Effects of dietary fish oil on exercising muscle blood flow in chronic heart failure rats

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Abstract

Impaired vasomotor control in chronic heart failure (CHF) limits the delivery of O_2 to skeletal muscle during exercise. Previous results demonstrate significant increases in skeletal muscle blood flow (Q) during exercise with omega-3 polyunsaturated fatty acid (PUFA) supplementation via fish oil (FO) versus safflower oil (SO) in healthy rats (Stebbins CL et al., Int J Sport Nutr Exerc Metab 20:475-86, 2010). Whether PUFA supplementation with FO will improve vasomotor control in CHF and skeletal muscle Q during exercise remains to be determined. **Purpose:** This investigation tested the hypothesis that PUFA supplementation with FO would augment the skeletal muscle Q response to exercise in rats with CHF when compared to SO. **Methods:** CHF was induced in male Sprague-Dawley rats (568 ± 24 g) by myocardial infarction produced by left coronary ligation. Rats were then randomized to dietary FO (20% docosahexaenoic acid and 30% eicosapentaenoic acid, n = 8) or SO (5% safflower, n = 6) supplementation for 6 weeks. After 6 weeks of dietary intervention, rats remained on their respective diets until final experiments were conducted. Following acute instrumentation and recovery (> 1 hour), mean arterial pressure (MAP), skeletal muscle Q to the total hindlimb and individual muscles (via radiolabeled microspheres), and blood lactate concentration were determined during submaximal treadmill exercise (20 m · min^{-1}, 5% incline). **Results:** Left ventricular end-diastolic pressure (LVEDP) measured in the SO and FO groups during instrumentation were similar and demonstrated moderate CHF (LVEDP; SO: 11 ± 1; FO: 10 ± 2 mmHg, p > 0.05). During submaximal exercise, MAP (SO: 132 ± 3; FO: 138 ± 4 mmHg), total hindlimb skeletal muscle Q (SO: 113 ± 15; FO: 92 ± 7 ml · min^{-1} · 100 g^{-1}) and blood lactate (SO: 4.0 ± 0.8; FO: 5.1 ± 0.6 mmol · l^{-1}) were similar (p > 0.05) between groups. In addition, all 28 individual hindlimb muscle Q's were similar (p > 0.05) between SO and FO groups. **Conclusion:** These data suggest that PUFA supplementation with FO in rats with moderate CHF does not increase the skeletal muscle Q response to submaximal whole body exercise.

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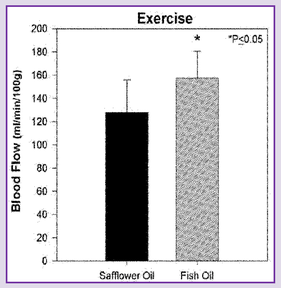
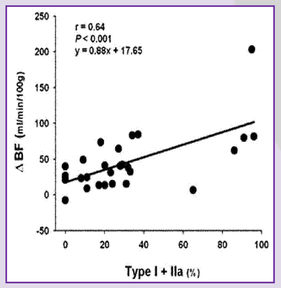
Background

Polyunsaturated fatty acid (PUFA) supplementation with dietary fish oil (FO) augments conduit vessel blood flow in healthy humans (Walser, 2006).

In chronic heart failure (CHF) endothelial dysfunction precludes an appropriate hyperemic response to exercise which contributes to severe exercise intolerance (Hirai, 1995).

In healthy rats hindlimb muscle blood flow is augmented with PUFA supplementation with the increases occurring principally within muscles and muscle portions composed of predominantly type I and IIa fibers (Stebbins et al. 2010).





Hypothesis

PUFA supplementation with FO augments the skeletal muscle blood flow response to dynamic whole body exercise in rats with CHF.

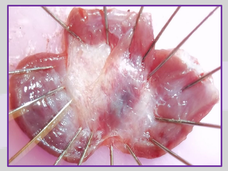
Methods

14 Young adult male Sprague-Dawley rats

CHF induction – myocardial infarction via left main coronary artery ligation

Diets: Isocaloric, 5% of either FO (20% docosahexaenoic acid, 30% eicosapentaenoic acid) or safflower oil (SO, control)

Left ventricle of representative non-infarcted healthy rat



Left ventricle of representative CHF rat (infarct area = 42.6%)

Timeline

Myocardial infarction procedure	3 week CHF induction	6 week dietary intervention	Blood flow protocol

Measurements

Hemodynamic (Millar catheter) and morphological (post-mortem) determination of infarct size.

