

Influences of postural alterations on the hemodynamic of the gait in patients with saphenous incompetence.

A preliminary study



Ann. Ital. Chir., 2019 90, 6: 545-550
pii: S0003469X19030938

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OBJECTIVES: *The aim of this study is to verify whether the postural alterations can influence the development of the varicose disease with unilateral and bilateral saphenous incompetence.*

MATERIALS AND METHODS: *39 patients suffering from saphenous incompetence diagnosed by hemodynamic study with eco-color doppler (20 patients with bilateral venous insufficiency (VI), 19 patients with unilateral VI) have performed the gait analysis through wireless inertial sensor and baropodometry to assess the plantar pressure distribution both statically and dynamically.*

RESULTS: *The 68% and the 60% of subjects suffering from unilateral or bilateral VI present a plantar pressure dysfunction a single foot or both feet in static and/or in dynamic. In 63% of subjects with unilateral VI the propulsion is reduced on the lower limb damaged. The number of asymmetries in walking and dysfunctions in planar pressure in both groups has been calculated. The average number of asymmetries in walking in the group of patients with unilateral VI is significantly greater ($p\text{-value}=0.0075$) compared to the group of patients with bilateral VI.*

CONCLUSIONS: *Plantar pressure and increased valvo-muscular pump pressure (VMPP) are not the main etiological factors that modify the hemodynamic in walking. In unilateral cases the postural alterations may contribute to worsening or to appearance of the varicose veins. Postural disorders treatment in children of phlebopaths during the childhood could maintain the mild condition of varicose disease silent. The treatment in adults suffering from unilateral VI may reduce or prevent the appearance of relapses*

KEY WORDS: Gait analysis, Hemodynamic of the gait, Postural alterations, Saphenous incompetence, Venous insufficiency

Introduction

Varicose veins are a very frequent disorder with prevalence in our adult population between 14 % for large varices and 59 % for small teleangiectasias. Subjective symptoms may be very non-specific. The term "chronic venous insufficiency (CVI)" defines functional abnormal-

ities of the venous system producing advanced symptoms like oedema, skin changes or leg ulcers. Both entities, varicose veins and CVI, may be summarized under the term "chronic venous disorders" which includes the full spectrum of morphological and functional abnormalities of the venous system ¹. Risk factors found to be associated with CVI include age, sex, a family history of varicose veins, obesity, pregnancy, phlebitis and previous leg injury. There are also environmental or behavioural factors associated with CVI, such as prolonged standing and perhaps a sitting posture at work ².

Many authors affirm that postural alterations could play an important role in this disease. Among them R. Saggini and al. have shown the improvement of the venous emptying capacity of foot-calf veno-muscular system due

Pervenuto in Redazione Maggio 2019. Accettato per la pubblicazione Luglio 2019

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to the use of specific insoles for the feet dimorphisms as flat feet or cave feet. The analysis have been performed through Doppler Ultrasonography, stabilometric platform and digital pedobarography ³.

Padberg and al. demonstrated calf muscle pump function and dynamic calf muscle strength were improved after a 6-month program of structured exercise. The authors suggested a directed physical conditioning of the calf musculature to improve patients with or without alternative management options for severe CV. Investigations included comprehensive venous duplex ultrasound scanning, air plethysmography and isokinetic dynamometry. ⁴

Mancini and al. presented an equipment for phlebologic rehabilitation in patients operated for thrombo-embolic prevention and CVI of the inferior limbs describing accurately the importance of the correct biomechanics in the sural tricipital ⁵.

Jawien asserted that prolonged standing position and plantar alteration have big correlation with the development of CVI and is aggravated by obesity and constipation ⁶. L'origine riferimento non è stata trovata..

J.F Uhl and al. studied the anatomy of the veno-muscular pumps (VMP) of the lower limb, particularly the calf pump on 400 cadaveric limbs affirming that a stiffness of the ankle or/and the dispersion of the collectors inside the gastrocnemius could impair this powerful pump and so worsen venous return, causing development of severe chronic venous insufficiency ⁷.

JD Raffetto and al. suggested that the effects of the MMPs matrix metalloproteinases (MMPs) on extracellular matrix (ECM) degradation could result in significant venous tissue remodelling and degenerative and structural changes in the vein wall, leading to venous dilation and valve dysfunction. MMPs may also induce early changes in the endothelium and venous smooth muscle function in the absence of significant ECM degradation or structural changes in the vein wall ⁸.

