Dynamic Pressure and Flow Changes Associated with Muscle Contraction In Legs Compressed with either Coban or Ace Bandages

Dr. HN Mayrovitz

April 2001

BACKGROUND

Compression bandaging is a main treatment modality for lower extremity venous ulcers and is a principal component of the treatment of peripheral edema and lymphedema.

Bandaging effectiveness is in part related to the pressure it exerts which depends on bandage type, wear-time and other factors.

Under resting conditions, sub-bandage pressures achieved and measured are "static" pressures and previous work has shown these affect lower extremity blood circulation[1-4].

In particular, bandaging, that achieves sub-bandage pressures of 28-42 mmHg, results in increased leg pulsatile blood flow at rest[2,4]. However, the possible role of dynamic pressure changes that occur during normal walking and other activities has, until recently[5], received little investigative attention.

OBJECTIVES

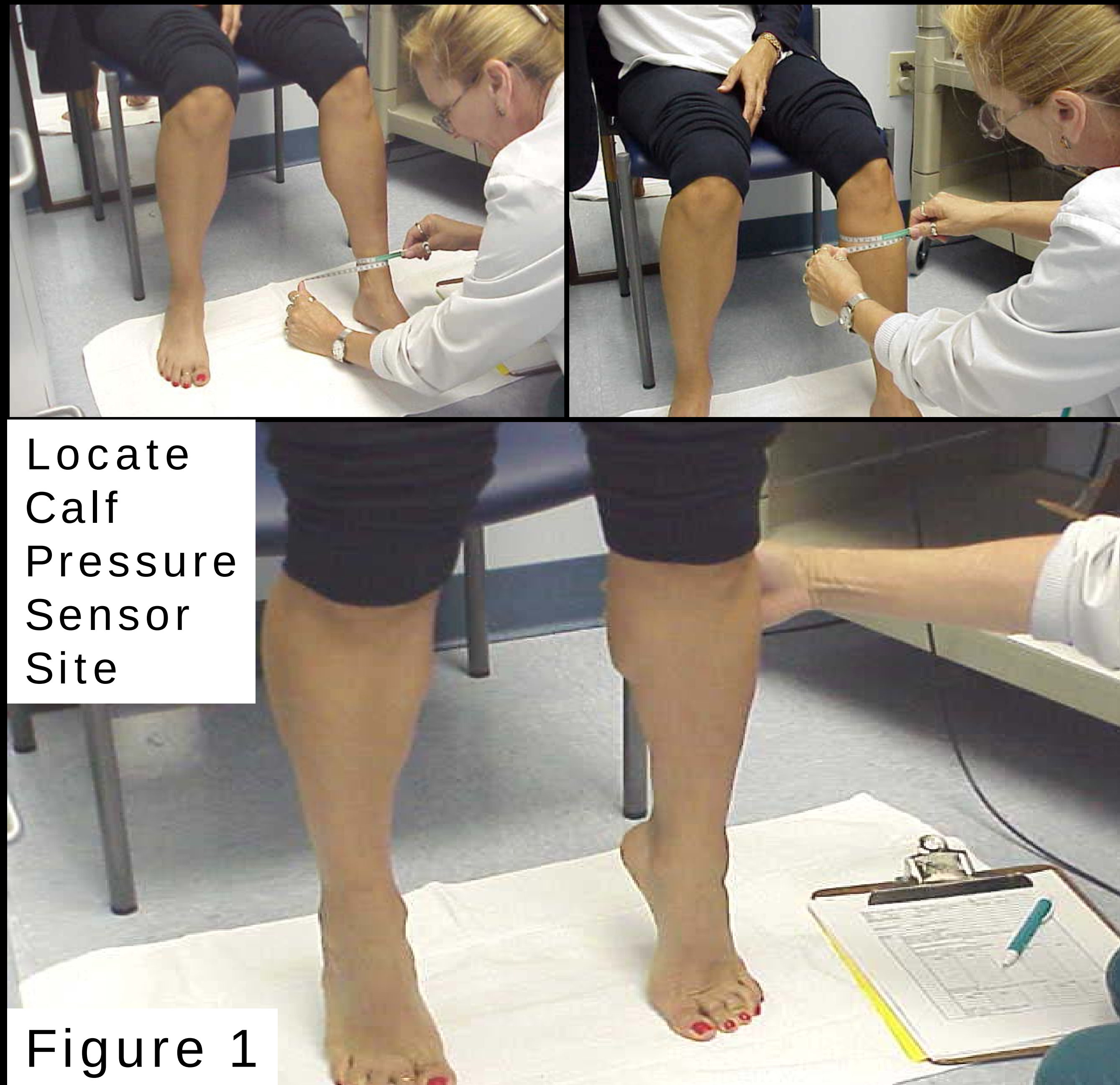
Static sub-bandage pressures can be very similar for quite diverse bandage material properties but once applied, working muscle-induced radial expansion depends on the bandage elastic properties. Pressure changes accompanying normal activities thus vary with bandage material, likely being greater for more inelastic materials.