Blood flow - radiolabelled microspheres (reference sample method) during treadmill running (20 m · min^{-1}, 5% incline).

Mean arterial pressure (MAP) and heart rate (HR) were determined via pressure transducer recordings.

Results

Dietary consumption was not different between groups (FO = 27.0 ± 1.7, SO = 27.6 ± 1.4, p > 0.05)

Body mass was significantly greater post-diet in SO versus FO (FO = 506 ± 15, SO = 615 ± 39, p = 0.008)

Table 1: Morphological and hemodynamic characteristics of FO and SO rats

CHF Index	FO	SO
Left ventricular end diastolic pressure (mmHg)	8 ± 2	12 ± 1
Lung/body mass (mg/g)	4.56 ± 0.5	4.24 ± 0.65
RV/body mass (mg/g)	2.23 ± 0.08	2.14 ± 0.20
LV/body mass (mg/g)	0.62 ± 0.02	0.60 ± 0.05
Infarct size (%)	33 ± 1	32 ± 2

Figure 1: MAP was not different between FO and SO groups at rest or during exercise

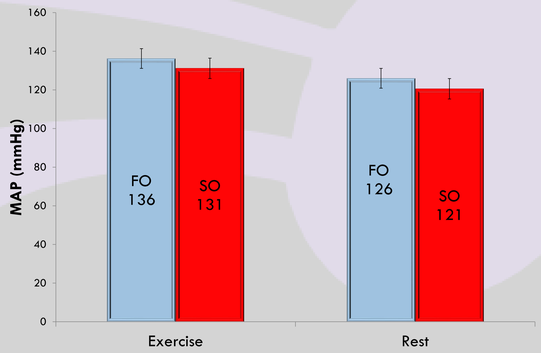


Figure 2: Total hindlimb blood flow during exercise was not different between FO and SO groups

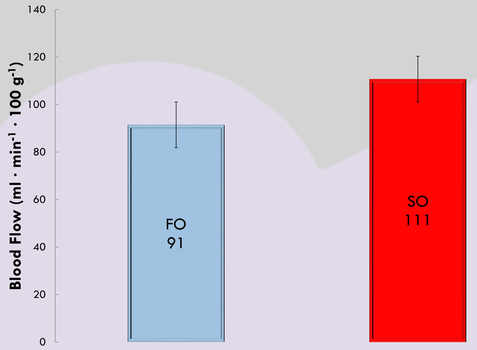


Figure 3: Blood flow was not different across the range of muscle fiber-type composition

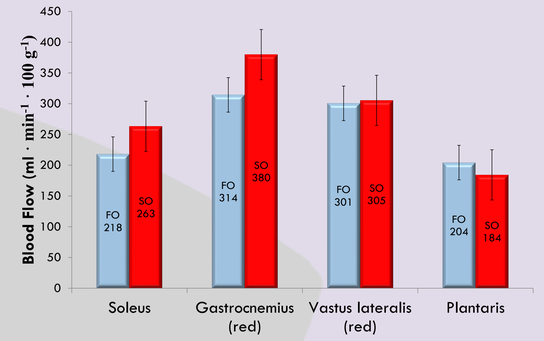
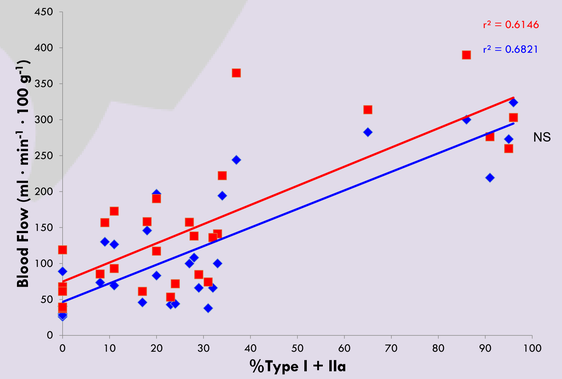


Figure 4: The fiber type-dependent relationship between FO and SO groups was unchanged



Conclusions

PUFA supplementation with dietary FO does not augment locomotor skeletal muscle hyperemia during whole body dynamic exercise in rats with CHF.

References

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