Effect of elastic stockings and ankle positions on the blood velocity in the common femoral vein

Kaori Toya1), Tetsuya Takahashi1), Yuta Fujimoto1), Teppei Nishimoto1), Tomomi Takasoh1), Ken Sasano1), Satomi Kusaka1)*

1) Department of Physical Therapy, Division of Health Science, Tokyo University of Technology:
5-23-22 Nishi-Kamata, Ohta-ku, Tokyo 144-8535, Japan

Abstract. [Purpose] The aim of this study was to identify how to effectively use elastic stockings. [Subjects and Methods] Ten young healthy men participated in this study. Time-averaged maximum flow velocity in the common femoral vein was measured for 20 seconds using a pulse Doppler method with a diagnostic ultrasound system under six conditions (three different positions and with and without stockings). Changes of blood flow velocity were compared. [Results] Elastic stockings did not affect the blood flow velocity in the common femoral vein. For both the with stockings condition and without stockings condition, the time-averaged maximum flow velocity in the head-up position was significantly lower than that in the supine and leg-up positions. Time-averaged maximum flow velocity showed no significant difference between the supine position and leg-up position. [Conclusion] Elastic stockings did not affect the blood flow velocity in the common femoral vein, but ankle positions did affect it. Further studies of patients with venous insufficiency are needed.

Key words: Elastic stocking, Ankle positions, Blood velocity

INTRODUCTION

Several guidelines have been published regarding the treatment and prevention of deep vein thrombosis (DVT)1, 2). The guidelines underscore the fact that comprehensive measures for prevention of DVT are necessary3). Guidelines for the diagnosis, treatment and prevention of pulmonary thromboembolism and deep vein thrombosis (JCS 2009)2) state that elastic stockings are effective for the prevention of DVT. The mechanisms by which wearing elastic stockings prevents DVT are prevention of blood stasis by increasing the blood flow volume and decrease of the caliber of venous blood vessels by compression of the lower limbs4). However, these effects are still under debate5, 6). Nara et al. reported that there is little effect when elastic stockings are used as a single application7), but Scurr et al. indicated that a combination of elastic stockings and intermittent pneumatic compression was effective for prevention of DVT8). Therefore, examination of the effects of combining elastic stockings with something else on prevention of DVT may be of clinical significance. Toya et al. previously reported that ankle positions affect the blood velocity in the common femoral vein during ankle pumping exercises9), which was recommended for the prevention of DVT.

The aim of this study was to identify how to effectively use elastic stockings to change the blood flow velocity in the common femoral vein under different ankle positions.

SUBJECTS AND METHODS

The study subjects were 10 males without a history of cardiovascular diseases and no contraindications for exercise testing and training according to the guidelines of the American Heart Association10).
One experimenter (Y.F.) measured the blood flow velocity in all of these experiments. Time-averaged maximum flow velocity (TAMV) in the left common femoral vein was measured using a pulse Doppler method with a diagnostic ultrasound system (ACUSON P300, Siemens Healthcare, Erlangen, Germany). TAMV is the averaged blood flow velocity per unit time in the left common femoral vein.

The subject’s heart rate, systolic blood pressure (SBP), and diastolic blood pressure (DBP) were monitored (SunTech Tango+, SunTech Medical, USA) continuously during measurement of TAMV.

In this study, Comprinet® pro (BSN medical, Inc., USA) stocking were used, and the right size for each subject according to the instruction manual was selected. Subjects had 2 conditions, wearing stockings and not wearing stockings. Subjects were asked to assume three different positions: supine (supine position), supine with the legs up after the examination bed was raised to an 18-degree angle (leg-up position), and supine with the head up after the examination bed was raised to a 30-degree angle (head-up position) (Fig. 1). At the beginning of each condition, the subjects had a 3-min rest period to acclimatize themselves to each position. After the 3 min of rest, the TAMV in the left common femoral vein was measured for 20 seconds. In total, the subjects were asked to undergo testing under six conditions, that is, each of the 3 positions with and without stockings. The order of the six conditions was randomized for each subject.

Two-way ANOVA for repeated measures was used to compare the TAMV values of blood flow velocity. Bonferroni adjustments were applied for multiple comparisons. All analyses were performed using SPSS Statistics ver. 17.0 (SPSS Inc., Chicago, IL, USA), and statistical significance was accepted at an alpha level of 0.05.

This study was approved by the Human Ethics Review of Tokyo University of Technology (approval number; E14HS-026). All subjects gave written informed consent prior to data collection. All authors declare that there are no conflicts of interest.

RESULTS

Under the without stockings condition, the TAMV in the head-up position (16.6 ± 6.1 cm/sec) was significantly lower than those in the supine (30.1 ± 17.8 cm/sec) and leg-up positions (28.9 ± 17.5 cm/sec) (supine vs. head up, p<0.05, leg up vs. head up, p<0.01). TAMV showed no significant difference between the supine position and leg-up position (Table 1). Under the with stockings condition, the TAMV in the head-up position (13.6 ± 4.4 cm/sec) was also significantly lower than those in the supine (33.1 ± 15.5 cm/sec) and leg-up positions (27.7 ± 9.4 cm/sec) (supine vs. head up, p<0.01, leg up vs. head up, p<0.01). TAMV showed no significant difference between the supine position and leg-up position (Table 1).