The exact role of such dynamic pressure changes in the therapeutic efficacy of compression bandaging is not known. Our working hypothesis is that such differences may differentially effect blood or lymphatic circulations.

Our intial goal was to investigate the blood perfusion aspect and obtain basic information on the magnitudes of static and dynamic sub-bandage pressures of two different bandaging materials and to determine if skin blood perfusion (SBF) after activity is differentially effected.

Eleven volunteer subjects were evaluated during a single test session. One leg was spiral wrapped from foot-to-knee with an elastic crepe self-adherent bandage (Coban, 3M Company) at full stretch extension with 50% overlap. After a series of pressure and SBF measurements, the bandage was removed and the leg was wrapped with a long stretch bandage (ACE) and measurements repeated. The leg circumference at ankle and calf were determined (figure 1) and a standardize site on the posterior calf located. With subjects seated, a pressure sensor pad (Cleveland Therapeutics), on which a laser-Doppler probe (Vasamedics) was taped near the sensor (figure 2), was placed on the posterior calf. A second sensor pad was placed on the lateral gaiter area (figure 3). Subjects then stood flat-footed while a baseline non-bandaged SBF was measured for two minutes starting one minute after standing. Subjects then sat and the leg was wrapped with Coban. Static pressure measurements were taken and subjects returned to a flat-footed standing position (figure 4). Then a standardized sequential protocol (figure 5) was followed in which SBF was measured before and after two minutes of heel-up maneuvers at a rate of 15/minute and again after bandage removal. The sequence was then repeated with the leg bandaged with an ACE wrap at full extension.

