

## Original Article

# The effect of different positions on lower limbs skin perfusion pressure

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### ABSTRACT

We have encountered situations of patients with critical limb ischemia accompanied by pain at rest and necrosis, who hang their legs down from the bed during sleep. This lower limb position is known to be a natural position, which reduces pain in the lower extremity induced by ischemia. However, the effect of this position on blood flow of the lower extremity is poorly understood. We studied whether measurements of skin perfusion pressure (SPP) changes by leg position and the difference between healthy adults and patients with critical limb ischemia. The subjects of this study were 10 healthy adults and 11 patients with critical limb ischemia. Patients with critical limb ischemia, including both dorsum of foot and plantar of foot, having SPP of lower limbs of less than 40 mmHg (supine position) were the object of this study. SPP was measured on four positions (supine position, lower limbs elevation position, sitting position, and reclining bed elevation of 20° position). In sitting position, both the number of healthy adults and critical patients show significant increases in SPP compared with the other three positions. These results suggest that sitting position is effective to keep good blood stream of lower limbs not only in healthy adults but also in patients with critical limb ischemia. However, an appropriate leg position should not have lower limbs hang downwards for long periods time because edema is caused by the fall in venous return in lower limbs, and the wound healing is prolonged.

Our clinical research could be more useful in the future, particularly in developing countries, for surgeons managing wounds in leg and foot and preserving ischemic limbs.

### KEY WORDS

Critical limb ischemia; peripheral arterial disease; position; skin perfusion pressure

### INTRODUCTION

Pain is generated in lower-limbs of patients with peripheral arterial disease due to a lack of blood flow. We have encountered situations of patients with critical limb ischemia accompanied by pain at rest and necrosis, who hang their legs down from the bed during sleep [Figure 1]. This lower limb position is known to be a natural position, which reduces pain in the lower extremity induced by ischemia. However, the effect of this

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position on blood flow of the lower extremity is poorly understood. Skin perfusion pressure (SPP) of healthy adults seems to increase when the lower limbs are at a lower elevation than the heart. However, there seems to be differences between healthy adults and patients with critical limb ischemia in respect to the change of SPP by lower limb position due to the blood vessel elasticity of patients with critical limb ischemia decreased by arterial sclerosis, or calcification of blood vessel walls.

Recently, among various noninvasive diagnostic methods, measurement of the SPP has proven useful as the assessment of severity of ischemia,<sup>[1-3]</sup> selecting the proper level of amputation,<sup>[4-7]</sup> and judging the likelihood that ischemic foot ulcers will heal.<sup>[8-10]</sup> It is easily performed at the bedside and requires only 15 min. It can be measured accurately in edematous skin as well as in heavily calcified arteries.<sup>[11]</sup>

In this study, we studied whether measurements of SPP changes by leg position and the difference between healthy adults and patients with critical limb ischemia.

## MATERIALS AND METHODS

### Subjects

The subjects were 10 healthy adults (4 men, 6 women; mean age,  $25.3 \pm 2.9$  years) and 11 patients with critical limb ischemia (10 men, 1 woman; mean age,  $71.7 \pm 9.9$  years including 5 hemodialysis patients). CLI was defined according to the TransAtlantic Inter-Society Consensus 2 (TASC 2) document as those patients whose arterial disease has resulted in a breakdown of the skin (ulcer or gangrene), or pain in the foot at rest. It corresponds to stage 3 and 4 of the Fontaine classification. Patients with critical limb ischemia, including both dorsum of foot and plantar aspect of foot, having SPP of lower limbs of less than 40 mmHg (supine position) were the object of this study.

### Methods

SPP was measured on the dorsum of the foot and plantar of the foot, using a PAD3000®. A laser Doppler probe enclosed within the bladder cuff was wrapped around the middle of the 1<sup>st</sup> metatarsal bone and 2<sup>nd</sup> metatarsal bone [Figure 2]. SPP was measured on four positions (supine position, lower limbs elevation position, sitting position and reclining bed elevation of 20° position) [Figure 3]. The subject was placed in a room at a temperature of 25 to 26° and humidity of 60 to 65%. Informed consent was obtained for all subjects.



