

The Effects of Squat Exercises in Postures for Toilet Use on Blood Flow Velocity of the Leg Vein

JUN HO EOM, PT¹⁾, SIN HO CHUNG, PhD, PT^{2)*}, JAE HUN SHIM, PhD, PT, OT¹⁾

¹⁾ Department of Physical Therapy, Baekseok University, Republic of Korea

²⁾ Hanyang University Medical Center: 222-1 Wangsimni-ro, Seongdong-gu, Seoul 133-792, Republic of Korea

Abstract. [Purpose] The purpose of this study was to identify the effects of squat exercises performed in toilet-using postures on the blood flow velocity of the lower extremities for the prevention of deep vein thrombosis. [Subjects] The subjects were 28 students who were attending B University in Cheonan. They were divided into a group of 14 subjects of sitting toilet users and a group of 14 subjects of squat toilet users. [Methods] The subjects performed squat exercises in different toilet-using postures and we investigated the changes in blood flow velocity. [Results] The variations in blood flow velocities before and after the exercises showed significant differences in both groups but the differences between the two groups were not significant. [Conclusion] Based on the results of this study, we consider squat exercises are effective at improving the variation in lower-extremity blood flow velocity when using a toilet.

Key words: Blood flow velocity, Squat exercises, Toilet-using postures

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INTRODUCTION

Squatting positions refer to positions in which the shoulder is placed on the knee, while the ankle, knee, and hip joints are bent. These positions are universal motions among Asians, including Koreans, that are repeatedly undertaken for daily living activities, agricultural activities, or work¹⁾.

If squatting positions are undertaken repeatedly for long periods of time, the blood vessels in the lower extremities will be compressed, and the blood flow velocity will decrease. If the wall of the lower-extremity vein is damaged, blood flow congestion and/or excessive coagulation may overcome the tendency to inhibit thrombus formation, and deep vein thrombosis (DVT) may occur in the lower extremity²⁾. DVT is a major public health challenge with an incidence rate of 0.3% in the general elderly population³⁾. DVT prevention is crucial and cost effective for critically ill patients. DVT tends to expand into proximal veins and/or pulmonary emboli⁴⁾.

Examples of squatting positions undertaken for a long period of time in daily living activities include defecating activities when using a toilet. Previous studies of squatting positions have reported that 22.5% of the subjects could not perform squatting positions⁵⁾, due to problems associated with ankle joint movements⁶⁾.

Previous studies have also reported that weight bearing exercises such as squats were functional, because these exercises require the movement of more joints than non weight bearing exercises, promote functional patterns of muscle mobilization, and stimulate proprioceptive senses⁷⁾. Also, static resistance exercises increase vascular compliance more than aerobic exercises⁸⁾, and one-shot gradual maximum exercises induce significant increases in the blood flow velocity in the middle cerebral artery⁹⁾.

In a previous study that measured the degrees of inconvenience in relation to lower-extremity positions, high degrees of inconvenience were shown at knee joint angles of 60° and 90°, and low degrees of inconvenience were shown at chair heights of 40 cm and 20 cm and in cross-legged sitting positions¹⁰⁾.

Although studies have been conducted on the degrees of inconvenience related to lower-extremity positions, few studies of the effects of lower-extremity positions on the blood flow velocity of the lower extremities have been conducted.

Therefore, this study examined the effects of squat exercises performed in toilet-using postures on the blood flow velocity of the lower extremities for the prevention of DVT.

SUBJECTS AND METHODS

Subjects

This study was conducted with 28 students who were attending B University in Cheonan. They were divided into a group of 14 subjects (6 males, 8 females) of sitting toilet users and a group of 14 subjects (7 males, 7 females) of squat toilet users. The mean age of the sitting toilet-using

*Corresponding author. Sin Ho Chung (E-mail: wwin72@empas.com)

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group was 22.78 ± 2.93 years, the mean height was 165.71 ± 6.67 cm, and the mean weight was 57.92 ± 11.39 kg. The mean age of the squat toilet-using group was 23.07 ± 2.58 years, the mean height was 168.00 ± 8.19 cm, and the mean weight was 62.07 ± 11.67 kg. When selecting the subjects, those who had limited range of lower-extremity joint motion, those who had problems found by ultrasonic diagnosis, and those who had vasomotor dysfunction¹¹⁾ were excluded. This study was approved by the Institutional Review Board of Bronco Memorial Hospital.

Methods

To examine the effects of squat exercises in different toilet-using postures on changes in blood flow velocity, the subjects were instructed to perform sitting toilet-using postures and squat toilet-using postures.

For the sitting toilet-using postures, the subjects were instructed to sit on a model toilet with a height of 40 cm, the standard height of pedestal toilets, and place their feet as they usually did, while maintaining their back upright. For the squat toilet-using postures, the subjects were instructed to sit with their heels 30 cm apart from each other, which is the standard width of squat toilets.

