
IN SKELETAL MUSCLE FUNCTIONAL VASODILATION

Julia M. Lash

Submitted to the faculty of the Graduate School
in partial fulfillment of the requirements
of the degree
Doctor of Philosophy
in the Department of Physiology and Biophysics
Indiana University

September 1985

Accepted by the Graduate Faculty, Indiana University,
in partial fulfillment of the requirements of the degree of
Doctor of Philosophy.

August 9, 1985



Dr. H. Glenn Bohlen, Ph.D.
Chairman, Associate Professor



Dr. Joseph DiMicco

Doctoral
Committee



Dr. Richard A. Meiss



Dr. Carl F. Rothe

Abstract

The spinotrapezius muscle of adult (250-350 g) male rats was prepared for microvascular observation. The muscle was electrically stimulated to contract with pulses of 0.2 msec duration, 3-6 V amplitude, and 2, 4, 8, or 12 Hz frequencies. Microvascular diameters and tissue PO_2 , pH, and $[K^+]$ were measured with microelectrodes at rest, during contraction, and during recovery. A significant (approx. 50%) functional vasodilation was observed at contraction frequencies greater than 4 Hz. All orders (sizes) of arterioles, the largest through smallest, dilated equal proportional amounts during muscle contraction. Since the large vessels (>30 μ m i.d.) contribute the most to vascular resistance, these vessels must dilate if blood flow is to support muscle metabolism and function.

Capillary bed and periarteriolar PO_2 values decreased significantly (approx. 15%) with the onset of muscle contraction, but returned to resting levels during the fourth and fifth minutes of contraction. Therefore, there was no apparent oxygen-related stimulus for vasodilation in the vicinity of the arteriolar vascular smooth muscle. Furthermore, artificial elevation of the capillary bed and periarteriolar PO_2 during contraction did not attenuate functional vasodilation. Therefore, functional vasodilation was expressed independently of capillary bed and periarteriolar PO_2 .

Perivenular PO_2 remained significantly depressed (approx. 50%) throughout the contraction period. Therefore, a potential indirect oxygen-related stimulus for functional vasodilation exists in the vicinity of the venous bed.

Periarteriolar and capillary bed pH tended to increase with the onset of contraction, then decreased as muscle contraction continued. A significant prolonged acidosis (+4.2 nM) was observed during 8 Hz contractions, however, superfusion of the resting tissue with acidic fluids demonstrated that this acidosis was not of sufficient magnitude to account for a significant portion (<20%) of functional vasodilation. There was essentially no alteration of periarteriolar $[K^+]$ during muscle contraction. Therefore, there were no direct stimuli for functional vasodilation related to H^+ or K^+ .

A significant functional vasodilation was observed in the absence of any significant changes in capillary bed or periarteriolar PO_2 , pH, or $[K^+]$, indicating that these factors do not play a direct role in the maintenance of functional vasodilation. Perivenular PO_2 , however, did remain depressed throughout the contraction period. Hence, an indirect oxygen effect, related to the perivenular tissues, cannot be excluded as a potential mediator of prolonged functional vasodilation.

Table of Contents

Page

Dedication.....	v
Acknowledgements.....	vi
Abstract.....	vii
Table of Contents.....	ix
List of Appendicies.....	xii
List of Figures.....	xiii
List of Tables.....	xiv
Introduction.....	1
Mechanisms Potentially Involved in	
the Expression of Exercise Hyperemia..	4
Mechanical.....	4
Neural.....	7
Metabolic.....	14
Hyperosmolarity.....	17
Adenosine and the	
Adenine Nucleotides.....	19
Phosphate.....	22
Magnesium.....	23
Prostaglandins.....	23
Oxygen.....	24
Hydrogen.....	29
Potassium.....	33

Potential Mechanisms of Vasodilation.....	91
Oxygen Tension.....	92
Hydrogen Ion Activity.....	100
Potassium Ion Activity.....	103
Summary.....	105
Future Studies.....	107
Appendices.....	110
References.....	123
Vita.....	140