Bernardini and al. have evaluated with haemodynamic and observational study an ascendant evolution of the saphenous tributary venous reflux and of the saphenous veins for the progressive dilatation of the veins wall with the consequent progression of the valves incompetence ^{7,10}.

Veins become varicose because genomics and epigenetics factors cause an increase in transmural pressure (PTM), due to minor parietal resistance opposing to the lateral intravenous pressure. In saphenous incompetence, these effects should show bilaterally but, in our clinical experience in about half of the cases, they are present unilaterally to extend consequently, but not always, to the other limb.

The aim of this study is to understand if the posture, can influence the development of the varicose disease unilaterally, and in particular the saphenous incompetence.

The previous studies focused only either on feet alterations or on functional problems in the calf muscle pump.

For this reason, besides the hemodynamic investigation to know the entity of the venous disease, the measure of the plantar pressure and the type of the foot in static and dynamic phases through baropodometric analysis, the gait analysis through an inertial sensor have been performed.

We believe that the evaluation of the gait characteristics plays a vital role in the research of the cause or contributing cause of the VI because it is a basic requirement for many daily activities.

For this purpose the gait analysis has been performed thorough a single wireless inertial sensing device stuck on the lower trunk to provide spatial-temporal parameters during level walking and gain information on the functional capabilities of subjects. L'origine riferimento non è stata trovata.

Materials and Methods

SUBJECTS: The study has been performed in the "Center of Phlebology and Postural Biomechanics" in Livorno. The assessments have been carried out from the same examiner, in the same place and in the same environment conditions.

39 subjects (age between 20 and 75 years old) with primitive varicose disease with incompetence of the venous great trunks (internal, external, accessory saphenous, Thiery vein and saphenous tributaries) have been examined.

Subjects with deep venous incompetence, obesity, deambulation impairment, herniated discs, scoliosis and with prosthesis have been excluded from this study.

The venous disease has been diagnosed through hemodynamic study with eco-color-doppler.

20 out of 39 subjects had bilaterally VI, while the resting 19 had unilaterally VI (11 on the left leg and 8 on the right leg).

MATERIALS: The haemodynamic study has been performed with Esaote MyLab Gold eco-color-doppler with 10-18 MHz linear probe.

Gait analysis has been carry out through a validated ¹¹ wireless inertial sensor G-Walk (BTS S.P.A., Milano, Italy). The sensor (size 70mm L x 40 mm W x 18 mm H and weight 37 g) has been attached to subjects' waists using a semi-elastic belt, covering the L4-L5 intervertebral space to determine the acceleration values for three anatomical axes: anterior-posterior, medial-lateral, and vertical. The accelerometer data were wirelessly transferred by a Bluetooth system and analysed with BTS G-studio software (BTS Bioengineering S.p.A., Italy) on a laptop computer. Park and Woo ¹². L'origine riferimento non è stata trovata. suggested that the G-WALK represents a valid method for assessing the effectiveness of clinical therapeutic interventions of gait analysis.

The static and dynamic baropodometry test have been

performed though P-Walk (BTS Bioengineering S.p.A., Italy) single platform (675 mm L x 540 mm W x 5 mm H), a valid device in both research and clinic field¹³.

The static tests allow to evaluate the plantar pressure distribution, the potential overload areas and feet typology (cave or flat foot) trough plantar arch index¹⁴. The dynamic tests allow to evaluate the plantar pressure and characteristics during different phases of the stride. Subjects have been asked to perform the test barefoot walking with a normal deambulation.

PROCEDURE: 39 subjects have been analysed through eco-color-doppler exam evaluating the deep and superficial venous system competence and reflux typology. The exam has been performed in standing position: axial reflux has been tested using compression-relaxation test, Valsalva technique and dynamic tests (Paranà manoeuvre, oscillation and lifting on the tiptoes). Immediately after the haemodynamic study, the gait analysis through inertial sensor G-Walk, static and dynamic baropodometry have been performed. To evaluate the gait analysis, subjects were asked to walk

