Effects of circulatory differences on muscle endurance performance during exercises in different postures

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Introduction
Muscle circulation is one of the determinant factors for muscle endurance performance, because blood flow through muscles has the role of oxygen and energy transportation as well as elimination of metabolic waste. Some prevalent environmental factors in human activity, such as gravity, give direct and large impact against the cardiovascular regulation, and may cause a difference in muscle circulation. By the existence of gravitation, differences of the heart and exercising muscle configuration cause circulatory changes by hydrostatic pressure (Nielsen, 1983), and this known to result in the difference of muscle endurance performance (Yata et al., 1983). But so far there were no study concerning about the effects of body posture differences on muscle endurance performance with reference to both the changes in muscle circulation and neuromuscular activity. The purpose of this study was to examine muscle circulation differences during exhaustive intermittent exercises with different body postures. Further, to discuss their effect on muscle endurance performance in relation to the neuromuscular activity.

Methods
Previous to the experiment, we measured tissue oxygenation of tibialis anterior muscle (TA) at rest in two different body postures which was used later as exercising posture, i.e., lower leg elevated (Leg up) or lowered (Leg down) from heart level. To determine the target torque we took maximum voluntary contraction torque of static dorsiflexion at the angle of 90 deg before each exercise. The subject performed intermittent (3 sec contraction, 2 sec rest) static dorsiflexion at 50% of maximal voluntary contraction (MVC) up to exhaustion with two different body postures. To examine the circulatory responses of the muscle, we used near-infrared spatially resolve spectroscopy (NIRS; NIRO 300L, Hamamatsu Photonics, Hamamatsu, Japan). Total hemoglobin volume change (total Hb), and tissue oxygen index (TOI: oxy-Hb / total Hb) of the TA was recorded by NIRS at a sampling frequency of 1 Hz and averaged for every 5 sec. The changes of total Hb and TOI was expressed as μM*cm (μM: μmol/l) and % respectively. Simultaneously we took the surface electromyogram (EMG) of TA during exercises. Integrated EMG for each contraction was obtained with full wave rectification and integration. The iEMG was expressed relatively as a percentage of that of MVC value (%iEMG). In addition, the effects of body posture differences on muscle endurance performance were compared between normal blood flow (non-ischemic) and ischemic condition.

Figure 1: Pictures of “Leg up” (left) and “Leg down” (right) postures.
Results & Discussion

At rest, the amount of total Hb decreased (–250 ± 20 μM*cm) when the subjects changed their posture from leg down to leg up, indicating that the blood supply to TA decreased due to posture change. The number of contractions at non-ischemic exercises in leg up was significantly smaller than that in leg down (leg up, 52.3 ± 11.6; leg down, 86.2 ± 12.7), although the MVC force were much the same in both postures. While the results obtained at exercises in both postures with ischemia were similar (leg up, 30.8 ± 1.0; leg down, 30.8 ± 1.5). These suggest that the blood flow differences by changing body postures have an effect on muscle endurance performance.

![Figure 2](image_url: https://example.com/figure2.png)

**Figure 2**: Number of contractions in exhausting exercise with leg up (blue column) and leg down (red column). Values are mean ± SE from all subjects. Left and right figure shows non-ischemic exercise and ischemic exercise respectively. * Significant (P <0.05) differences between leg up and leg down.

Although the change of total Hb was larger in leg up during non-ischemic exercises (leg up, 138.7 ± 46.3 μM*cm: leg down, 9.3 ± 55.4 μM*cm), it was not enough to countervail the difference at the beginning of exercise (i.e. difference at rest). TOI showed a lower value (leg up, 13.62 ± 3.71 %: leg down, 21.33 ± 5.25 %) and integrated EMG inclination was sharper (leg up, 1.37 ± 0.35 %/contraction: leg down, 0.68 ± 0.20 %/contraction) in leg up than in leg down during non-ischemic exercises. These may be the results of the increase in both of motor unit recruitment and discharging rate to compensate the declined contractility of the muscle caused by reduction of blood flow in leg up.

![Figure 3](image_url: https://example.com/figure3.png)

**Figure 3**: Typical recordings of iEMG (upper figure), ΔHbtot (middle figure) and TOI (lower figure) change during non-ischemic exercise with leg up (blue) and leg down (red). Values of iEMG are expressed as a percentage of MVC values.
References

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