Putting a Class I Stocking over a Class I Stocking Does Not Make a Class II Stocking

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Objectives: To evaluate the interface pressures (IP) obtained by double compression stockings.

Methods: Ten healthy volunteers with legs fitting size S stockings wore single and double class I stockings, sizes S to 4L. We measured IPs with the patient wearing each stocking standing and supine.

Results: IPs obtained wearing double S size stockings, standing and supine, were 1.7 times and 20 mmHg higher than those obtained by a single S size stocking (52.1 ± 4.7 and 46.4 ± 4.5 mmHg vs. 31.5 ± 3.3 and 27.3 ± 2.3 mmHg, respectively). Despite the decreasing IP with increased stocking sizes, all IPs obtained by double stockings, standing and supine, even with size 4L (43.2 ± 5.1 and 37.3 ± 5.5 mmHg respectively), were significantly higher than those obtained by a single S stocking.

Conclusion: Significantly higher IPs were achieved standing and supine, by doubling stockings. We should rather be aware that double stockings in the supine position can result in excessively high IPs.

Keywords: compression stocking, interface pressure, static stiffness index

INTRODUCTION

Strong compression stockings are recommended in the treatment of chronic venous insufficiency (CVI), particularly in severe cases. However, many elderly, weak, or arthritic patients cannot put on elastic stockings by themselves. To assist such patients in putting on resistant, tight stockings, a number of aids, such as an inner silk sleeve for open-toe stockings and the “Butler” device, have been developed.1) “Stocking on stocking” is one of the techniques designed to achieve higher interface pressures (IPs) comfortably, using stockings that generate lower IPs. This technique is used widely with various combinations of stockings; however, because the IPs achieved by this technique have not been investigated well, we lack a theoretical basis on which to instruct patients in using this technique effectively and safely. We conducted the present study to clarify this point.

PATIENTS AND METHODS

This study was approved by Institutional Review Board of Yamaguchi University Hospital (Ube, Yamaguchi, Japan). All participants signed an informed consent before enrollment. The ready-made stockings we evaluated were knee-high, round-knitted stockings (Medical Support class I Knee-high stockings®, Medics Corporation, Tokushima, Japan). These stockings are designed to generate 20–30 mmHg pressure around the ankle in the standing position. The subjects were 10 healthy volunteers (10 women, aged 25–55 (median 37) years), with leg sizes fitted for an S stocking according to the brochure, in which S size is defined by a calf circumference of 30.5–33.5 cm and an ankle circumference of 18.5–20.5 cm.

First, the subjects put on a size 4L stocking and then...
Put on another 4L stocking over the top. They then changed down sizes of stockings until they were wearing a size S. Accordingly, each subject put on stockings in the following size sequence: 4L, 4L on 4L, 3L, 3L on 3L, 2L, 2L on 2L, L on L, M, M on M, S, and finally S on S. The IP under each stocking was measured with the subject supine and then standing, using an air pack-type analyzer (Model AMI-3037-SB, AMI Co., Tokyo, Japan). The sensor was placed on the medial aspect of the lower leg at the level of transposition of the medial gastrocnemius muscle into the Achilles tendon (level of B1). We used the static stiffness index (SSI) to evaluate the stiffness of the stockings. The SSI is defined as the difference between the interface pressure in the supine and standing positions.

Statistical Analysis

Results are expressed as means ± standard deviation or count, unless otherwise indicated. The Wilcoxon signed-rank test was used to calculate the significance of changes in IPs and SSIs with stockings. Statistical analyses were performed using StatView J-5.0 (SAS Institute, Cary, NC, USA). A p-value of less than 0.05 was considered significant.

Results

The leg length, being the distance between the head of the fibula and the upper edge of the lateral malleolus; the circumference of the ankle; and the maximum circumference of the calf were 30.0 ± 2.6, 32.0 ± 1.1, and 20.0 ± 0.5 cm, respectively, in the volunteers. (Fig. 1) lists the IPs recorded for each stocking worn by the subjects. The IPs under the single S stocking were 31.5 ± 3.3 mmHg in the standing position and 27.3 ± 2.3 mmHg in the supine position. As the stocking sizes increased, the IPs in both positions decreased gradually. When a second S stocking was put over the first one, the IP in the standing position increased to 52.1 ± 4.7 mmHg, which was approximately 20 mmHg higher and 1.7 times greater than the IP achieved by the single S stocking. The IP in the supine position also increased to 46.4 ± 4.5 mmHg, which was again approximately 20 mmHg higher and 1.7 times greater than the IP achieved by the single S stocking. The IPs in the standing and supine positions gradually decreased in line with the single stockings. The relationship between IPs obtained by single and double stockings was consistent in the standing and supine positions: In other words, an IP obtained by double stockings was constantly higher by approximately 20 mmHg, with an IP 1.7 to 1.8 times greater by single stocking in all sizes, in both the standing and supine positions. IPs obtained by double stockings of all sizes were significantly higher than the IP obtained by the single S stocking in both the standing and supine positions. Even the IPs obtained by double 4L stockings (43.2 ± 5.1 mmHg in the standing position and 37.3 ± 5.5 mmHg in the supine position) were significantly higher than those obtained by the single S stocking.

