



# Evaluation of the Isokinetic Calf Muscle Strength and the Range of Motion of Joint in C<sub>3</sub> Chronic Venous Insufficiency

Sabriye Ercan<sup>1</sup>, Cem Çetin<sup>1</sup>, Turhan Yavuz<sup>2</sup>, Hilmi Mustafa Demir<sup>3</sup>, and Yurdagül Baygül Atalay<sup>4</sup>

Departments of <sup>1</sup>Sports Medicine and <sup>2</sup>Cardiovascular Surgery, Faculty of Medicine, Süleyman Demirel University, Isparta, <sup>3</sup>Department of Sports Medicine, Van Education and Research Hospital, Van, <sup>4</sup>Department of Sports Medicine, Isparta State Hospital, Isparta, Turkey

**Purpose:** The present study aimed to compare the isokinetic muscle strength and range of motion (ROM) values of the ankle between patients diagnosed with C<sub>3</sub> chronic venous insufficiency (group 1, n=57) and healthy individuals (group 2, n=30).

**Materials and Methods:** After identifying the venous refilling time (VRT) of all participants, the active ROM of the ankle joint and plantar flexion (PF) and dorsiflexion (DF) muscle strength in the concentric/concentric mode at angular velocities of 60°/sec and 120°/sec were measured.

**Results:** No statistically significant differences were found between the demographic data of groups 1 and 2 (P>0.05). In total, 102 lower extremities were included in group 1 and 60 lower extremities in group 2. The VRT of the patients in group 1 was 15.5±5.6 seconds, the PF ROM of the ankle joint was 39.3°±9.5°, and the DF ROM of the ankle joint was 27°±8°; in group 2, the VRT, PF ROM, and DF ROM were 36±8.1 seconds, 41°±6.2°, and 27.2°±7.5°, respectively. Statistically significant differences were found between the two groups in terms of VRT (P<0.05); however, no statistically significant difference was observed in terms of ankle ROM (P>0.05). Statistically significant difference was found in terms of all parameters of isokinetic muscle strength measurements, such as peak torque, peak torque/body weight, total work done, and ratio (DF/PF) in group 1 (P=0.001).

**Conclusion:** The lower extremity muscle strength of patients with chronic venous insufficiency was low, and this weakness was prominent particularly in the direction of PF.

**Key Words:** Venous insufficiency, Muscle strength dynamometer, Muscle strength, Range of motion, articular

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**Corresponding author:** Sabriye Ercan

Department of Sports Medicine, Faculty of Medicine, East Campus, Süleyman Demirel University, 32260 Isparta, Turkey  
Tel: 90-2462112000

Fax: 90-2462112830

E-mail: sabriyeercan@gmail.com

<https://orcid.org/0000-0001-9500-698X>

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## INTRODUCTION

Chronic venous insufficiency (CVI) is a significant disease with a wide clinical presentation that may range from telangiectasia to painful venous ulcers [1].

The prevalence rate of trunk varicose vein is approximately 25.9% among females and 12.9% among males in the Tecumseh Community Health Study. Some epidemiological studies have shown that CVI is more common in females than in males. However, other studies have shown

conflicting results [2].

According to the San Diego Population Study, the risk of CVI is highest in white race and the lowest in Americans of African and Asian origin [3]. Apart from age, sex, and ethnic origin, family history, lower extremity injury, long-term standing, and obesity are the other risk factors affecting the incidence of CVI, and hormonal balance is an additional risk factor in females [4-7].

Clinical symptoms may significantly vary since several etiological, anatomical, and pathophysiological mechanisms act simultaneously at varying levels in the development of CVI. Therefore, the clinical symptoms, etiology, anatomical features, and underlying pathophysiological case (CEAP) classification was developed to establish the full definition of such a condition [8].

Three major components ensure the return of venous blood in the lower extremity to the heart: efficacy of the lower extremity calf muscle pump, non-obstructed venous flow, and sufficiency of the venous valves [9-11]. The calf pump is the most important muscle pump in the lower extremity, and changes in the range of motion (ROM) of the ankle may cause greater hemodynamic changes [12,13]. Normal venous return depends on the valves in the veins and the strength of the lower extremity muscles. Muscle pump function and the valves allowing one-directional flow seen against gravity and from distal to proximal. Functional disability of muscle pump function due to impaired muscle strength plays an important role in the pathophysiology and clinical course of CVI [13].