Ankle-Calf Measures

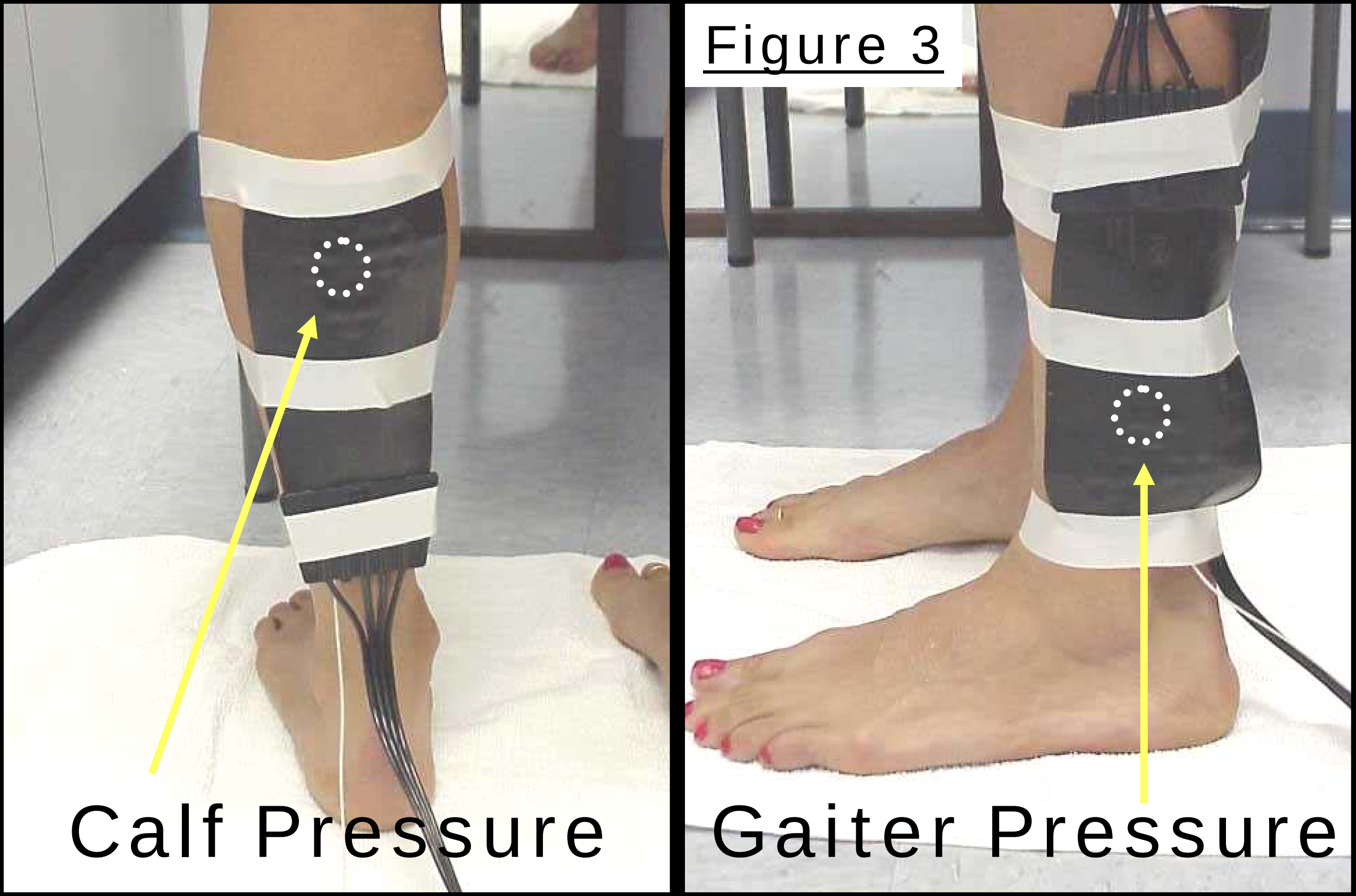


Locate Calf Pressure Sensor Site

Figure 1

Pressure & Perfusion Sensors

Pressure Sensor Positioning



