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## **Ankle Exercise Increases Venous Blood Velocity, Compression Stockings Have No Effect**

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### **ABSTRACT**

**Background:** Methods for preventing venous stasis include graduated compression stockings and ankle exercise in the form of repetitive dorsiflexion and plantar flexion. We measured the effects of graduated compression stockings and ankle exercise on venous blood velocity.

**Methods:** Time averaged peak blood velocity in the popliteal vein of 25 men aged 23-39 years was measured while supine and sitting, at rest and with ankle exercise, with and without graduated compression stockings.

**Results:** Popliteal vein blood velocity was lower when sitting than when lying supine. Blood velocity increased with ankle exercise. Graduated compression stockings had no effect at rest and stockings did not augment blood velocity with ankle exercise.

**Conclusion:** Ankle exercise may be useful for decreasing venous stasis. In healthy young men, graduated compression stockings had no effect, but these data on compression stockings may not apply to hospitalized patients, many of whom have venous insufficiency.

Prevention of venous stasis is one of the methods by which the incidence of deep venous thrombosis presumably can be reduced. Mechanical methods for preventing venous stasis include graduated compression stockings, intermittent pneumatic compression devices and the venous foot pump (1). These interventions have been shown to reduce the risk of deep venous thrombosis after general surgery (2), neurosurgery (2), elective hip arthroplasty (3), total knee arthroplasty (4,5), and surgery for hip fracture (6).

Randomized controlled trials of graduated compression stockings have demonstrated a 64% reduction in the relative risk of venous thrombosis in general surgical patients and 57% relative risk reduction following total hip replacement compared to no treatment (7). Meta-analysis showed that after moderate risk surgery, graduated compression stockings resulted in a significant risk reduction of venous thromboembolism (8). Cochrane review showed that there was an overall effect favoring treatment with graduated compression stockings, comparing stockings to no stockings and comparing stockings plus another method to that method alone (9). Graduated compression stockings, however, have not uniformly been shown to be effective. Some showed no benefit in the prevention of deep venous thrombosis after stroke (10) or in elderly patients (11).

Review of randomized trials shows that the incidence of asymptomatic deep venous thrombosis in long distance air travelers who wore stockings was 10% that of non-wearers (12). Randomized trials also showed less edema in travelers who wore compression stockings compared with those who did not (12). A prominent cause of deep venous thrombosis during airline travel would appear to be venous stasis. Venous blood velocity and/or flow decrease while sitting (13,14), although activation of coagulation may also play a role (15). A marker of activated coagulation, thrombin-antithrombin complex, has been shown to increase after air travel (15). Elastic compression in the supine reverse Trendelenburg position has been shown to increase systemic plasma levels of tissue factor pathway inhibitor (TFPI) (16). Compression stockings may also cause improved tissue oxygenation through decreased venous pooling (17).

Another benefit of graduated compression stockings is reduction of the prevalence of post-thrombotic syndrome (18). Based on 5 randomized trials of patients with deep venous thrombosis comparing treatment with venous compression to controls, mild to moderate post-thrombotic syndrome occurred in 22% treated with venous compression stockings or elastic bandages compared with 37% in patients with deep venous thrombosis who did not receive either (18). Severe post-thrombotic syndrome occurred in 5% of those treated with graduated compression stockings or elastic bandages compared with 12% with deep venous thrombosis who did not receive venous compression.

Ankle exercise in the form of repetitive dorsiflexion and plantar flexion is another option for reducing venous stasis. Early and frequent ambulation of hospitalized patients at risk of venous thromboembolism is an important principle of patient care (1). Previous investigators have shown that ankle exercise increases venous blood velocity while supine (19-21). It has also been shown that periodic foot exercise performed against resistance enhanced popliteal blood velocity and volume flow when measured some minutes later with the subject sitting but not exercising (14).

Recognizing the potential beneficial effects of graduated compression stockings and of ankle exercise, in the prevention of venous stasis, we assessed their effects on venous blood velocity. Unanswered questions included the effects of sitting on blood velocity and the extent to which blood velocity was increased in the sitting position, as well as in the supine position, with compression stockings. We further assessed whether ankle exercise was effective in increasing blood velocity (22) and whether compression stockings further enhanced the effects of ankle exercise on blood velocity (23).

We evaluated 20 healthy men aged 20-33 years at rest and during ankle exercise (22) and repeated the investigations with ankle exercise with and without graduated compression stockings in 25 healthy men, aged 23-39 years (23). Some men volunteered for both investigations. Time-averaged peak velocity was measured in the popliteal vein with Doppler ultrasonography. Thigh-length new fitted graduated compression stockings were used (23). A hole was cut in the stocking to permit measurement of blood velocity in the popliteal vein.

The following observations were made (22,23)(Figures 1,2):

- When sitting at rest, venous blood velocity decreased, compared with blood velocity in the supine position at rest.
- Ankle exercise nearly tripled venous blood velocity when supine.
- Ankle exercise tripled venous blood velocity when sitting, but blood velocity remained lower than with ankle exercise when supine.

- Graduated compression stockings did not increase venous blood velocity while resting quietly in a supine position.
- Graduated compression stockings did not increase venous blood velocity while resting quietly in a sitting position.
- Graduated compression stockings did not augment venous blood velocity with ankle exercise in a supine position.
- Graduated compression stockings did not augment venous blood velocity with ankle exercise in a sitting position.

It is important to emphasize that these data were obtained in healthy volunteers. Ankle exercise increased blood velocity and, therefore, would reduce stasis. The fact that ankle exercise increased blood velocity while sitting, as well as when supine, suggests that ankle exercise may be useful in reducing the prevalence of deep venous thrombosis in travelers.

The beneficial effects of graduated compression stockings on the prevention of deep venous thrombosis are not explained by our data. We showed no augmentation of blood velocity with graduated compression stockings while supine or sitting, at rest or during exercise. Others, using venous ultrasound, also showed no increased blood velocity with compression stockings (24-26). Some, however, using older methods, showed increased blood velocity with venous compression (27-29).

Our studies were in healthy young men. Venous insufficiency of the deep veins occurs in 9% of adults (30) and 21% of men >50 years and 12% of women >50 years (31). It is reasonable to assume that graduated compression stockings would be more effective in patients with venous insufficiency. Regarding the effects of graduated compression stockings on the prevention of post-thrombotic syndrome, we can assume that patients with deep venous thrombosis have damaged venous valves. Therefore, compression would assist venous flow in such patients.

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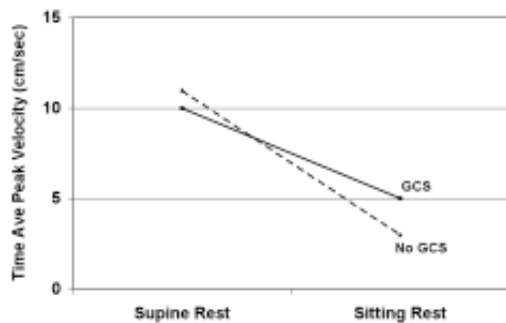
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**LEGENDS:**

**Figure 1.**

Time averaged peak blood velocity in the popliteal vein while supine and sitting at rest, with and without graded compression stockings (GCS). There was no statistically significant difference between blood velocity with and without GCS. Data are from Stein et al (23).

**Figure 1**



**Figure 2.**

Time averaged peak blood velocity in the popliteal vein while supine and sitting at rest and during ankle exercise, with and without graded compression stockings (GCS). There was no statistically significant difference between blood velocity with and without GCS. Data are from Stein et al (23).

Figure 2