The present study aimed to compare isokinetic muscle strength during plantar flexion (PF) and dorsiflexion (DF) and ROM values for the ankle between patients diagnosed with C<sub>3</sub> CVI (group 1) and healthy individuals (group 2).

## MATERIALS AND METHODS

Fifty-seven patients who visited the Süleyman Demirel University, Department of Cardiovascular Surgery Clinic, who were diagnosed with CVI according to their history, examination findings, and doppler ultrasonography and photoplethysmography (PPG) examination results, and who presented with phase C<sub>3</sub> CVI according to the CEAP classification for homogeneity of study were included in this study [13].

Thirty patients with musculoskeletal complaints in the upper extremity who were admitted at Süleyman Demirel University, Department of Sports Medicine Clinic were included in the control group of the study. The participants in this group had no CVI, a history of deep vein thrombosis, and trauma in the lower extremity. Physical examination revealed no arterial and venous insufficiency, and PPG test

results showed no arterial and venous insufficiency.

The exclusion criteria for this study were painful venous ulceration, active local infection, non-compliance during the testing, decompensated cardiac insufficiency and lung failure, peripheral artery disease, diabetes, receiving vasodilator treatment, having an orthopedic disorder in the ankle, and systemic illnesses preventing the work of an isokinetic dynamometer.

The weight and height (kg and cm at 50-g accuracy, respectively) of the participants were measured with a mechanical adult scale and height rod (SECA 700; Seca, Hamburg, Germany), respectively.

Doppler ultrasonography was carried out to confirm the diagnosis. The PPG device (ELCAT Vasoquant VQ1000 D-PPG®; ELCAT, Wolfratshausen, Germany) was used for the diagnosis of CVI and disease staging. The diagnosis of clinical venous insufficiency was confirmed, with the PPG test results showing that the venous refilling time (VRT) was less than 25 seconds. After the VRT of all participants had been measured, the active ROM of the ankle joint as well as the PF and DF muscle strength were measured.

A metal goniometer (Baseline Stainless Steel Goniometer; Fabrication Enterprises Inc., Elmsford, NY, USA) was used for ROM measurement, and an isokinetic dynamometer (HUMAC® NORM™ Testing & Rehabilitation System, Model 770; Computer Sports Medicine Inc., Stoughton, MA, USA) was used for muscle strength measurements. The use of the isokinetic test systems is a technique that can best measure muscle strength, which is one of the most important parameters in defining the current status and planning rehabilitation process. This is the most effective method for identifying muscle strength (at low angular velocities, e.g., 60°/sec), muscle endurance (at high angular velocities, e.g., 120°/sec), and agonist/antagonist muscle ratio (at both low and high angular velocities) [14]. The ROM in the ankle joint was measured while the patient was in a prone position; then, the muscle strength was measured. Warming-cooling and stretching exercises were performed before and after the test. ROM limits for the isokinetic testing of the ankle were between 15° DF and 40° PF. Isokinetic tests were conducted in the concentric/concentric mode at angular velocities of 60°/sec and 120°/sec while the patients were in the prone position (Fig. 1). The values of peak torque (PT), PT/body weight (PT/BW), ratio (DF/PF), and total work done (TWD) of PF and DF were used in the analyses.

The study was approved by the clinical research ethics committee of Süleyman Demirel University Faculty of Medicine (date: 18/01/2017, decision number: 3). All participants were informed about the aims and the methods of the study and afterward they have signed the informed consent.



Fig. 1. Isokinetic test for ankle.

### 1) Statistical analysis

IBM SPSS Statistics 22.0 version software package (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Descriptive statistical data and the frequency distribution of the data were examined. Since the normal distribution was provided according to the skewness and kurtosis test, independent samples t-test was performed to determine the difference between the two groups. Results were expressed as mean±standard deviation. A significance level of alpha=0.05 was considered statistically significant.

## RESULTS

In group 1 (of which 7 were males and 50 were females), the age, height, and weight of the participants were 46.7±9.5 years, 160.5±8 cm, and 73.7±13.4 kg, respectively. In group 2 (of which 10 were males and 20 were females), the age, height, and weight of the participants were 43.7±10.8 years, 165±10.5 cm, and 68.3±10 kg, respectively.