Bandaged with Sensors in Place

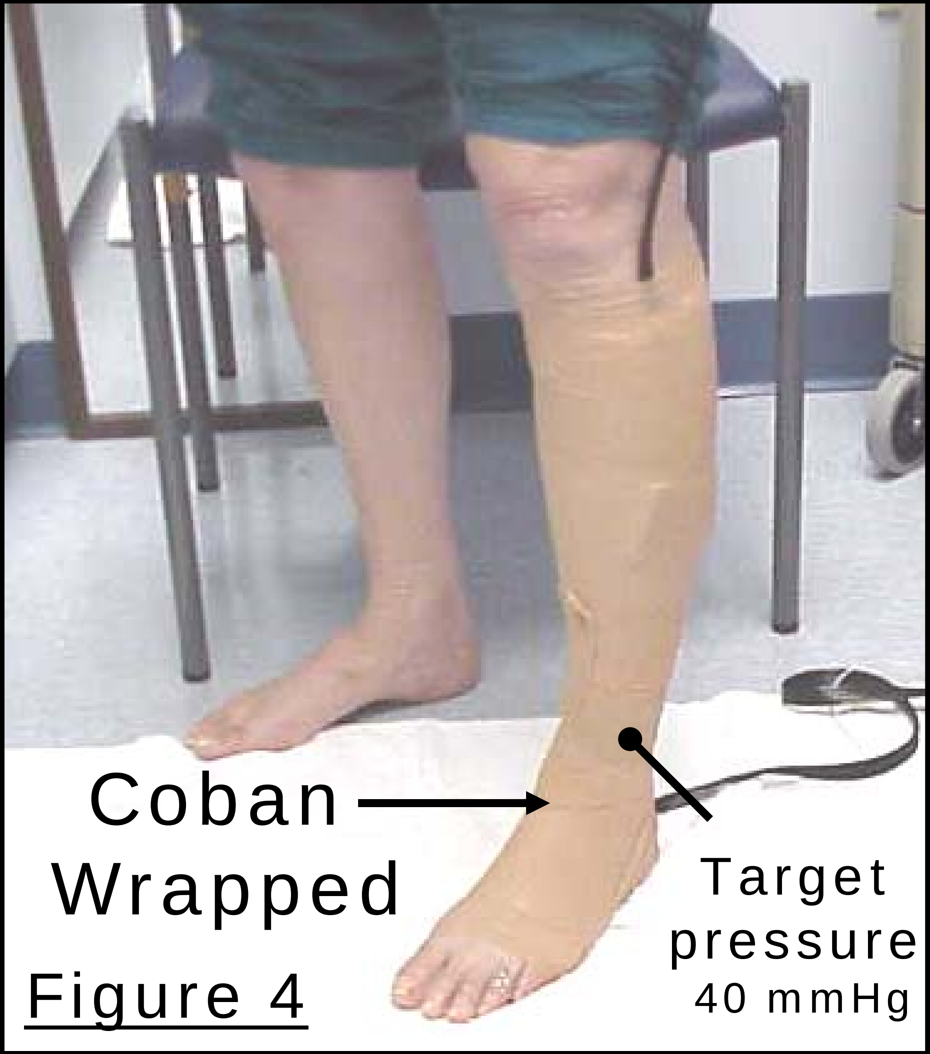


Figure 4

PROTOCOL SEQUENCE

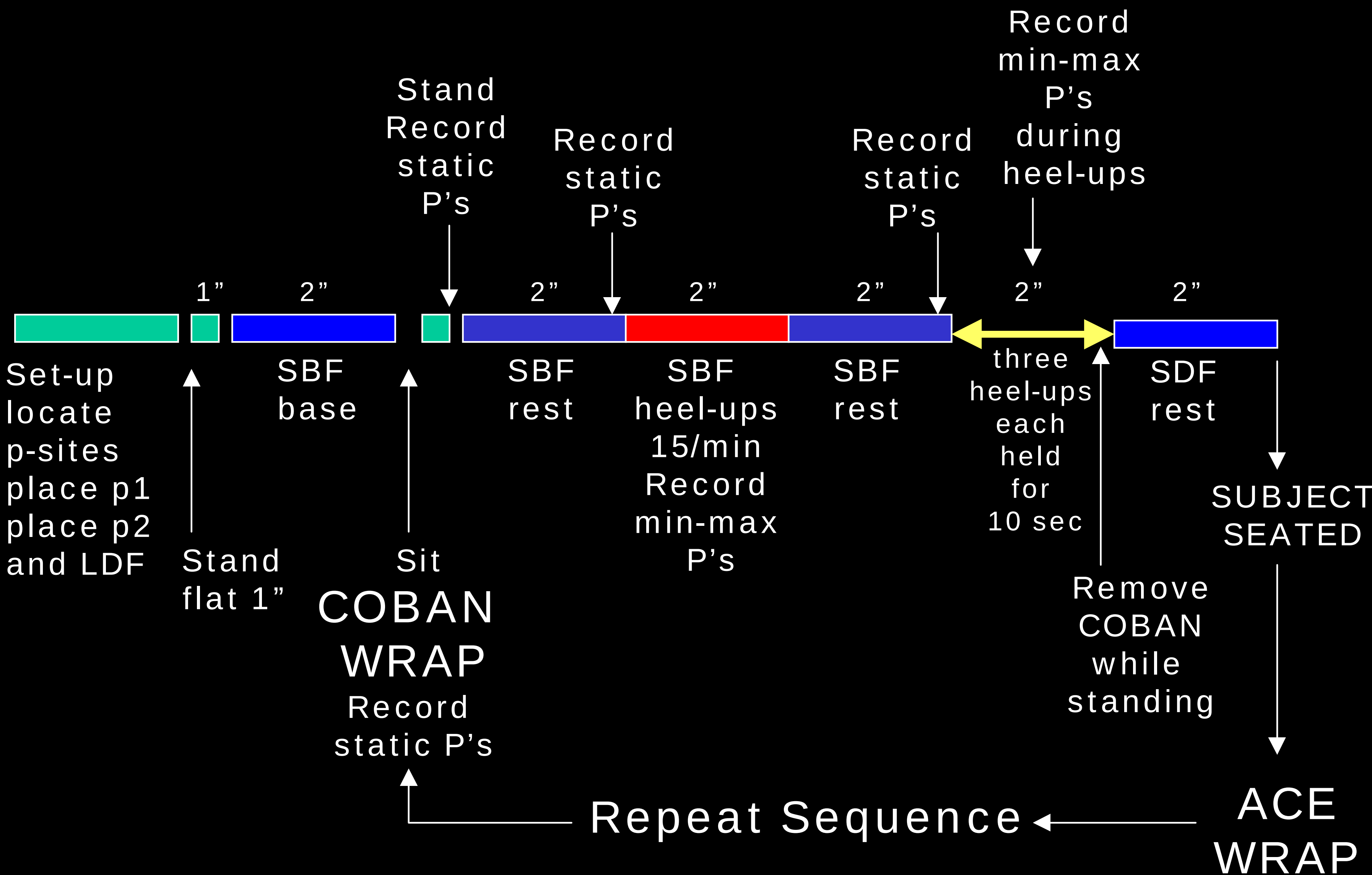
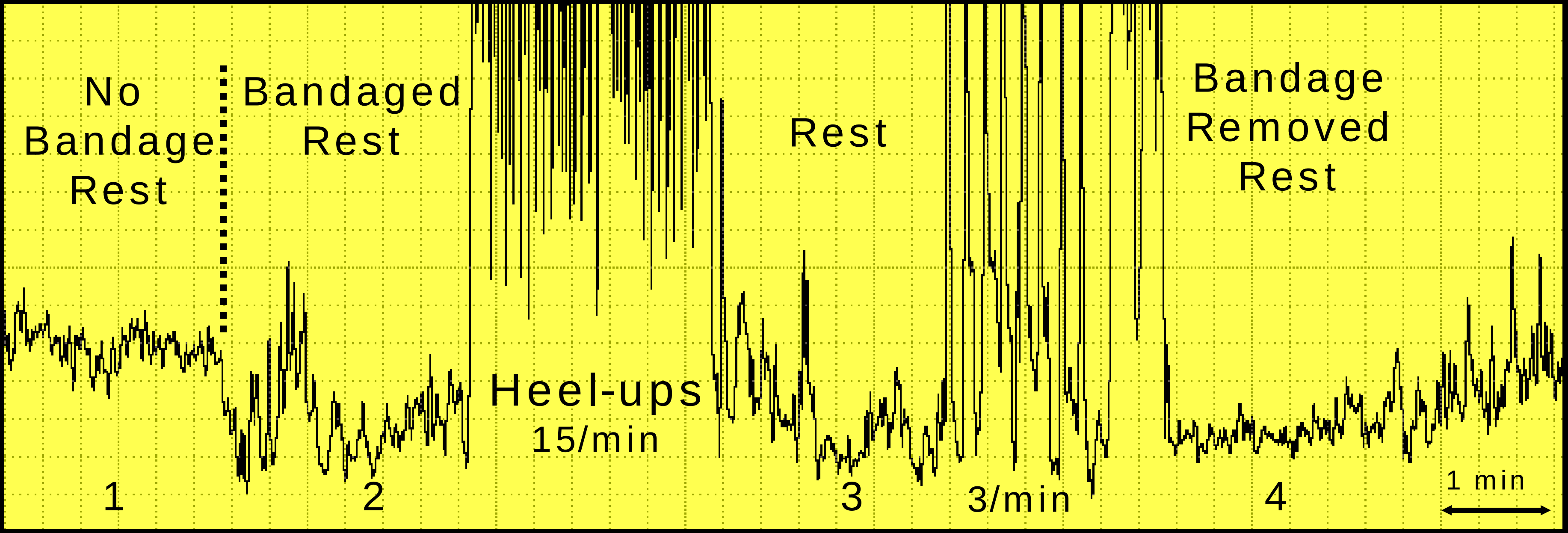


