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Dynamic evaluation of venous pressure gradients comparing walking and bending and stretching of the foot and toes

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Abstract

Background. *The objective of the current study was to evaluate variations in the venous pressure gradient during walking and bending and stretching of the foot and toes in physiological situations.*

Material and methods. *The medial vein of the big toe of a volunteer was punctured and an Angiocat catheter was inserted connected to a DTX Sensor Plus TM. This portable device measures blood pressure at half-second intervals and stores the data in the form of numbers. The venous pressure gradients were measured for two to three minutes in 10 experiments for each type of exercise: walking and bending and stretching of the foot and toes. The paired t-test was utilized for statistical analysis with an alpha error of 5% (p-value < 0.05) considered acceptable.*

Results. *Walking exerts higher venous pressure differences than bending and stretching of the foot or of the toes.*

Conclusions. *In conclusion, walking and movements of the joints of the foot and toes cause a pulsating flow which is important to overcome gravitational pressure while standing.*

Key words: walking, venous pressures, dynamic study, lower limbs

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Introduction

Walking is part of normal day-to-day activity and has been used to prevent and treat some diseases [1––3]. It is the main form of moving from one place to another; however, the bipedal structure required our organism to adapt the venous return system in order to overcome the harmful effects of gravitational pressure. The utilization of the musculature as a contracting instrument to assist blood flow was the alternative that developed with the evolution of humankind, so the walking pressure gradient has become an important method to evaluate venous disease. A pressure gradient can be identified between the thigh and leg veins as a consequence of the contractile mechanism [4, 5].

There are no published dynamical studies of the pressure gradient under physiological conditions.

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The objective of the current study is to demonstrate the venous pressure gradient during walking and bending and stretching of the foot and toes.

Material and methods

An evaluation using Doppler echocardiography was performed of the saphenous and deep veins of the lower limbs of a 46-year-old male volunteer. The medial vein of the big toe was punctured using a 0.9 mm Angiocat catheter which was then connected to a DTXTM Plus Sensor. This is a portable device developed by Godoy and Braile at Braile Biomédica in Sao José do Rio Preto, Brazil. The apparatus measures the blood pressure at half-second intervals and stores the data for future processing. The venous pressure gradients were measured for two to three minutes for 10 experiments using each type of exercise: walking and bending and stretching of the foot and of the toes.

The minimum and maximum pressures and the pressure gradient were analyzed for each experiment. All movements were initiated in the seated position. The paired t-test was utilized for statistical analysis with an alpha error of 5% (p-value < 0.05) being considered acceptable.

Results

Variations in the pressure gradient were calculated from half-second measurements of the pressure. Bending and stretching the toes causes smaller pressure variations when compared to walking and bending and stretching the foot (non-paired t-test: p-value < 0.0001). Additionally, walking caused higher pressure variations when compared to bending and stretching the foot (non-paired t test: p-value < 0.0001).

Figures 1–3 show the pressures measured at half-second intervals during walking and bending and stretching of the foot and toes.

During walking, the minimum pressure drops to around 10 mm Hg, with bending and stretching of the foot the drop is to about 16 mm Hg, and with movement of the toes the pressure drops to about 45 mm Hg. The maximum pressure was seen with walking and was higher than the highest possible reading of the apparatus of 100 mm Hg, while with movement of the foot and toes the maximum pressures were 60 mm Hg and 30 mm Hg, respectively.

Discussion

The current study shows the importance of movement of the toes and foot joints and of walking in causing working pressures under normal physiological movements. Walking causes greater variations in the pressure followed by bending and stretching of the foot and finally movement of the toes. During walking the minimum pressure drops to less than 10 mm Hg after starting from the seated position. Movement of the toes causes working pressures but the minimum pressure does not drop as significantly as bending and stretching the foot, or as walking.

The limitation of the method is related to the time of the evaluation, as the ideal would be to measure for a longer period. However, this study supplies data on the pressure differences. There are no publications indexed to Medline utilizing dynamic methods to eva-

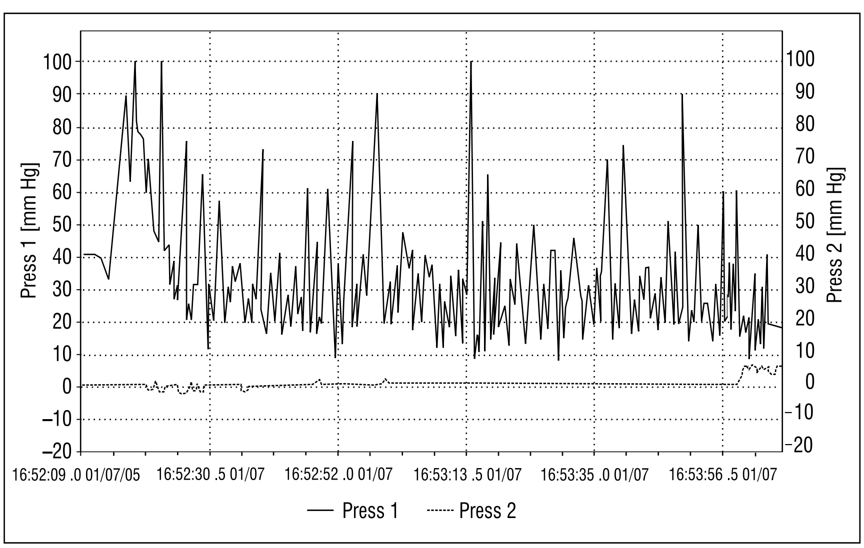

Figure 1. Varriations in pressures measured at half-second intervals in the medial vein of the big left toe during walking