Blood flow velocities were measured using ultrasonic imaging equipment (LOGIQ e Portable, GE Inc., USA) with 10 MHz linear probes. To take images of the same measurement regions of the subjects, the region where the right medial ankle bone meets the second toe (the location where the dorsal venous arch and the great saphenous vein meet) was marked using the color flow mode of the ultrasonic equipment¹²⁾. Blood flow velocities were measured in individual measurement postures and measured again 15 minutes later. A rest was given for 20 minutes thereafter.

Squat exercises were performed with the subject's arms folded and the subject's back maintained upright while putting the feet at shoulder width and maintaining a knee angle of 60° ¹³⁾. Each motion was maintained for 10 seconds, and 5 sets of 10 repetitions were performed. A rest of one minute was given after each set. Blood flow velocities were measured in individual measurement postures after the exercises and remeasured 15 minutes later. Variations in blood flow velocities were measured using analytic software (R5.x.x software for the LOGIQ e ultrasound system, GE Inc., USA).

Statistical analyses were conducted using SPSS for Windows (version 18.0). The data were analyzed using independent t-test to verify the homogeneity of demographic characteristics and dependent variables. The data were also analyzed using the paired t-test to compare differences in the variations in blood flow velocities before and after the exercises and the independent t-tests for comparisons between the two groups. The significance level was chosen as 0.05.

RESULTS

The variations in blood flow velocities before and after the exercises showed significant differences, with a change from 1.83 ± 1.13 cm/sec to 1.18 ± 0.88 cm/sec in the sitting

Table 1. Comparison of variations in blood flow velocities ($N=28$)

	Sitting toilet-using group	Squat toilet-using group
Pre squat exercise	1.83 ± 1.13	3.38 ± 2.10
Post squat exercise	$1.18 \pm 0.88^*$	$2.01 \pm 1.23^*$

Unit: cm/sec. * $p < 0.05$. Mean \pm SD.

toilet-using group and a change from 3.38 ± 2.10 cm/sec to 2.01 ± 1.23 cm/sec in the squat toilet-using group ($p < 0.05$), but the differences between the two groups were not significant (Table 1).

DISCUSSION

Koreans frequently use squatting motions due to their cultural tradition. The motions are comparable to the motions used to sit on chairs in Western culture. Squatting positions lead to complaints of pain in the lower leg rather than in the lower back or the upper leg, because squat positions move the center of mass forward and increase loads on the ankles and the feet¹⁾. Performing activities of daily living or work in squatting positions with diverse knee joint angles for a long time affects the blood flow velocity of the lower extremities. If the motions that affect the blood flow velocity of the lower extremities are repeatedly performed, deformation and defects may occur in the knee cartilage and the collagen fiber networks of the meniscus, even though the motions' momentary loads are not large¹⁴⁻¹⁶⁾, and squatting positions for long periods of time may cause musculoskeletal system diseases in workers¹⁷⁾.

In this study, the variations in blood flow velocities in the different toilet-using postures after squat exercises showed significant decreases from the variations before the exercises. Squat exercises are closed-chain exercises, which are widely used in knee joint rehabilitation because of their functional characteristics, including simultaneous contractions of the quadriceps femoris muscle and the hamstring muscle. In addition decreases in the anterior-posterior knee-femoral displacement, decreases in the pressure on the knee joint, and selective contraction of the vastus medialis muscle have been reported^{18, 19)}. Resistance exercises, which are one of the best methods for developing muscle strength, stimulate the body to promote interactions between skeletal muscles and neuromuscles, and also affect the nervous system by increasing the number of motor units, thereby improving muscle strength and increasing muscle size^{20, 21)}.

In previous studies of blood flow rates, Zhang et al.²²⁾ suggested that increases in arterial tension would increase blood flow velocity in the arteries. Sato et al.²³⁾ reported increases in blood flow velocities in the carotid and vertebral arteries after exercises at 40%, 60%, and 80% of VO₂ peak compared to at rest, indicating increases in blood flow after exercises, and Jang²⁴⁾ showed there was a significant decrease in the variation in the average blood flow velocity of the left subclavian artery, from 38.2 cm/sec before a dance exercise to 33.4 cm/sec after the exercise. Therefore, although the measurement sites were different, we consider

the decrease in the variation in blood flow velocities seen in our present study is attributable to the fact that the squat exercises stimulated the temperature control centers in the muscles, triggering the spinal reflex to increase blood flow rates.

In this study, differences in the variation in blood flow velocities between the types of toilets were not significant, and the variation in blood flow velocities was found to be lower when sitting toilets were used.

Based on the results of this study, we consider squat exercises are effective at reducing the variation in lower-extremity blood flow velocity and can be recommended for increasing blood flow rates. Limitations of this study were that the subjects comprised males and females in their twenties, and thus the results cannot be generalized to all age groups. Also, diverse sitting postures were not investigated, and patients with lower-extremity blood flow disorders were not included. In future studies, the effects of exercises performed for a long period of time and blood flow rates in diverse sitting postures should be compared.

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