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Original Article

Effects of friction massage of the popliteal fossa on blood flow velocity of the popliteal vein

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Abstract. [Purpose] Friction massage (friction) of the popliteal fossa is provided for the purpose of relieving pain related to circulatory disorders by improving venous flow in the lower legs. The purpose of this study is to verify the effects of enhancing the venous flow based on measuring the blood flow velocity of the popliteal vein before and after providing friction to the patients. [Subjects and Methods] Fifteen healthy male university students participated in the study. The Doppler ultrasonography (DU) was used to measure the blood flow velocity of the popliteal vein, in order to verify the effects of enhancing the venous flow by comparing the measured values before and after a friction massage. [Results] The result of comparing the blood flow velocity before and after providing friction showed that there was a significant increase after friction. [Conclusion] This study proved that friction to the popliteal fossa is effectively enhances venous flow by increasing the blood flow velocity in the popliteal vein.
Key words: Friction massage, Doppler sonography, Blood flow velocity

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INTRODUCTION

Massotherapy, defined as a manipulation of the soft tissues, is often provided to specific areas or whole body parts aiming at the following effects: enhanced blood flow, relief of muscle tension, improvement of autonomic nerve functions, prevention of bad conditions or injuries, and easing of pains[1–3)]. In recent years, massages have been admitted in international treatment guidelines[4, 5)] as one of the recommended therapies requiring further scientific verification.

Massages are provided in the following cases: subcutaneous emphysema caused by fracturing the breastbone or ribs, external injuries, chest bruises, and crashes[6)]; treatment at childbirth that shortens the delivery time[7)]; healing of Cobb angle of idiopathic scoliosis[8)]; relief of patients suffering from musculoskeletal disorders including back pain[9)]. Massages are reported to be effective to alleviate pain and to enhance bodily functions. However, while these reports refer to the effects of massages, there are some cases which do not actively research the mechanism for how the massage is effective. Therefore, there are those who insist that massotherapy lacks scientific evidence and needs to be verified scientifically[10–12)].

In clinical practice, we obtained certain effects such as the relief of pain or improvement of the range of joint motion by providing friction to patients with popliteal edemas due to osteoarthritis of the knees or disorder of venous flow.

Friction is defined as “an accurately delivered penetrating pressure applied through the fingertips”[13)]. Hammer’s report referred to histamine or bradykinin as the elements involved in the effects of friction provided to chronic bursitis of the

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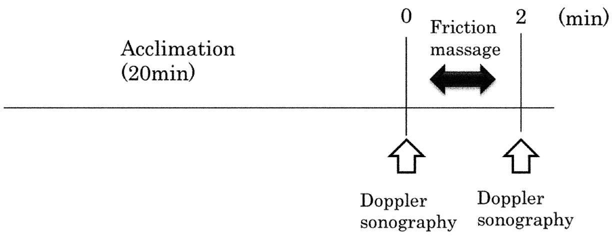

Fig. 1. Experimental protocol

hip and shoulder joints[14]. It was assumed that the effect to alleviate pain or to enhance the range of motion after providing friction would facilitate healing of edemas and relief of pain while enhancing the blood flow of the popliteal vein caused by the vascular dilatation or the vasodilator action by use of histamine or bradykinin.

Physiologically, the lower legs venous sinuses play a major role in venous return, and venous sinuses in the soleus and gastrocnemius play the main role. Anatomically, these venous sinuses flow into the popliteal vein directly and indirectly through the posterior tibial and peroneal veins. The popliteal vein transports venous blood to the heart through the femoral region. Accordingly, the condition of lower legs venous return is reflected in the rate of blood flow passing through the popliteal vein. It was clarified that friction massage of the region below the popliteal fossa causes Dynamic Changes in Muscle Oxygenation[15], but it was unclear what influence this effect has on venous return.

Based on this assumption, an aim was set at researching the influences of friction on the popliteal region as a manipulation of the body surface, and at considering the mechanism of friction's effects from the viewpoint of venous flow.

SUBJECTS AND METHODS

During this study, friction massage was performed on the area surrounding the popliteal vein in healthy volunteers. Friction massage was performed on the intermediate point between the medial and lateral heads of the gastrocnemius muscle. Friction massage was performed by the thumbs, moving them in small circles (2–3 cm^2) at a frequency of 3 Hz. Friction massage was applied to the right leg at a pressure level of 2[16]. Changes in blood flow velocity of the popliteal vein was monitored before and after intervention (a comparative study: after versus before).

Fifteen male students who satisfied the selection criteria were gathered from Ibaraki Prefectural University of Health Sciences as subjects (means ± SD: age=21.4 ± 1.7 years). The subjects signed a letter of consent after the purpose of the study, method, benefits and risks, and rights of participants were explained. All of the subjects were recreationally active. Exclusion criteria were as follows: diagnosis or evidence of any cardiovascular, metabolic, orthopedic, neurological or endocrine disease that are known to affect endothelial function; use of any medication that can interfere with cardiovascular function; and a risk of adverse response to exercise. The study protocol was approved in advance by the authors' institutional review board and adhered to the Declaration of Helsinki. Written informed consent was obtained from all of the individual participants included in the study.