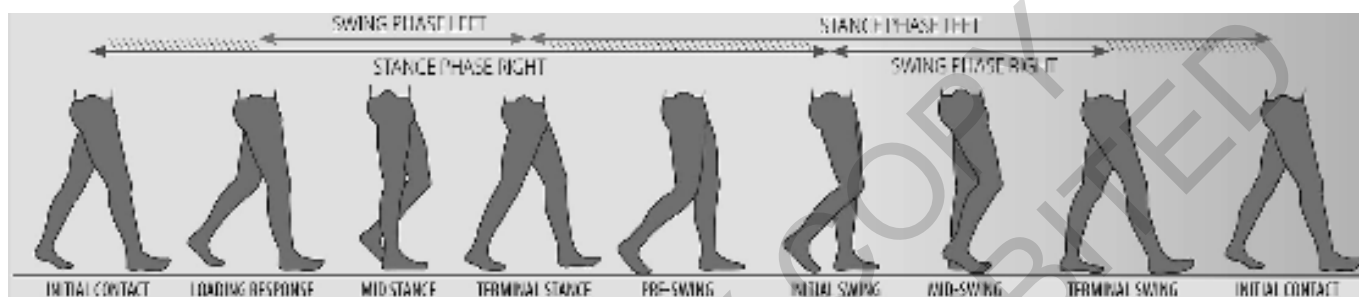


Fig. 1: (taken from BTS S.P.A., Milano, Italy): Walking right and left cycle.

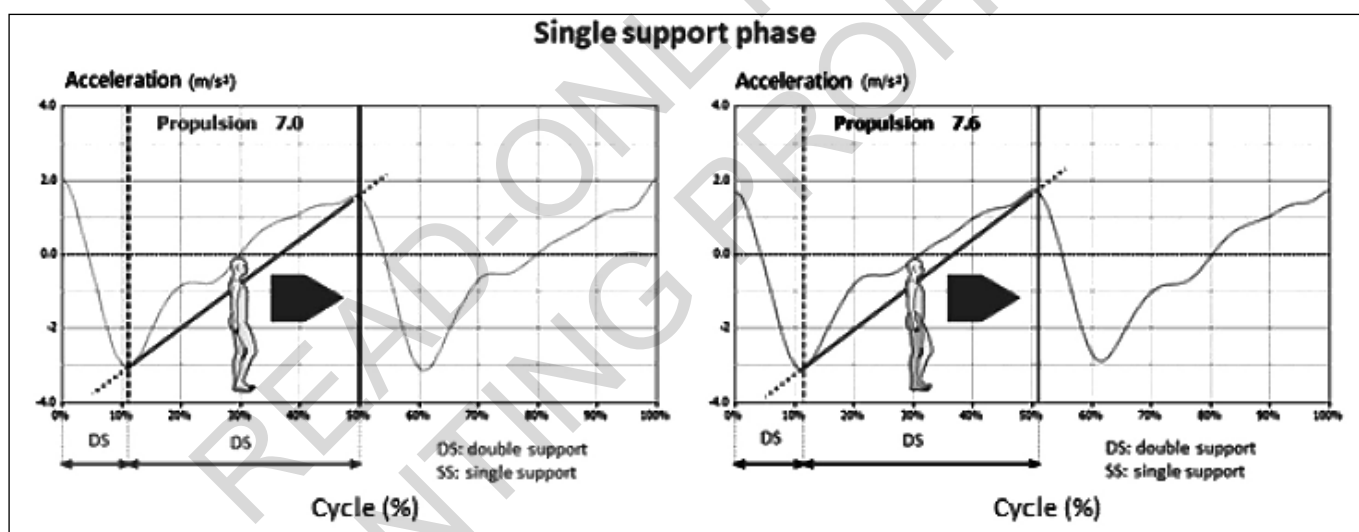


Fig. 2: (taken from BTS S.P.A., Milano, Italy): Propulsion in the left (left graphic) and in the right limb (right graphic). The propulsion is the inclination of the straight line of the anterior/posterior component of the acceleration of the centre of gravity during single support phase.