Figure 1: The position of a critical limb ischemia patient on a bed



Figure 2: Measure point — When measuring the dorsum of the foot, the probe was placed between the 1<sup>st</sup> metatarsal bone and 2<sup>nd</sup> metatarsal bone, and SPP was measured. Similarly, when measuring the plantar of the foot, the probe was placed at the central plantar space, and SPP was measured

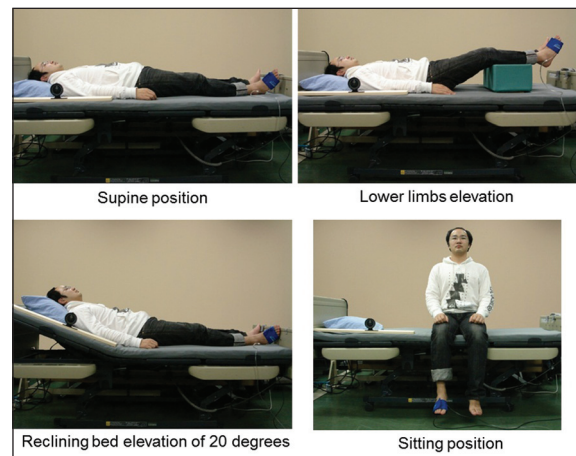


Figure 3: Measure posture — SPP was measured on four positions (supine position, lower limbs elevation, reclining bed elevation of 20 degrees and sitting position)

### Statistical analysis

Statistical significance was assessed using the repeated measure ANOVA and Tukey's Honestly Significant Difference Test. Results are given as mean with standard error. *P*-values less than 0.05 were considered significant. All data were analyzed by PASW statistics 18 (SPSS Japan, Tokyo, Japan).

**RESULTS**

**Changing of SPP by difference of position**

One limb in each of 10 healthy adults and one limb in each 11 patients with critical limb ischemia were evaluated in regard to associations between difference in position and SPP. SPP values significantly compared between sitting position and reclining bed elevation of 20 degrees increase to supine position or lower limbs elevation. The changes of SPP in healthy adults and patients with critical limb ischemia are shown in [Tables 1 and 2].

**Statistical analysis result of SPP in each position**

Tukey’s Honestly Significant Difference Test showed that SPP value was significantly increased in healthy adults [Figures 4 and 5] and patients with critical limb ischemia [Figures 6 and 7]. For healthy adults and patients with

critical limb ischemia, the SPP value rose significantly as the position of lower limbs were set at a level lower than the heart.

**DISCUSSION**

A patient who has diabetic or peripheral arterial disease often causes the refractory skin ulcer.<sup>[12-14]</sup> When the skin ulcer of a patient who has an underlying disease is treated, it is necessary to treat the underlying disease in parallel with the usual treatment. Furthermore, thinking about a good position to keep the blood stream of lower limbs is important when considering the relief of pain and recovery of the ulcer. This study examined whether the SPP of lower limbs changed by a difference of position in healthy adults and patients with critical limb ischemia. For not only healthy adults, but also the CLI patients, the value of SPP has increased significantly when the position of lower limbs is located below the heart. Neither the lower limbs elevation nor the reclining bed elevation of 20 degrees had a significant difference in the patients compared with the supine position. However, as for the sitting position, both number of healthy adults and the CLI patients have increased significantly compared with the other three positions. These results suggest that the sitting position is an effective means to keep a good blood stream of lower limbs not only in healthy adults, but also in patients with critical limb ischemia. However, an appropriate leg position should not have lower limbs hang downwards for long period time because edema is caused by the fall in venous return in lower limbs, and the wound healing is prolonged.

