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Original Article

Handgrip exercise elevates basilic venous hemodynamic parameters in healthy subjects

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ABSTRACT

Purpose: This study examined the effect of handgrip exercise on hemodynamic indices to determine the most effective regimen for promoting blood circulation.

Methods: Healthy individuals were divided into three treatment groups with each performing exercises using an electronic handgrip. Groups performed exercises to determine the most appropriate tap position, frequency, and duration. The hemodynamic indices were measured by Doppler ultrasound.

Results: The best handgrip position was the weak tap position. Venous blood flow velocity and blood flow increased significantly with each exercise relative to the resting state ($p < 0.01$). Venous blood flow velocity and blood flow peaked with handgrip exercise frequency of 25 times/min for 2 min ($p < 0.01$). No significant differences were observed between sexes.

Conclusion: Handgrip exercise is an effective method for improving blood circulation in the upper extremities.

1. Introduction

Venous stasis, vein vascular injury, and coagulopathy are the three major factors of venous thrombosis. For patients prone to venous thrombosis, early regular activity is an important factor; however, many patients are not able to complete a regular exercise regimen [1]. For lower extremities, some studies have reported that foot exercises can increase venous blood flow velocity and blood flow, thereby transiently reducing the tendency of venous stasis and potentially preventing deep venous thrombosis [2–4]. To prevent upper limb vein thrombosis, one study has reported that handgrip exercise enhanced upper arm muscle contraction after loading and promoted upper limb blood and lymphatic circumfluence and circulation [5]. Although handgrip exercises are readily available to patients, the most effective pattern of handgrip exercise has not been investigated. In this study, various handgrip exercises with electronic handgrips were tested in 300 healthy volunteers to determine the most effective exercise regimen for promoting blood circulation within the upper extremities. Changes in venous blood flow

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velocity and blood flow after different frequencies and durations were analyzed.

2. Design and methods

2.1. Subjects

Using the convenience sampling method, we selected 300 healthy volunteers, ranging in age from 45 to 65 years, and who had no history of thrombosis, upper limb trauma, surgery, swelling, lymph edema, hypertension, mental illness, cardiovascular diseases, venous reflux, or outflow obstruction. Subjects were divided into three treatment groups: A, B, and C ($n = 100$ for each group). The ratio of men to women in each group was 1:1. The average age of the men and women in group A was 50.04 ± 11.82 years and 51.06 ± 7.07 years, respectively; in group B was 49.91 ± 8.94 years and 50.58 ± 11.64 years, respectively; and in group C 52.72 ± 9.43 years and 52.96 ± 8.74 years, respectively. The study was guided by the Declaration of Helsinki and approved by the Research Ethics Committee of Binzhou Medical University Hospital. Informed consent was obtained from all individuals. No statistical differences in age and sex baseline data were observed.

2.2. Equipment and quality control

2.2.1. Equipment

A GE LOGIQe portable ultrasound diagnostic instrument (LOGIQe GE, USA) and CAMRY electronic handgrip (EH101; Guangdong, China) were used.

2.2.2. Quality control

Grip indices were measured by the same operator using the ultrasonic diagnostic instrument. All measurements and exercises were carried out in a draft-free room with a constant temperature of 25 °C.

2.3. Doppler ultrasonic recordings

The venous blood flow velocity and vessel diameter were measured in each subject's right upper limb 10 cm above the elbow joint by a single examiner. Pulse-wave Doppler recordings in the basilica veins were measured using the LOGIQe ultrasound system and L10-5 broadband linear array transducer with an extended operating frequency range of 5–10 MHz. The gain, contrast, and rejection settings were optimized after an initial evaluation and then kept constant. The sampling site was guided by color flow mapping that positioned the sample volume at the center of the color signal to create the smallest angle of insonation, ranging from 45° to 60°, between the direction of blood flow and the Doppler beam. Sample volume was preset and maintained at 2.0 mm.

The venous hemodynamic parameters evaluated were venous blood flow velocity (cm/s), blood vessel diameter (cm), cross-sectional area (cm^2), and venous blood flow (mL/s). Venous blood flow was calculated from the venous blood flow velocity multiplied by the cross-sectional area ($\pi \times \text{diameter}^2/4$) of the basilic vein.

2.4. Handgrip exercise regimens

Throughout the research process, a fixed researcher explained the purpose, frequency and length of the handgrip exercise to ensure the subjects' understanding and a smooth study implementation.

2.4.1. First stage: group A

Each subject conducted a handgrip exercise to determine the best handgrip strength, or tap position. Tap positions were categorized as weak, intermediate, or strong. An electronic handgrip measured the grip strength with each subject testing their maximum grip strength for a total of three times. Between attempts, the subjects rested for 15 minutes. If the tap positions of the three measurements were not consistent for a subject, then the following steps were performed. If the tap position measurements varied by a ratio of two to one, then the two consistent tap positions were chosen. If the three tap positions were completely inconsistent, then the intermediate tap position was chosen. The venous blood flow velocity and blood vessel diameter were measured by the same examiner before and after the handgrip exercise.

2.4.2. Second stage: group B

The most suitable handgrip frequency was chosen from the appropriate tap position. First, the subjects rested for 15 minutes. Using the tap position determined in the first stage, the handgrip exercise was performed with varying frequencies of either 15, 20, 25, or 30 times/min using an electronic handgrip. After the handgrip exercise, the subjects rested another 15 minutes. During the implementation process, the guidance personnel played a recorded sound pattern of “hold, loosen, hold, loosen, …” for each frequency to ensure an accurate handgrip exercise was performed. The venous blood flow velocity and blood vessel diameter were measured by the same examiner as in the first stage.

2.4.3. Third stage: group C

The ideal duration for the handgrip exercise was chosen based on the information from the most appropriate tap position determined in the first stage and the most suitable frequency determined in the second stage. The subjects first rested for 15 minutes and then performed the handgrip exercise for 1, 2, or 3 min under the appropriate tap position. The guidance personnel played a recorded sound pattern as for Group B. After performing the exercise for various lengths of time, the subjects rested for 15 minutes. The venous blood velocity and blood vessel diameter were measured by the same examiner before and after the handgrip exercise.

2.5. Statistical analysis

Data are expressed as the mean ± standard error. Analysis of variance of randomized block design using the Friedman M test was used to test venous blood flow velocity, vessel diameter, and blood flow, and the least significant differences test was used for multiple comparisons. The Statistical Package for the Social Sciences (SPSS), version 13.0 (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis with the level of significance set at $p < 0.05$.