Figure 5

EXAMPLE SBF RECORD



Average SBF determined in intervals 1-4

Figure 6

RESULTS

Static Sub-bandage Pressures

At the gaiter, seated pressures tended to be higher with Coban (39.9 ± 6.9 vs. 31.3 ± 17.7, p=0.110) as were standing pressures (54.3 ± 12.7 vs. 42.6 ± 14.5, p=0,086) but did not achieve statistical significance. Contrastingly, at the calf, pressures during sitting (56.3±13.2 vs. 36.8±7.7) and standing (70.3±10.9 vs. 41.9±10.8) were significantly (p<0.01) greater for Coban vs. ACE. For both bandages, pressures were significantly greater when standing vs. sitting (figure 7)

Dynamic Pressures

During heel-up maneuvers, all max and most min pressures achieved with Coban were significantly greater than with ACE (figure 8).

Pulse Pressures (max-min during heel-ups)

Pulse pressures were significantly (p=0.001) greater for Coban at gaiter and calf sites (figure 9). Pulse pressures achieved with Coban were similar at gaiter and calf (19.0±8.7 vs. 22.2±11.4). In comparison, corresponding values for ACE were 0.9 ± 6.1 vs. 9.8 ± 2.8 mmHg

Blood Perfusion

Baseline SBF (158±58) did not significantly change after bandaging or after exercise with either Coban or ACE. However, SBF showed a tendency to increase after Coban bandaging (figure 10). SBF tended to be greater for Coban than with ACE bandaging but only after exercise was the difference significant (183.3 ± 108 vs. 160.2 ± 82.1, p<0,05).