**Table 1: SPP data in each position (Healthy adults)**

Health adults		(mmHg)		
Dorsum of the foot	Mean	SD	Minimum	Maximum
Lower limbs elevation	56.1	7.8	43	66
Supine position	69.2	9.5	58	92
Bed elevation of 20 degrees	80.0	12.7	54	98
Sitting position	119.7	13.1	99	142
Plantar of the foot	Mean	SD	Minimum	Maximum
Lower limbs elevation	59.2	11.0	41	73
Supine position	69.3	10.2	55	84
Bed elevation of 20 degrees	76.9	10.4	58	97
Sitting position	120.5	17.4	99	150

SD: Standard deviation

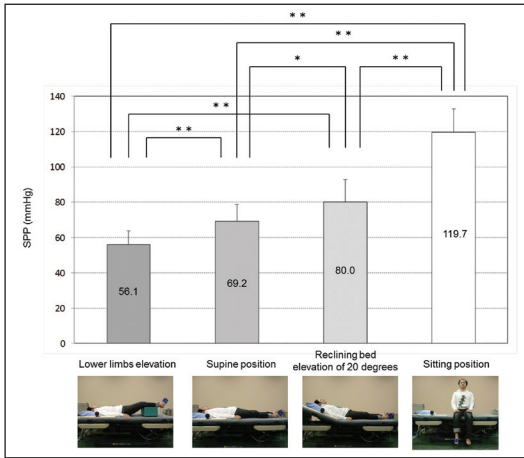
**Table 2: SPP data in each position (Patients with critical limb ischemia)**

Patients with critical limb ischemia		(mmHg)		
Dorsum of the foot	Mean	SD	Minimum	Maximum
Lower limbs elevation	20.6	8.7	8	35
Supine position	29.2	7.8	17	39
Bed elevation of 20 degrees	39.2	11.4	17	58
Sitting position	78.5	14.3	50	97
Plantar of the foot	Mean	SD	Minimum	Maximum
Lower limbs elevation	17.6	5.2	10	26
Supine position	26.3	8.2	17	40
Bed elevation of 20 degrees	34.3	13.1	17	62
Sitting position	79.5	17.8	42	109

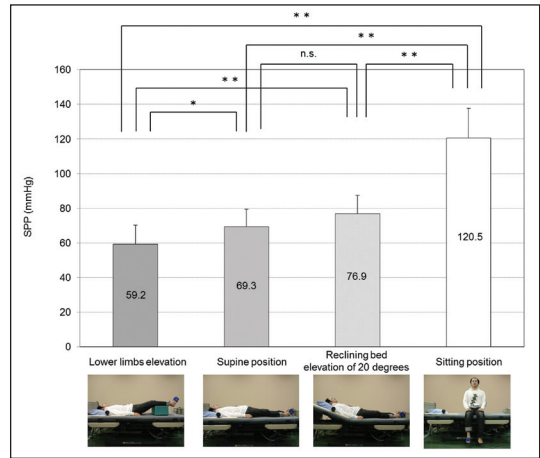
SD: Standard deviation

The Buerger-Allen exercise<sup>[15]</sup> and the Ratschow’s exercise<sup>[16]</sup> may be performed for the purpose of collateral blood circulation promotion of patients with peripheral circulatory disturbance. However, it may be difficult to perform these exercises in patients to whom ADL is decreased. Therefore, given the effect of these exercises and the result of the present study, we think that to repeat a supine position and a sitting position periodically, for example, passive body raising, sitting, and leg hanging; wheelchair style in bedside is a method effective in hemodynamic status improvement of the leg in patients with critical limb ischemia [Figure 10].

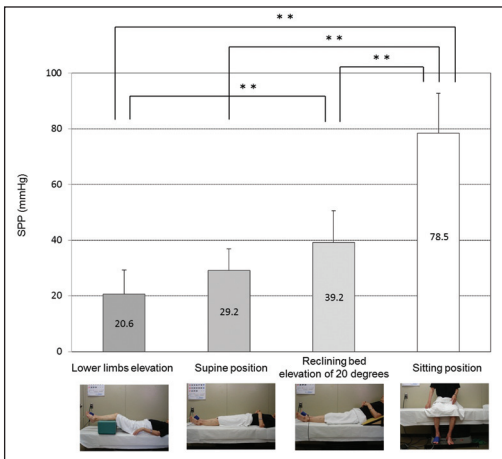
Our clinical research includes very new opinion for the management in hospital and outpatients clinic for the life



