**Microvascular Blood Flow is Shunted from Bone to Muscle during Post-exercise Hyperemia**

**Introduction**
During exercise, metabolic demand of muscle greatly increases, but the muscle microcirculation is unable to meet this increase in demand until the muscle relaxes. Since intramuscular pressure during contraction is greater than microvascular perfusion pressure, vasodilatation and vascular recruitment of the muscle microvasculature occur during rest immediately following contraction. This phenomenon is termed post-exercise hyperemia. Using microspheres in several animal models, it is demonstrated that bone blood flow responds paradoxically to exercise with decreases in microvascular flow and increases in vascular resistance. However, these findings have not been documented in humans due to the invasive nature of the experiments. In this investigation, we present non-invasive measurements of bone microvascular flow in the human anterior tibia. We hypothesize that post-exercise hyperemia will preferentially increase muscle microvascular flow at the expense of bone microvascular flow.

**Methods**
Relative changes in muscle and bone microvascular flows of 6 healthy subjects (3 men, 3 women, ages 23 – 44) were measured. One photoplethysmography (PPG) probe was placed on the skin overlying the tibialis anterior muscle, and one PPG probe was placed on the skin overlying the diaphysis of the anterior tibia. Initial resting baseline flows for both muscle and bone were measured. Following baseline measurement, the subject performed 1 min of isometric dorsiflexion of the ankle joint, and measurements were continued until 1 min following exercise. Dorsiflexion of the ankle joint was standardized to 50N by using a custom-built ergometer. For each subject, the mean PPG value obtained at the initial resting period was used as a reference value. All subsequent PPG data were normalized by dividing the reference value and multiplying by 100, thus giving an initial value of 100% for normalized data. A repeated measures ANOVA was used for statistical comparisons, and statistical significance was set at p<0.05.

**Results**
Immediately following exercise (Fig. 1), muscle microvascular flow increased significantly to 265±36%, while bone microvascular flow decreased to 58±10% (means±SE compared to baseline of 100%, p<0.01). Muscle microvascular flow was significantly different from bone flow (p<0.05, repeated measures ANOVA).

**Discussion**
Post-exercise hyperemia in muscle is well documented with PPG, but to our knowledge, this study is the first to measure bone microcirculation non-invasively following exercise and to find that BMF is shunted to MMF. Four major mechanisms may contribute to post-exercise hyperemia in muscle. The exercising muscle pumps venous blood towards the heart, decreasing venous pressure and increasing the effective perfusion pressure of the muscle upon relaxation. Since most of the venous drainage of the tibia is intramedullary, venous pumping likely contributes more to increases in muscle microvascular flow than to bone microvascular flow. Another possible mechanism is that exercising skeletal muscle releases vasoactive substances which act on local muscle microvasculature and do not affect bone blood flow. Other mechanisms of microvascular control include the humoral and neural control systems, but it is thought that both muscle and bone microcirculation respond similarly. These two latter mechanisms are unlikely to contribute to the differences following exercise in muscle and bone microcirculation. In summary, mechanisms such as venous pumping and release of local vasodilators likely cause increases in muscle microvascular flow at the expense of bone microvascular flow during post-exercise hyperemia.

**References**

**Acknowledgements**
Funding provided by NIH Kirschstein T32 Training Grant, the Göteborg Medical Society, and the Swedish Society of Medicine.

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**Figure 1:** Post-exercise hyperemia of tibialis anterior muscle and corresponding decreases in bone microvascular flow. Baseline measurements were normalized to 100%. Muscle microvascular flow (MMF) was significantly different from bone microvascular flow (BMF), repeated measures ANOVA, p<0.05.