STATIC PRESSURES

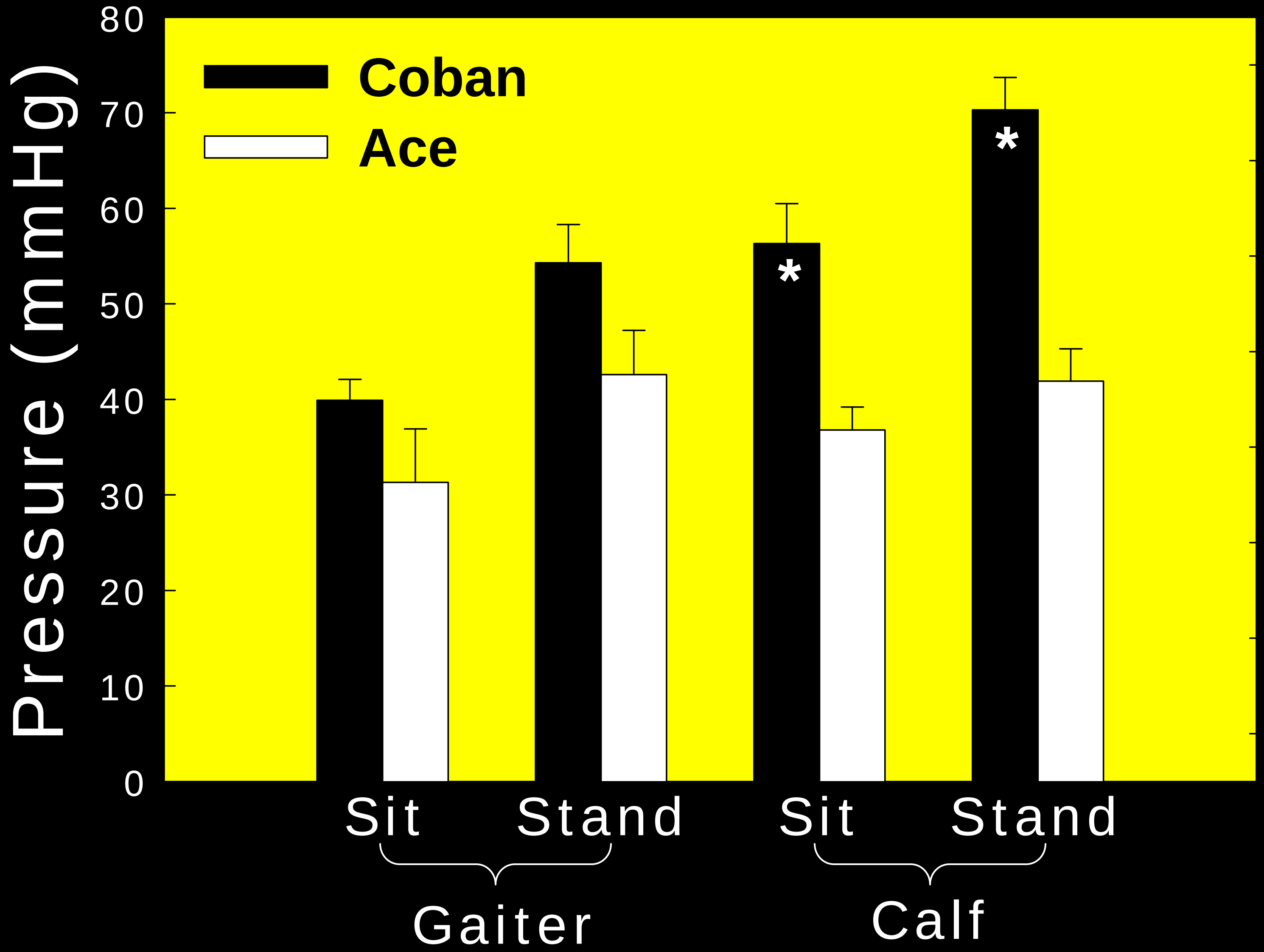


Figure 7

DYNAMIC PRESSURES