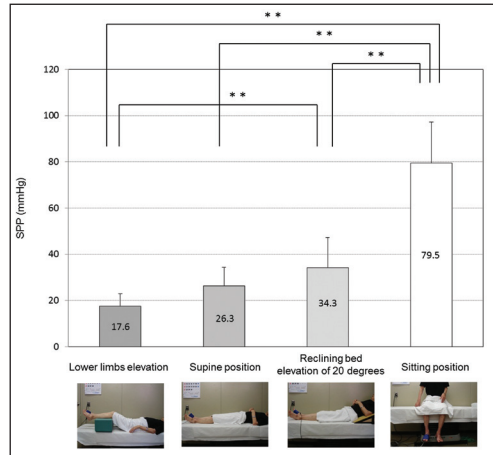
**Figure 4:** SPP (the dorsum of the foot) for healthy adults — There were statistically significant differences in all groups.  $**P < 0.01$ ,  $*P < 0.05$  repeated measure ANOVA and Tukey's Honestly Significant Difference Test



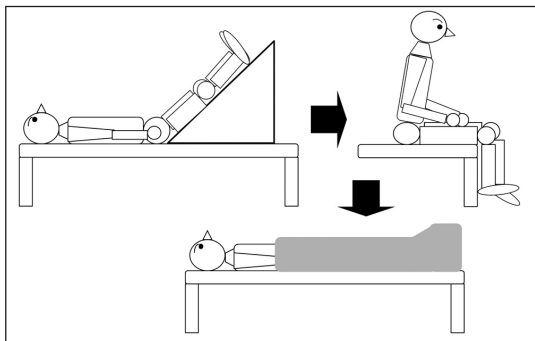
**Figure 5:** SPP (the plantar of the foot) for healthy adults — There were no statistically significant differences between the supine position and the reclining bed elevation of 20 degrees. However, there were statistically significant differences among other groups.  $**P < 0.01$ ,  $*P < 0.05$ , n.s.: not significant repeated measure ANOVA and Tukey's Honestly Significant Difference Test



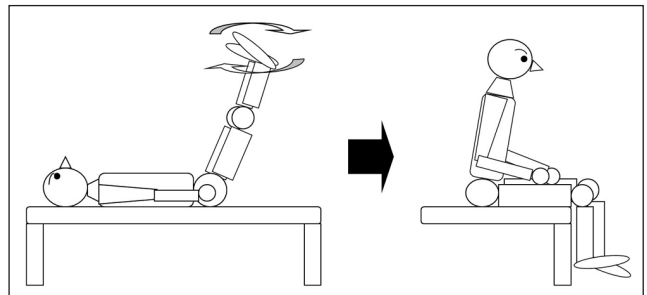
**Figure 6:** SPP (the dorsum of the foot) for patients of critical limb ischemia —  $**P < 0.01$  repeated measure ANOVA and Tukey's Honestly Significant Difference Test



**Figure 7:** SPP (the plantar of the foot) for patients with critical limb ischemia — There were statistically significant differences between the sitting position, reclining bed elevation of 20 degrees, supine position and lower limbs elevation. In addition, there were statistically significant differences between the reclining bed elevation of 20 degrees and lower limbs elevation.  $**P < 0.01$  repeated measure ANOVA and Tukey's Honestly Significant Difference Test

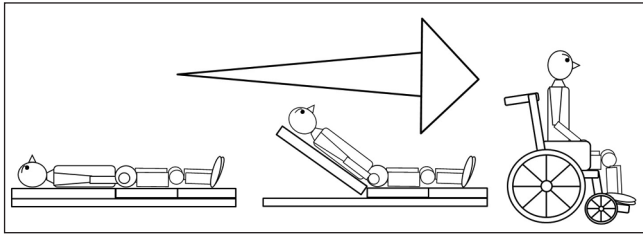


**Figure 8:** Buerger-Allen exercise — Specific exercises intended to improve circulation to the feet and legs. The lower extremities are elevated to a 45 to 90 degree angle and supported in this position until the skin blanches (appears dead white). The feet and legs are then lowered below the level of the rest of the body until redness appears (care should be taken that there is no pressure against the back of the knees); finally, the legs are placed flat on the bed for a few minutes. The length of time for each position varies with the patient's tolerance and the speed with which color change occurs. Usually the exercises are prescribed so that the legs are elevated for 2 to 3 minutes, down 5 to 10 minutes, and then flat on the bed for 10 minutes. 15



**Figure 9:** Ratschow's exercise — Specific exercises intended to improve circulation to the feet and legs. The lower extremities are elevated to a 45 to 90 degree angle and ankle joint rotation is exercised until the skin blanches (appears dead white). The feet and legs are then lowered below the level of the rest of the body until redness appears. A positive effect is achieved by repeating and carrying out this exercise several times a day





**Figure 10:** We think that to keep a good blood stream to lower limbs in CLI patients, it is best to be in a reclining or seated position throughout the daytime compared to a supine position

style of CLI patients who is getting more in number.

