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Short Communication

Comparison of calf blood flow during and immediately after rhythmic exercise.

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Blood flow change in the human limb during rhythmic exercise has hitherto been determined by xenon 133 clearance or indicater dye-dilution methods. However, the use of these methods may be restricted during a limited type of exercise and risky for measurement during strenuous exercise because these methods need blood sampling or catheterization. On the other hand, venous occlusion plethysmography, which don't require blood sampling or dye injection, seems to be one of the useful method for measuring the blood flow in the human limb. Since the blood flow during rhythmic exercise could not measure with this technique until 1949, it was infered from the blood flow which was determined immediately after exercise[2,5]; the first successful attempt to determined the blood flow in the human calf during rhythmic exercise by means of venous occlusion plethysmography was reported by Barcroft and Dornhorst in 1949[1]. In this report, however, the relation between the blood flow during and immediately after exercise has never been clear. The present study was undertaken to compare the calf blood flow obtained during and immediately after rhythmic exercise by venous occlusion plethysmography.

The subjects were healthy normal 10 male students of our university, aged 19 to 21 years. The subjects were lying on the firm couch, and their foots were suspended from the ceiling. The rhythmic exercise of dorsi-flection of the ankle joint was performed by the electrical stimulator(3F37, San-ei Instrument, Tokyo) for about 5 min. The nervous stimulation of cutaneous surae lateralis was made with monopolar technique between a small circular metal electrode with a diameter of 9 mm on the knee joint and a large electrode placed over the thigh. Both electrodes were kept in place by adhensive tape. The pulse width, current intensity and frequency of the stimulation were 5.0 msec, 4 – 8 mA and 3 Hz, respectively. The work performed by the electrical stimulation was 9.0 to 27.0 kg·m/min. The venous occlusion plethysmography with mercury in rubber strain gauge was used to determine the calf blood flow before, during and immediately after exercise because the reliability of this method (press method) have been confirmed previously (Matsui et al, 1978)[4]; the rubber strain gauge was wound lightly around the maximal circumference of the calf with tension of 25 g in recumbent subjects, and calibrated with a micrometer before and after experiments. The venous femoralis was pressed to 2 – 3 kg/cm^2 on the anterior surface of the inguino-crural near the sulcus inguinalis by means of pressing appartus which was made of

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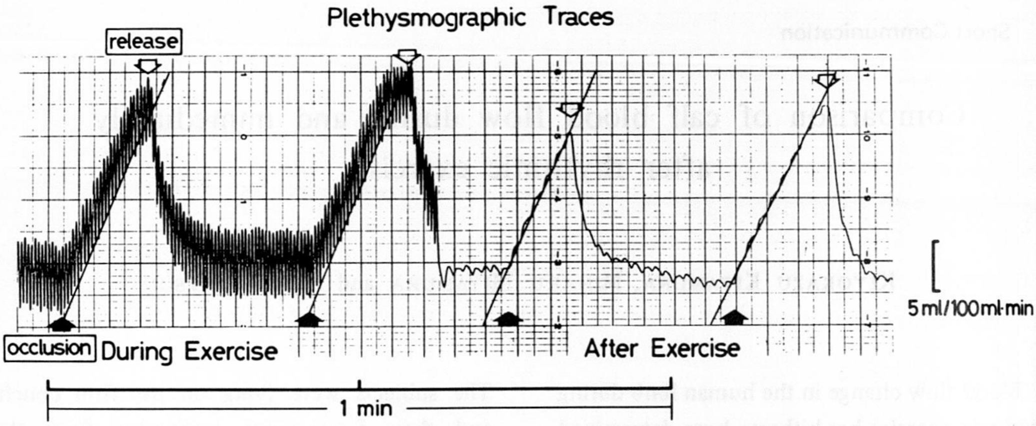

Figure 1. An actual record of volume changes in the calf during and after rhythmic exercise.