A total of 102 lower extremities (45 bilateral, 4 right, and 8 left) were included in group 1, and 60 lower extremities were included in group 2. The VRT was 15.5±5.6 seconds, the PF ROM of the ankle joint was 39.3±9.5°, and the DF ROM of the ankle joint was 27°±8° in group 1, and the VRT was 36±8.1 seconds, the PF ROM of the ankle joint was 41°±6.2°, and the DF ROM of the ankle joint was 27.2°±7.5° in group 2. A statistically significant difference was observed between the groups in terms of the VRT (P<0.05); however, no statistically significant difference was observed between the measurement results of the ROM of the joint (P>0.05). All isokinetic muscle strength, muscle endurance, and agonist/antagonist muscle ratio measurement parameters (PT, PT/BW, TWD, and DF/PF) of group 1 were insufficient than those of group 2 (P=0.001; Table 1).

Table 1. Isokinetic muscle strength measurement parameters between the two groups

Parameter	Group 1 (n=102)	Group 2 (n=60)	P-value
PF PT (Nm) @60°/sec	27.4±20.3	65.3±25.4	0.001
DF PT (Nm) @60°/sec	17.5±8.4	26±8.6	0.001
Ratio PT (DF/PF) @60°/sec	78±31.1	41.4±8.8	0.001
PF PT/BW (Nm) @60°/sec	35.2±22.4	99.2±37.4	0.001
DF PT/BW (Nm) @60°/sec	22.9±9.5	39.1±13.5	0.001
PF PT (Nm) @120°/sec	19.3±12.8	40.7±16.8	0.001
DF PT (Nm) @120°/sec	13.3±5.4	18.3±4.9	0.001
Ratio PT (DF/PF) @120°/sec	79.9±28	47.8±11.6	0.001
PF TWD (Nm) @120°/sec	110.7±98.7	283.6±128.6	0.001
DF TWD (Nm) @120°/sec	86±51.3	126.8±37.4	0.001
Ratio TWD (DF/PF) @120°/sec	96.6±44.5	49.4±15.8	0.001

Values are presented as mean±standard deviation.

Group 1, non-ulcerated varicose vein group; group 2, control group; PF, plantar flexion; PT, peak torque; Nm, Newtonmeter; DF, dorsiflexion; BW, body weight; TWD, total work done.

## DISCUSSION

In our study, no statistically significant difference was observed in terms of the ROM of the ankle between the two groups; however, statistically significant differences were noted in terms of isokinetic muscle strength parameters. This difference was more prominent in the PF muscle groups than in the other groups.

Venous diseases are progressive diseases that are frequently observed in the lower extremities, and such diseases can occur in various forms, ranging from telangiectasias that cause cosmetic problems to painful varicose veins and even skin ulcers that develop due to severe venous insufficiency [15]. According to the Edinburgh Vein Study data, CVI is observed in 9% of males and 7% of females, and it increases with age and is not correlated with social status [16]. On the basis of the result of the 13-year follow-up of the same study, the incidence rates of CVI were 10.6% in males and 8.1% in females [15].

Progression of the disease is not associated with age, sex, or whether the disease is in the right or left leg. However, CVI will progress in the extremity initially diagnosed with venous reflux, and it is more commonly observed in ageing females [17]. Overweight, obesity, and history of 4 or more pregnancies are risk factors for the development of C<sub>2</sub> varicose vein and C<sub>3</sub>-C<sub>6</sub> CVI. However, smoking, use of oral contraceptive medications, hormone replacement treatment, and active work life are not correlated with the incidence of the disease [15]. In our study, female dominance was observed in the sex distribution of patients with C<sub>3</sub> CVI. Furthermore, similar to those in other studies, our study groups

comprised overweight and middle-aged individuals.

Normal venous return depends on the venous valves and the strength of the muscles surrounding the veins. Muscle pump dysfunction and a decrease in lower extremity muscle strength play important roles in the pathophysiology of CVI [18].

CVI classification is extremely important in terms of clinical follow-up and patients' treatment. PPG is an effective method for determining the presence and severity of venous hypertension and CVI classification. It is advantageous in terms of diagnosis and staging compared to other methods as it provides quantitative data about muscle pump measurement and is affordable, non-invasive, easy to apply, and portable [19,20].

Isokinetic muscle strength measurement systems have high reliability and accuracy in determining muscle strength and torque value. Isokinetic dynamometers using the load at a maximal level at all points along the ROM of a joint are preferred by users in rehabilitation and in dynamic muscle test applications [14]. During these measurements, the ROM of the joint for which the test will be performed is important for the standardization of the isokinetic muscle strength [13].