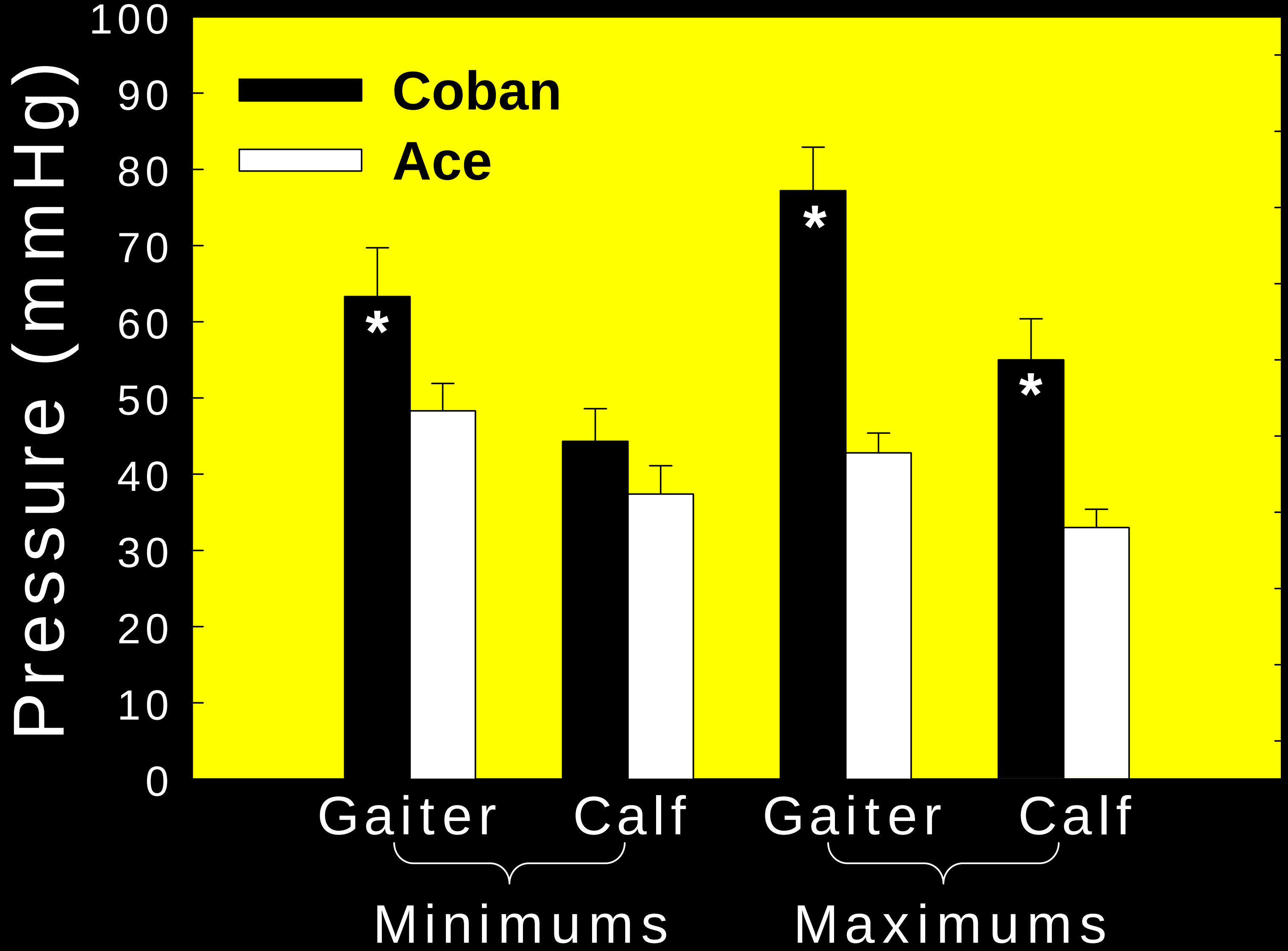
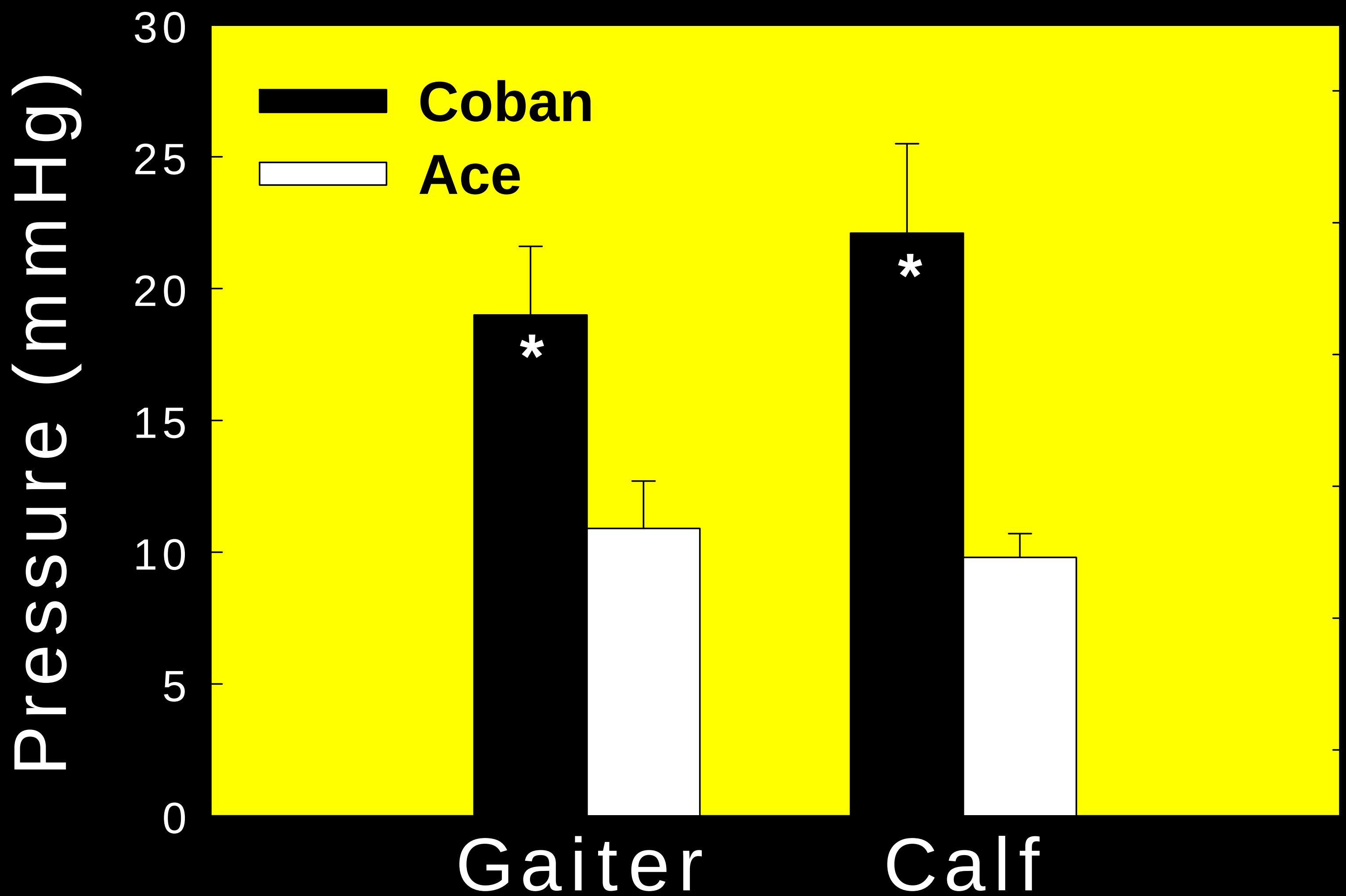