The subjects underwent a single testing session in which all of the experimental procedures were conducted. Before reporting to the laboratory, subjects were asked to fast and refrain from caffeine, tobacco, alcohol, and strenuous physical activity for at least 12 h before the experiment.

The measurement profiles of the blood flow velocity were obtained from pictures of the right popliteal vein by reference to the international guideline[17]. Based on all the pictures, the sizes in vein diameter and blood flow were analyzed utilizing a LOGIQ Book XP (GE Healthcare Products, Milwaukee, WI, USA) system with an 8 MHZ linear transducer. The pictures of popliteal veins were identified in the B mode on the location two centimeters from the central region of the popliteal fossa. Gain settings were adjusted in order to get appropriate views of the front and the rear of the intimal interfaces of veins, thus identifying the vein in the Color Doppler-mode. A measurement setting was then conducted for the vascular caliber (sample volume) of the popliteal veins. Doppler velocity profiles were collected simultaneously using a pulsed signal at a corrected insonation angle of 60° to the vessel, with the velocity cursor positioned mid-artery to sample the volume. All pictures were captured by a USB video board at a frequency of 30 Hz, and then saved in the external hard drive in order to be analyzed offline afterwards.

Measurement of the popliteal vein was conducted using Doppler ultrasonography with the subjects in a prone position. Initially, the subjects were placed in a prone position for 20 minutes at a constant temperature of 24–26 °C (relative humidity at 40–60%) for acclimation according to the experimental protocol (Fig. 1). After that, the blood flow velocity of the popliteal vein was measured for the first time. Next, friction was provided for two minutes and then the blood flow velocity was measured for the second time. The transition was then analyzed with the first measured value set as the base line. Measurement parameters, such as Average Blood Flow Velocity (V mean), Pulsatility Index (PI), and Resistance Index (RI), were utilized[18, 19].

Table 1. Characteristics of study participants

Parameters	(n=15)
Age (years)	21.4 ± 1.7
Height (cm)	173.6 ± 3.8
Weight (kg)	59.3 ± 3.2
BMI (kg/m^2)	19.7 ± 0.9

Values are expressed as means ± SD.
BMI: body mass index

Table 2. Blood flow velocity changes before and after friction massage

	Pre	Post
Blood flow velocity (cm/s)	13.8 ± 2.8	23.3 ± 6.9*

Values are expressed as means ± SD.
Significantly different between pre- and post-friction measurements, *p<0.01

Statistical analyses focused on differences between pre-friction and post-friction blood flow velocity states of the popliteal veins measured using Doppler sonography. Changes in parameters were compared using within-subject paired t-tests. All statistical tests were performed using IBM SPSS statistics version 21.

RESULTS

Participants' characteristics are shown in Table 1. In addition, parameter values before and after friction are shown in Table 2. When a t-test was conducted, there were significantly large differences between pre- and post-friction measurements (t=−7.162, df=14, p<0.01). Based on this result and the average values, it is possible to understand that the blood flow of the popliteal vein had a higher velocity after friction compared to before friction.

DISCUSSION

In this study, regarding the venous flow of the lower legs, the effects of friction on popliteal regions was evaluated, using the blood flow velocity of the popliteal vein as an index. The blood flow velocity of the popliteal vein increased when friction was provided to the popliteal region. Based on this result, it was shown that friction is effective to improve the venous flow of the lower legs. Due to the fact that the lower legs, including the gastrocnemius and soleus muscles, have anatomical characteristics such as specific forms of vascular channels[20)], lower legs compartment syndrome, deep venous thrombosis, edema, and venous congestion are prone to occur. The result of this study showed that friction had an effect to heal these clinical conditions and disorders.

Moreover, adding to circulatory disorders caused by the anatomical characteristics of the lower legs' vascular channels, there are also disorders caused by autonomic nervous system malfunctions[21)] and disorders of the metabolism[22)]. Diabetes is one disorder of the metabolism which invokes muscle pain or muscle fatigue due to disordered blood circulation. Therefore, it is considered that enhancing the venous flow of the lower legs would alleviate pain and relieve muscle fatigue. Furthermore, it is expected that friction can be used as physical therapy to facilitate healing of injured parts during the period where muscle contraction is not available due to muscle injury, patients being in the postoperative period, and when body parts are bound in a cast. It is also pointed out that friction has other effects such as an enhancement of the circulation when being provided strongly enough to cause neurogenic inflammation. That is, when the massage is provided to the skin, the nociceptor is stimulated, inducing the discharge of neuropeptide such as substance p from the cell body. This stimulates not only the central nerves but also descends to the peripheral nerves, inducing the peptide from the sensory nerve terminal. It has been explained that as a result of the above process, the mast cells and the internal smooth muscles widen the blood vessels[23)]. The authors believe it to be necessary to start substantiating the study of these effects.

Since dysfunction of the lower legs venous system, which plays the main role in venous return, is involved in the development of circulatory disorder in many cases, the indication of friction massage for circulatory disorders, such as lower legs compartment syndrome, edema, and diabetic muscle pain, was suggested. However, the results were obtained from young subjects and the autonomic and blood flow-related nervous systems were not investigated, and these are limitations of this study. We will continue the study in consideration of these.

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