THE EFFECT OF DIFFERENCES IN PASSIVE MUSCLE LENGTH CHANGES ON MUSCLE BLOOD VOLUME

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INTRODUCTION
In a passive calf muscle stretching, the muscle blood volume changes during stretching have been reported. Compared to static stretching methods with a constant muscle fiber length change, dynamic stretching methods with repetitive muscle fiber length changes have led to several changes in blood vessels relative position of the muscle fibers. Changes in muscle blood volume in dynamic stretching are considered to be different from static stretching. The purpose of this study was to clarify the effect of differences in passive muscle stretch-relaxation pattern on muscle blood volume.

METHODS
Subjects were supine position with full knee extension, and their foot was fixed to the foot-plate attached to the force meter (LPR-S-1KNS17, KYOWA, Japan).

Ankle joint angle 105 deg (angle between the leg and foot) was rest position. To measure “the joint angles begin to cause the feeling of pain”, passive dorsiflexion was taken 1 deg/sec, and we adopted that ankle joint angle as the stretching position in following tests.

After taking at least 5min rest, 3 types of stretching described below were performed. (1) After holding for 60 sec, return to rest position in 15 sec (60S). (2) After holding for 30 sec, return to rest position in 15 sec, and repeat it again (30S). (3) After holding 15 sec, return to rest position in 15 sec, and repeat it 3 times (15S).

Blood volume in medial gastrocnemius was measured by near infrared spectroscopy (NIRO-200, HAMAMATSU, Japan) during and after stretching. Total hemoglobin (total Hb) was considered as muscle blood volume. For confirmation that the muscle was stretched passively, surface EMG (SX-230, DKH, Japan) was derived from the muscle. Passive force was expressed as percentage of maximal voluntary contraction (%MVC).

RESULTS AND DISCUSSION
When the stretching started, passive force increased and total Hb decreased (Figure 1). Passive force was varied 19.5-23.0 % while maintaining the stretching position.

In all protocols, while the 60-second stretching, passive force decreased about 3%. Muscle blood volume during maintaining a constant joint angle increased after 30 sec in 60S protocol.

This was due to the increase in the muscle fibers by stretching, blood vessels being placed parallel to the muscle fibers were also extending, thereby muscle blood volume decreased. However, while maintaining a certain joint angle, the blood vessels were loosen by decreasing the passive force, therefore, it was considered that the blood was easier to flow into the muscle.

Changes in muscle blood volume relative to the pattern at the start of each muscle length changes, even the repetitive stretching in 30S and 15S protocols, the blood volume during passive dorsiflexion decreased same levels. Decreasing muscle blood volume during stretching tended to be less according to many times (Figure 2). In this protocol, the blood volume may not fully recovered upon the joint angle returning to rest position.

After the second sets of stretching, though the stretching started from more less blood volume, blood volume was considered to be decreased to the same level as the first set, because blood vessels in the muscle was stretched same as the first set.

Figure 1: A typical example of passive force and total Hb.
CONCLUSIONS
In conclusion, the greater the number of stretching and relaxation, the less muscle blood volume reduction in passive dorsiflexion. However, muscle blood volume while maintaining a constant joint angle was almost same throughout repetitive stretching.

Figure 2: Changes of muscle blood volume during each passive dorsiflexions (stretching).