Figure 8

PULSE PRESSURES



Heel-ups at 15/min for two-minutes

Figure 9

RESTING PERFUSION

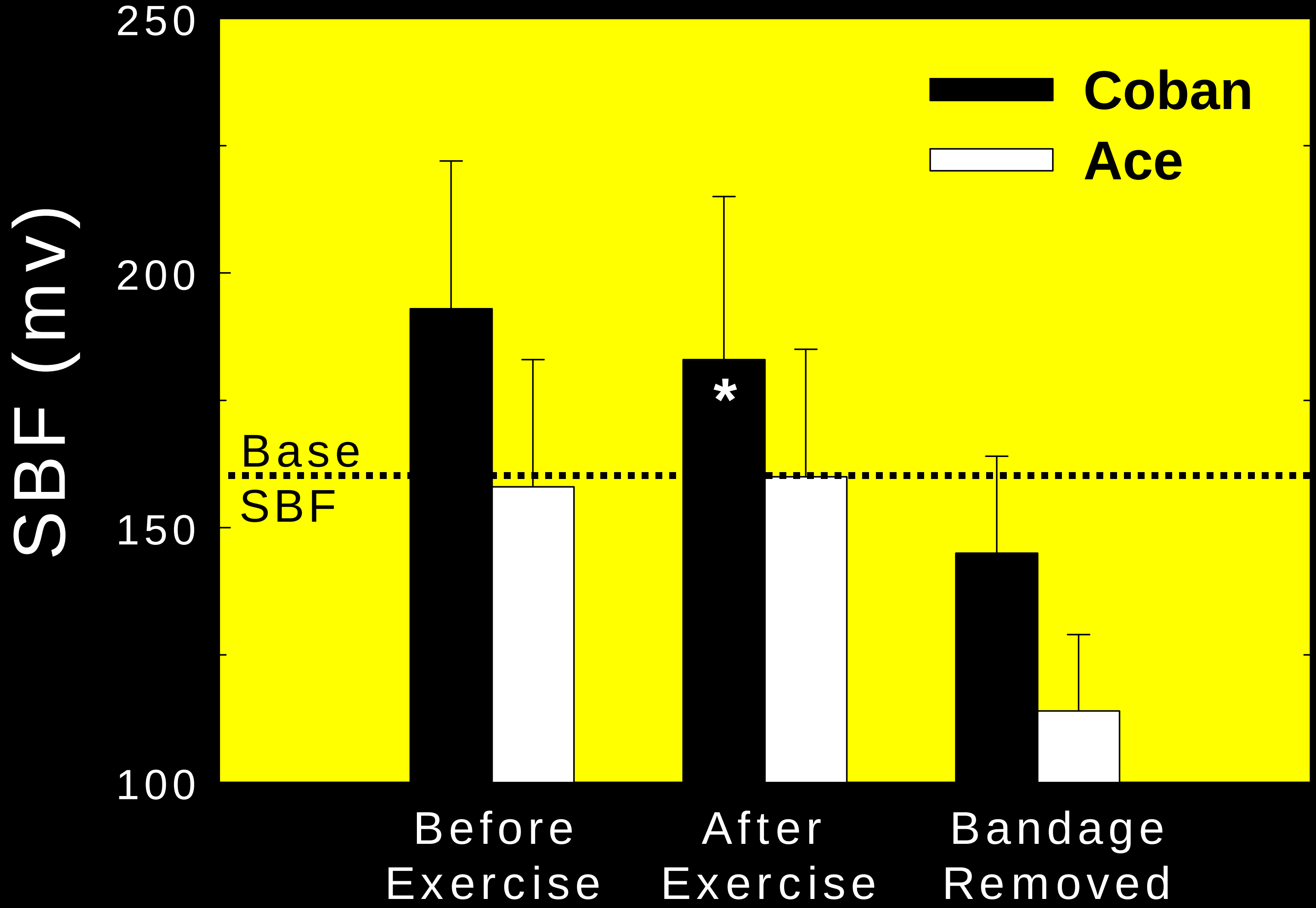


Figure 10

Discussion and Conclusions

- Sub-bandage pulse pressures achieved with an elastic crepe self-adherent bandage (Coban) during activity were about twice that achieved with a standard long-stretch bandage
- Pressure pulse amplitudes found with Coban (~ 20 mmHg), are consistent with the notion that activity-related pulses effect underlying lymphatic vessels with the possibility of beneficial displacement of lymphatic and tissue fluids
- But, as no direct measurements of fluid movement associated with the pulses have been made, definitive statements as to actual effects on patients with lymphedema are premature
- On average, pressures achieved did not adversely affect sub-bandage skin blood perfusion. In fact, with the elastic crepe bandage, SBF tended to be greater than when non-bandaged. In a few cases, as shown by figure 6, slight reductions in SBF were observed
- During activity-induced pressure changes, possible direct effects on SBF are masked by movement artifact. However, post-activity resting SBF was found to be insignificantly different from pre-activity values. This suggests that if pressure pulsations alter SBF, then these would be restricted to the activity interval.

REFERENCES

1. Mayrovitz HN, Delgado M. Effects of compression bandaging on lower extremity skin microcirculation. Wounds 1996;8:1-8

2. Mayrovitz HN , Larsen PB. Effects of compression bandaging on leg pulsatile blood flow. Clinical Physiology 1997;17:105-117

3. Mayrovitz HN, Delgado M., Smith J. Compression bandaging effects on lower extremity peripheral and sub-bandage skin blood perfusion. Wounds 1997;9:146-152.

4. Mayrovitz HN Compression-induced pulsatile blood flow changes in human legs. Clinical Physiology. 1998;18:117-124

5. Hafner J, Botanakis L, Burg G. A comparison of multilayer bandage systems during rest, exercise and over 2 days of wear time. Arch Dermatol 2000;136:857-863