Figure 2 shows the SSIs recorded for each stocking worn by the subjects. In contrast to the IPs, the SSIs did not decrease in accordance with the increase in size of the stockings. However, significant increases in the SSI were observed by adding a second stocking in sizes M, L, and 4L. The SSIs obtained by the other stockings also tended to increase, although these SSIs were below 10 mmHg.

Discussion

The major findings of this study were as follows: First, the IP obtained by double stockings is not double that obtained by a single stocking, but consistently 1.7 to 1.8 times greater than that for all sizes of stockings evaluated...
in the current study, exerting approximately 20 mmHg more pressure, both in the supine and standing positions. Moreover, adding a second stocking may increase the SSI.

Stockings on stockings, or stockings plus bandages are popularly used to increase compression more comfortably. However, the IP obtained by double stockings has not been investigated well, and so many physicians prescribe these stockings as an alternative for higher class stockings: for example, they will prescribe double class I stockings in place of a class II stocking. Since ready-made knee-high stockings are often provided as a pair, this seems an easy way to obtain a higher IP. However, this study demonstrated clearly that the IP obtained by double appropriate size class I stockings are 20 mmHg higher than that obtained by a single class I stockings both in the standing and supine positions. The manufacturer of the stockings we studied defines that class I and II stockings are supposed to generate 20–30 and 30–40 mmHg respectively. In our preliminary study, single class II stocking provided by the same manufacturer actually generated 40.7 ± 3.0 in the standing position (unpublished data). Definition of compression class varies depending on different National Standards.4) However, in general, the differences of IPs between class I and class II, or class II and class III do not exceed 20 mmHg. Accordingly, IPs obtained by doubled appropriate size class I stockings are too much higher than that obtained by an appropriate size class II stocking. Although the IP decreases gradually as the stocking size is increased, even the IP obtained by double 4L stockings, which is the largest size of ready-made stockings in this series, is still higher than the IP of 30–40 mmHg.

A high IP in the supine position is another problem that can result from using double stockings. The pressure necessary to occlude the lower leg veins in the supine position is reported to be 20–25 mmHg.5) Judging from the current results, the IPs obtained by double stockings in the supine position is too much higher than 20–25 mmHg even when the largest stockings are used. In this study, the highest IP obtained by double appropriate sized stocking in the supine position was 54 mmHg, which is reaching the contraindicated sustained pressure of 60 mmHg. This pressure is considered to be a safe upper limit for externally applied sustained compression based on several microcirculatory investigations.1) An excessively high resting pressure can also be unpleasant for the patient. Considering all these factors, we recommend that patients using double stockings be advised to remove at least one layer of stockings when they are at rest.

It remains uncertain why the IP obtained by double stockings is not simply double that obtained by single stockings, but consistently 1.7 to 1.8 times greater. One explanation is that the first stocking decreases the calf circumference, making the leg size smaller than it used to be. In fact, when an appropriate size class I stocking is applied, the calf circumference decreases by 1–2 cm, for which a stocking one size smaller would be appropriate. However, even if a stocking one size smaller is put over the right sized stocking, the IP obtained by these stockings is still less than double the IP obtained by an appropriate size class I stocking in our preliminary study. This warrants further investigation.

In terms of the SSI, van der Wegen-Franken et al. reported that large standard deviations make it difficult to find significant differences in stiffness when evaluating various ready-made stockings.6) Nevertheless, we observed significant increases in the SSI by doubling stockings in three of the six sizes evaluated in this study. The fact that stiffness can be increased by friction between the layers, as in multilayer bandages, supports this, although the SSIs were below 10 mmHg even with double stockings. Since a higher SSI of 10 mmHg or greater, is reported to be associated with higher healing rates of venous ulcers,7) double ready-made round-knitted stockings may still be insufficient for patients with severe CVI.

As a matter of course, the current results should be considered flexibly since the size, shape, stiffness, and IP, are set differently by each manufacturer. We analyzed only the IPs measured immediately after the stockings were put on by the healthy volunteers; however, the IP...
alone cannot be a surrogate parameter for evaluating both the efficacy and tolerability of a compression stocking. In practice, it is ambulant compression therapy that is effective and not static compression. Moreover, leg sizes vary widely, even within an S fitting, and the stockings only fit legs according to their tolerance, defined by stiffness and hysteresis. Thus, studies on a greater number of legs may be needed to obtain sufficient statistic evidence.

**CONCLUSION**

The IPs obtained by a single class I stockings in both the standing and the supine position increased by 1.7 to 1.8 times and became 20 mmHg greater when these stockings were doubled: This was remarkably higher than the IP that would be obtained by class II stockings. Moreover, the IP obtained by double layers of stockings when the patient is in the supine position may reach levels that can cause complications. Therefore, special considerations, such as doubling oversized stockings, may be necessary when the “double stocking method” is used.

**DISCLOSURE STATEMENT**

There are no conflicts of interest to declare.

**REFERENCES**


6) van der Wegen-Franken CP, Mulder P, Tank B, et al. Variation in the dynamic stiffness index of different types of medical elastic compression stockings. Phlebology 2008; 23: 77-84. [Medline] [CrossRef]