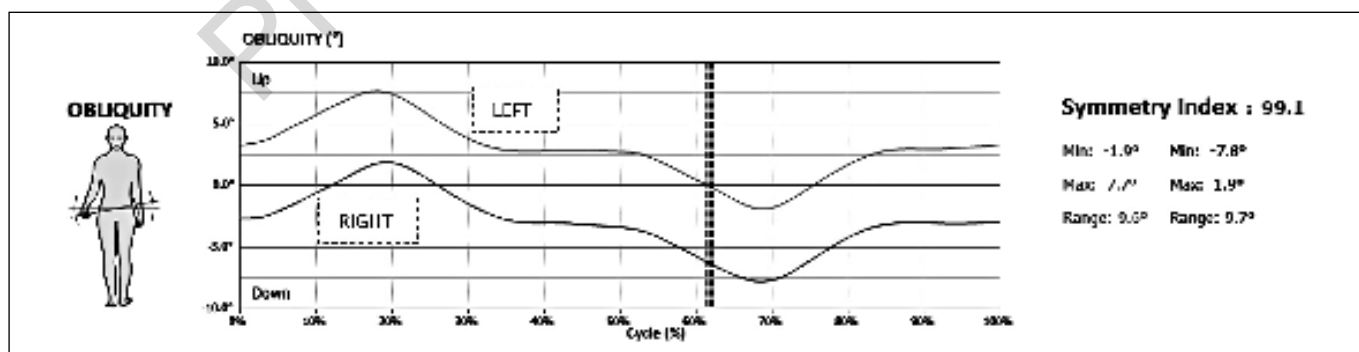


Fig. 3: Obliquity during left and right walking cycle.

barefoot on a 40 meters distance. We focused our study on the following data:

- Step length (% cycle length): average value of the distances between initial contacts (foot strike) and the alternating foot.
- Stance phases (% cycle): average value of the period of time the foot is on the ground.
- Propulsion: index showing the forward thrust during single support phase.
- Obliquity (degree): average of the maximum difference in height of the pelvis during the left and the right walking cycle (initial contact to initial contact of the same foot).

Static baropodometric analysis consisted in the data digital acquisition for a period of 10 seconds. Subjects were asked to stand in an upright position on the platform barefoot and the arms at their sides and were asked to fix a point on the wall far 3 m from them.

Dynamic baropodometric analysis consisted in the data digital acquisition asking subjects to walk barefoot on the platform back and forth 3 times.

Typology of the feet according with arch index defined from Cavanagh P.R. and Rodgers M.M.¹⁵ have been acquired during baropodometric trials.

The arch index during the dynamic baropodometry is the result of the average of three steps for each foot.

STATISTICAL ANALYSIS

Gaussian distribution of the data have been verified using Kolmogorov–Smirnov test.

“t” test of Student have been used for the statistical analysis to determine correlations of the variables of the groups. A value of $p < 0.05$ was chosen as the cut-off for statistical significance.

Results

Respectively the 68% and 60% of subjects with unilateral and bilateral VI had a plantar dysfunction (arch index $\neq$ 21-28%) on a single foot or both feet in static and/or in dynamic.

In Table I, which shows the average values of 4 gait parameters investigated, the values of unilateral VI group are higher compared to the other group of subjects with

bilateral VI, even though these values are not statistically significant.

Subsequently the number of asymmetries of both groups have been calculated fixing a cut off based on the average of the total population (Table II). Values higher than cut-offs have been considered as asymmetry. In Table III is proved that the average number of asymmetries in the group of subjects with unilateral VI is significantly greater (p -value=0.0075) compared to the group of subjects with bilateral VI.

Ultimately has been demonstrated that in the 63% of subjects with unilateral VI the propulsion is reduced on the lower limb damaged

Discussion

Genic anomalies represent the principal etiologic factor of the varicose disease and VI due to venous parietal structural damage that reduce the resistance. The PTM boosts for the increase of the intravenous lateral pressure caused by minor parietal resistance, developing varicose veins, the saphenous valve incompetence, in a progressive and ascending manner. The venous disease is chronic and evolutionary, it predominantly has an hereditary nature and it damages the lower limbs due to the major hydrostatic pressure (maximum to the foot). It develops from latent stadium to intermediate stages up to the full-blown and severe pathology with edema, pain, paraesthesia, cramps, skin dystrophy and ulcer.

Even though the hydrostatic pressure is identical in both lower limbs, the varicose disease develops in just one side, in about 50% of cases. Therefore it may be more plausible that aggravating factors, also postural alterations, can determinate an unilateral haemodynamic failure.

In our study we found that individually each altered parameter or dysfunction, such as the alteration of the foot (60-68%) cannot be pointed out as the main cause or contributory cause of the VI for statistical reasons. On the other hand, the set of alteration of several parameters and dysfunctions is statistically significant.

In the cases of severe parietal structural damage the varicose disease can show up independently of postural disorders, which are not necessarily present in the bilateral saphenous incompetence.

For the venous system, in the unilateral cases we can suppose a mild genetic alteration or an influence by

TABLE I - Differences between the average and standard deviation of two groups (subjects with unilateral and bilateral VI) and the respective p -value. (*) specify the values not statistically significant.