DISCUSSION

In this study, elastic stockings did not affect the blood flow velocity in the common femoral vein. This can be attributed to the fact that subjects were young health males who had no problem in their venous valves and venous vascular walls. Generally, the venous diameter is wider than the arterial diameter, but the venous vascular wall is thinner than the arterial vascular wall because it has a thinner layer of smooth muscle and fewer elastic components. For this reason, veins have great compliance and thus a high blood volume, and compression can easily change the venous shape. In venous incompetence, the number of collagen fibers increases, and the fibers are randomly aligned. Furthermore, veins cannot constrict and expand adequately in response to the stimulation of noradrenaline, potassium chloride, angiotensin II, nitric oxide, calcium ion, etc., and they do not function normally. Additionally, expansion of veins and blood stasis occur easily because dysfunction of venous valves causes the blood pressure to increase in veins. Thus, it is likely that elastic stockings are effective in preventing blood stasis in venous incompetence by compressing veins continuously and preventing them from expanding.

In this study, the subjects were young healthy males. Therefore, it is suspected that compression by elastic stockings does not lead an increase in blood flow velocity, as their venous valves and venous vascular walls functioned properly.

On the other hand, ankle positions affect the blood velocity in the common femoral vein. This result suggests that the hydrostatic pressure had an influence on venous return. It is known that an increase in hydrostatic pressure disturbs venous return, thus in venous incompetence, the blood velocity in the common femoral vein can decrease markedly because venous incompetence disturbing venous return may be affected profoundly by gravity.

**Table 1.** Time-averaged maximum flow velocity in the common femoral vein in three different positions with and without stockings

| Position     | With stockings (cm/sec) | Without stockings (cm/sec) |
|--------------|-------------------------|-----------------------------|
| Supine       | 33.1 ± 15.5             | 30.1 ± 17.8                 |
| Leg up       | 27.7 ± 9.4              | 28.9 ± 17.5                 |
| Head up      | 13.6 ± 4.4              | 16.6 ± 6.1                  |

* p<0.05; ** p<0.01

Fig. 1. Experimental protocol
This study has some limitations: (1) the number of subjects in this study was relatively low, and (2) the subjects were only young healthy male volunteers. This could have affected results, and a study for different age groups of people should be performed. Further research of patients with venous incompetence is also needed.

REFERENCES

1) JCS Joint Working Group: Guidelines for the diagnosis, treatment and prevention of pulmonary thromboembolism and deep vein thrombosis (JCS 2009). Circ J, 2011, 75: 1258–1281. [Medline] [CrossRef]
2) Editorial Committee on Japanese Guideline for Prevention of Venous Thromboembolism: Japanese Guideline for Prevention of Venous Thromboembolism. Medical Front International Limited, 2013.
3) Satokawa H, Yokoyama H: Mechanical methods of prophylaxis for prevention of venous thromboembolism including medical instruments. JJMI, 2008, 78: 894–902.
4) Geerts WH, Bergqvist D, Pineo GF, et al.: Prevention of venous thromboembolism: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines, 8th ed. Chest 2008; 133 (6 Suppl), pp 381S–453S.
5) Stein PD, Matta F, Yaekoub AY, et al.: Effect of compression stockings on venous blood velocity and blood flow. Thromb Haemost, 2010, 103: 138–144. [Medline] [CrossRef]
6) Kuroiwa M, Ujihashi Y, Takahira N, et al.: Effect of graduated compression stockings on deep venous blood velocity. Jpn J Phlebology, 2014, 25: 326–331. [CrossRef]
7) Nara S, Asai Y: Deep vein thrombosis, prophylaxis. Jpn J Intensive Care Med., 2004, 28: 869–871.
8) Scurr JH, Coleridge-Smith PD, Hasty JH: Regimen for improved effectiveness of intermittent pneumatic compression in deep venous thrombosis prophylaxis. Surgery, 1987, 102: 816–820. [Medline]
9) Toya K, Sasano K, Takasoh T, et al.: Ankle positions and exercise intervals effect on the blood flow velocity in the common femoral vein during ankle pumping exercises. J Phys Ther Sci, 2016, 28: 685–688. [Medline] [CrossRef]
10) Fletcher GF, Ades PA, Kligfield P, et al. American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee of the Council on Clinical Cardiology, Council on Nutrition, Physical Activity and Metabolism, Council on Cardiovascular and Stroke Nursing, and Council on Epidemiology and Prevention: Exercise standards for testing and training: a scientific statement from the American Heart Association. Circulation, 2013, 128: 873–934. [Medline] [CrossRef]
11) Ozaki T: Kensashigasitteokitaijyoumyakunokaitouryouseiri. Vasc Lab, 2006, 4: 394–399 (in Japanese).
12) Rose SS, Ahmed A: Some thoughts on the aetiology of varicose veins. J Cardiovasc Surg (Torino), 1986, 27: 534–543. [Medline]
13) Travers JP, Brookes CE, Evans J, et al.: Assessment of wall structure and composition of varicose veins with reference to collagen, elastin and smooth muscle content. Eur J Vasc Endovasc Surg, 1996, 11: 230–237. [Medline] [CrossRef]
14) Rizzi A, Quaglio D, Vasquez G, et al.: Effects of vasoactive agents in healthy and diseased human saphenous veins. J Vasc Surg, 1998, 28: 855–861. [Medline] [CrossRef]
15) Hirabayashi T, Mano N, Aikawa K: Effect of the subject position on venous diameter of normal or insufficient saphenous vein. Jpn J Phlebology, 2015, 26: 29–33. [CrossRef]
16) Koshikawa M, Ikeda U: Jyoumyakunoseiri kessennshousinryounihitorousakonakise kihishiki. Vasc Lab, 2005, 3: 273–275 (in Japanese).