When our plastic surgeon helps the physician as the wound management surgeon in leg and foot ulcer to preserve the limb, this research could be more informative in the future in developing country.

## REFERENCES

- Holstein P, Trap-Jensen J, Bagger H, Larsen B. Skin perfusion pressure measured by isotope washout in legs with arterial occlusive disease. Evaluation of different tracers, comparison to segmental systolic pressure, angiography and transcutaneous oxygen tension and variations during changes in systemic blood pressure. *Clin Physiol* 1983;3:313-24.
- Castronuovo JJ Jr, Pabst TS, Flanigan DP, Foster LG. Noninvasive determination of skin perfusion pressure using a laser Doppler. *J Cardiovasc Surg (Torino)* 1987;28:253-7.
- Castronuovo JJ Jr, Adera HM, Smiell JM, Price RM. Skin perfusion pressure measurement is valuable in the diagnosis of critical limb ischemia. *J Vasc Surg* 1997;26:629-37.
- Holstein P, Sager P, Lassen NA. Wound healing in below-knee amputations in relation to skin perfusion pressure. *Acta Orthop Scand* 1979;50:49-58.
- Stockel M, Brochner-Mortensen J. A simple and reliable method for determination of skin perfusion pressure in patients with severe occlusive arterial disease. *Clin Physiol* 1981;1:471-7.
- Holstein P. Level selection in leg amputation for arterial occlusive disease: A comparison of clinical evaluation and skin perfusion pressure. *Acta Orthop Scand* 1982;53:821-31.
- Jorgensen HR, Pedersen NW, Oxhøj H, Damholt V. Selection of amputation level in ischemic. Skin blood flow and perfusion pressure equally predictive. *Acta Orthop Scand* 1990;61:62-5.
- Faris I, Duncan H. Skin perfusion pressure in the prediction of healing in diabetic patients with ulcers or gangrene of the foot. *J Vasc Surg* 1985;2:536-40.
- Duncan HJ, Faris IB. Skin vascular resistance and skin perfusion pressure as predictors of healing of ischemic lesion of the lower limb: Influences of diabetes mellitus, hypertension, and age. *Surgery* 1986;99:432-8.
- Guillot B, Dandurand M, Guilhou JJ. Skin perfusion pressure in leg ulcers assessed by photoplethysmography. *Int Angiol* 1988;7(Suppl 2):33-4.
- Muto A, Kondo Y, Pimiento JM, Fitzgerald TN, Dardik A, Nishibe T. Vasodilator response correlates with outcome in chronic critical limb ischemia. *J Surg Res* 2010;161:156-61.
- Schaffer MR, Tantry U, Efron PA, Ahrendt GM, Thornton FJ, Barbul A. Diabetes-impaired healing and reduced wound nitric oxide synthesis: A possible pathophysiologic correlation. *Surgery* 1997;121:513-9.
- Greenhalgh DG. Wound healing and diabetes mellitus. *Clin Plastic Surg* 2003;30:37-45.
- Michaels J 5th, Churgin SS, Blechman KM, Greives MR, Aarabi S, Galiano RD, *et al.* db/db mice exhibit severe wound-healing impairments compared with other murine diabetic strains in a silicone-splinted excisional wound model. *Wound Rep Reg* 2007;15:665-70.
- Miller-Keane Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health, 7<sup>th</sup> ed. Philadelphia: Saunders, an imprint of Elsevier, Inc.; 2003. p. 258.
- Schoop W. *Praktische Angiologie*. Georg Thieme Verlag Stuttgart 1975; 60-2

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