Parameters	Bilateral VI	Unilateral VI	P-value
Stance phases differences (%)	1.08 (0.98)	1.79 (2.24)	0.21*
Step length differences (%)	1.72(1.49)	2.36 (1.74)	0.22*
Maximum difference in height of the pelvis (°)	2.33(3.10)	3.42 (2.73)	0.25*
Propulsion differences	0.59 (0.58)	1.03 (0.82)	0.06*

TABLE II - The cut off indicates the average values of the 5 gait parameters evaluated on 39 subjects

Parameters	Cut off
Arch index in static and/or dynamic	≠21-28%
Stance phases differences (%)	> 1.43
Step length differences (%)	> 2.04
Maximum difference in height of the pelvis (°)	> 2.87
Propulsion differences	> 0.8

TABLE III - Average number and standard deviation of asymmetries in the group of subjects with unilateral VI and with bilateral VI

N° of average asymmetries in the unilateral VI	N° of average asymmetries in the bilateral VI	P-value
2.58 (1.26)	1.60 (0.82)	0.0075

external factors, starting in childhood. These factors or alterations can cause a silent venous disease which might be triggered by several asymmetries in gait and plantar pressure.

So, the postural disorders are a combination of more factors, that might interfere in some cases with either the increase or decrease of veno-muscular pump pressure (VMPP) of the lower limb or with the boost or reduction of the venous flow rate.

In contrast to other previous studies, that considered the dysfunction of plantar pressure or the disorder of VMP, especially of the gastrocnemius, as contributory cause of VI, our study proves that the plantar pressure and propulsion are not the only parameters to consider in an hemodynamic study.

In fact we found that the podalic disorder is present in 60-68% of cases and the unilateral varicose disease the propulsion is reduced in just 63% of cases. Therefore, VI cannot be always caused by an increase of VMPP. Posturology is a very complex subject because the alterations can develop in many ways such as ascendant, descendant, combined syndromes. In conclusion, the high number of postural asymmetries identified and referred as possible contributory cause of the hemodynamic failure could result from many interferences of different kinds.

Conclusion

The full-blown varicose disease in both lower limbs is indisputably caused by congenital parietal weakness. In the unilateral cases, different epigenetic factors, such as postural disorders, may contribute both in the worsening or in the appearance of the varicose veins. Postural disorders treatment in children of phlebopaths

during the childhood could maintain the mild condition of varicose disease silent.

Moreover the same treatment in adults suffering from unilateral varicose disease treated with ablative or conservative therapy may reduce or prevent the appearance of relapses.

More histologic studies on the veins walls of unilateral and bilateral phlebopaths should be performed to verify significant differences on genic stadium.

Last but not least, gait surface electromyography assessment should be done to comprehend motor patterns differences between group of subjects with unilateral and bilateral VI.

Riassunto

OBIETTIVI: Lo studio è stato quello di verificare se le alterazioni posturali possono influenzare lo sviluppo della malattia varicosa con incontinenza safenica monolaterale e bilaterale

MATERIALI E METODI: 39 pazienti affetti da incontinenze safeniche diagnosticate con studio emodinamico con eco-color doppler (20 affetti da insufficienza venosa (IV) bilaterale, 19 affetti da IV monolaterale) hanno effettuato un'analisi del cammino attraverso sensore inerziale wireless e baropodometro per valutare la distribuzione delle pressioni plantari sia staticamente che dinamicamente

RISULTATI: Il 68% e il 60% dei soggetti affetti da IV monolaterale e bilaterale presentano una disfunzione di appoggio su uno o su entrambi i piedi in statica e/o in dinamica. Nel 63% dei casi di IV monolaterale la propulsione è ridotta dal lato colpito. È stato calcolato il numero di asimmetrie del cammino e disfunzioni dell'appoggio plantare di entrambi i gruppi. Il numero delle asimmetrie medio nel gruppo di soggetti con IV monolaterale è significativamente maggiore (p-value=0.0075) rispetto al gruppo di soggetti con IV bilaterale

CONCLUSIONI: Appoggio plantare e aumento della pressione della pompa valvolo-muscolare (PPVM) non sono i principali fattori eziologici che modificano l'emodinamica del cammino. Nei casi di monolateralità le alterazioni posturali possono contribuire al peggioramento o alla comparsa delle varici. La loro correzione nei figli dei flebopatici durante l'età evolutiva potrebbe mantenere allo stato latente la malattia varicosa di lieve grado, mentre negli adulti con malattia varicosa monolaterale trattata con terapia ablative o conservativa potrebbe ridurre o arrestare la comparsa delle recidive.

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