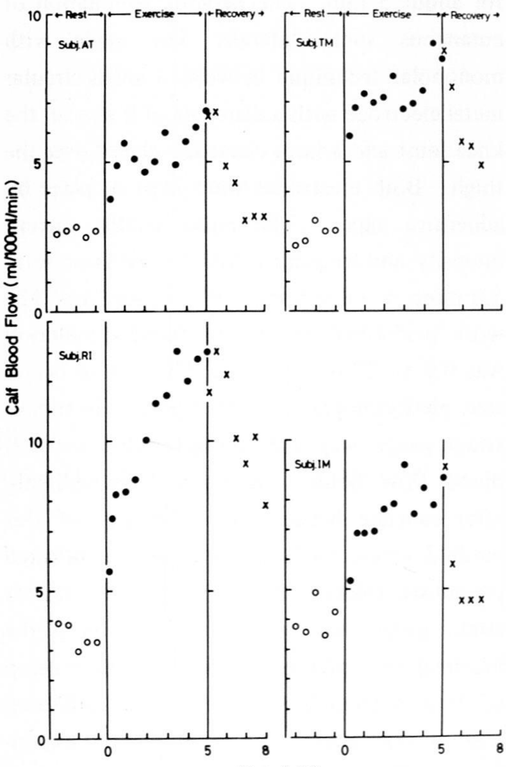

Figure 2. Calf blood flow before (open symbol), during (solid symbol) and after (cross symbol) rhythmic exercise.

a block of stiff rubber. An actual record of volume change in the calf during and immediately after rhythmic exercise was shown in Fig. 1. From these volume change thus obtained, the calf blood flow was calculated based on the assumption described by Whitney (1953)[6]. The calf blood flow was measured at 30 second intervals during exercise, and it was determined as fast as possible immediately after exercise (within 15 second).

The resting mean values of the calf blood flow was 3.0 ml/100 ml·min. This value was almost identical to those reported by Elsner and Carlson (1962)[2] and Kitamura et al (1976)[3] who were determined calf blood flow at resting condition using the venous occlusion plethysmography. Figure 2 shows the representative results of the calf blood flow before, during and after rhythmic exercise. The calf blood flow increased with increasing exercise time, while there was a wide range of the degree for the calf blood flow around the mean increment. As described above, Barcroft and Dornhorst (1949)[1] have attempted to determine the calf blood flow during rhythmic

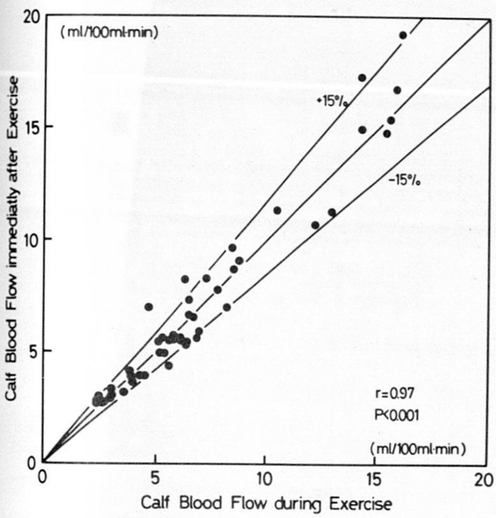

Figure 3. Relationship between calf blood flow during and immediately after rhythmic exercise.

exercise with plethysmography; they estimated the blood flow during exercise of the gastrocnemius and soleus as the sum of apparent inflow, apparent pumped outflow and collateral inflow. They have reported that the immediately post-exercise flow really analogous to an interpolated relaxation flow, and was greater than the exercise flow. However, it was found in this study that there are close correlation between the calf blood flow immediately before stopping the exercise and after exercise ($r = 0.97$, $P<0.001$) as shown in Fig. 3. From these results, it was suggested that at least in the conditions like this experiments the calf blood flow during rhythmic exercise may be able to predict from those obtained immediately after exercise. Although the discrepancy between Barcroft and Dornhorst[1] and our results seem to be due to the difference in the work load, the method of calculating the blood flow during exercise etc, it will be further investigation to estimate the blood flow during exercise by means of plethysmography.

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