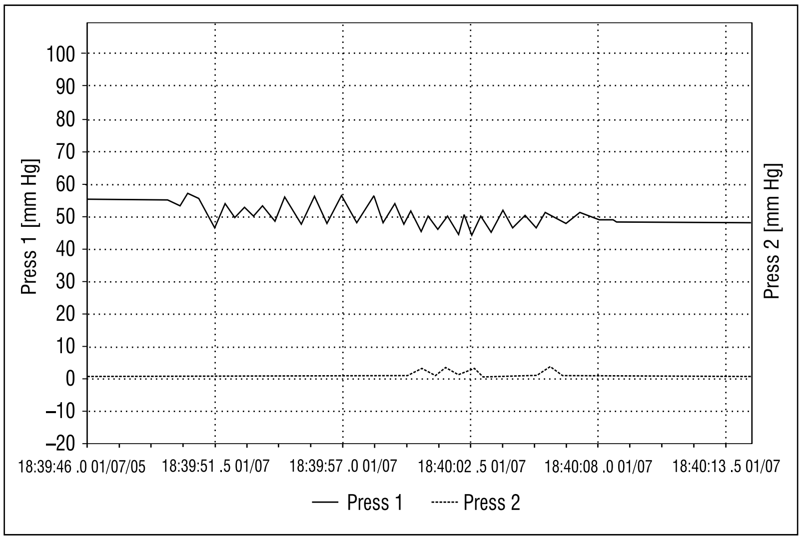

Figure 2. Varriations in pressures measured at half-second intervals in the medial vein of the big left toe during bending and stretching of the toes

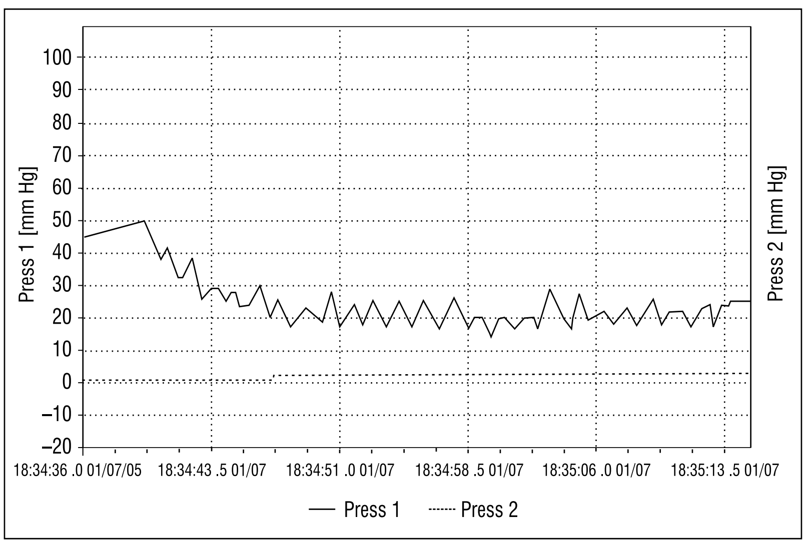

Figure 3. Varriations in pressures measured at half-second intervals in the medial vein of the big left toe during bending and stretching of the foot

luate venous pressure gradients during walking. In all the evaluations, the muscle working pressure was seen as an important mechanism with respect to the pulsating flow to overcome gravitational pressure. The calf muscle confirms its denomination as a pulsating heart with voluntary control; it performs the function of the ventricle, with bending and stretching of the toes performing the function of the atrium. Bending and stretching in the seated position reduces the minimum values to below 20 mm Hg, thereby protecting people from conditions of venous hypertension. Nature utilizes a heart with involuntary control to maintain the circulation and uses the voluntary pulsating heart of the muscle to overcome gravitational pressure, which became necessary with the evolution of the species, thus avoiding complications of chronic venous hypertension. Maintenance of the integrity of the muscle pump has a similar importance in terms of venous return as the heart does in maintaining systemic circulation. However, the venous system has been neglected over the last few decades; this system requires further studies in order to better understand it and to discover new alternatives to correct problems of the system.

Conclusions

In conclusion, walking creates a pulsating flow with voluntary control, which is of fundamental importance to overcome the effects of gravitational pressure.

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