In the literature, different researchers have used various diagnostic and measurement methods to demonstrate venous pump function and calf muscle insufficiency [18,21-23]. In this study, we preferred the use of PPG to measure calf muscle pump function and isokinetic systems to measure muscle strength.

The severity of the problems in muscle pump function and calf muscle dysfunction is correlated to the stage of the disease, and as the disease progresses particularly in patients with ulcer, a decrease in the muscle pump function, ROM of the joint, and muscle strength is observed [18,24].

Araki et al. [25] have classified patients who were clinically diagnosed with CVI as non-ulcerated and with healed ulcer or active ulcer and have examined the calf muscle pump functions using air plethysmography. Results of their study showed that the venous refilling index was not normal and those with active ulcer had a lower ejection fraction and a high residual volume fraction. In conclusion, venous insufficiency played a role, but not sufficient, in the development of ulcer, and the venous ulceration level was significantly associated with calf muscle pump insufficiency.

According to the CEAP classification, Dix et al. [24] have reported that upon selecting all groups in CEAP<sub>0-6</sub> as cases, the ROM of the joint in CEAP<sub>4,5</sub> and CEAP<sub>6</sub> in both the PF and DF directions was correlated to the stage of the disease. The PF and DF ROM for CEAP<sub>0</sub>, CEAP<sub>2</sub>, CEAP<sub>4,5</sub>, and CEAP<sub>6</sub> were 47° and 14.4°; 39.5° and 10.2°; 32.9° and 9.2°; and 37.5° and 3.4°, respectively.

The calf muscles are affected in patients diagnosed with CVI. Qiao et al. [26] have performed muscle biopsy to show the effects of having affected calf muscles on these patients. Thus, myofibril structure was found to be affected by venous hypertension in the gastrocnemius muscle.

Van Uden et al. [27] have found that gait and endurance of the calf muscle were lower even if it had been healed or had an active ulcer, on the basis of evaluation of the functional status of the calf muscles of patients with CVI using the heel rise test and gait parameters. In the study of Heinen et al. [28] conducted on patients with a venous ulcer, 35% of the patients were found incapable of walking for more than 10 minutes due to calf muscle insufficiency.

Yang et al. [29]'s study that included a group of patients with CVI (n=49) and a control group has shown statistically significant differences between the groups in terms of ankle isokinetic PF muscle strength, PT/BW, and TWD. Cetin et al. [13]'s study has compared the group of patients with CVI and the control group and has found that the calf and thigh muscle strengths of patients diagnosed with non-ulcerated CVI were weak. Upon performing PPG and CVI staging, they reported that the ankle PF muscle strength decreased and the visual analog scale pain score increased as the disease stage progressed. A muscle ratio of more than 33% for the ankle DF/PF obtained from the isokinetic muscle strength measurements and strength imbalance between muscles were found to be correlated to the stage of CVI.

De Moura et al. [30] have selected the CVI case group diagnosed with CEAP<sub>4-6</sub> in their studies and have compared the gait speed, functional capacity, PF and DF ROM of ankle joint, and isokinetic muscle strength measurements of such group to those of the control group. As a result, the ROM of the joint of patients diagnosed with CVI was more limited, the isokinetic PF PT/BW and PF strength results were lower, and the social restriction amount was higher. Upon subgrouping the patients according to the CEAP classification, no difference was observed in terms of the results of the DF ROM of joint and isokinetic PF PT/BW and PF strength; however, it was observed that the limitation in the PF ROM of the joint results increased as the stage of the disease increased.

## CONCLUSION

Various studies have shown that the calf muscle strength of the group with CVI was insufficient than that of the healthy control group. The insufficiency in calf muscle strength was more prominent in the PF direction than in the DF direction. The identification of patients with CVI at an early stage and execution of exercises that increase lower extremity muscle strength will prevent the progres-

sion of the disease and contribute to the treatment.

## CONFLICTS OF INTEREST

The authors have nothing to disclose.

## ORCID

Sabriye Ercan  
<https://orcid.org/0000-0001-9500-698X>  
 Cem Çetin  
<https://orcid.org/0000-0002-8151-9554>  
 Turhan Yavuz  
<https://orcid.org/0000-0002-0022-2856>  
 Hilmi Mustafa Demir  
<https://orcid.org/0000-0003-2263-7427>  
 Yurdagül Baygöl Atalay  
<https://orcid.org/0000-0003-3695-5995>

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