

Prevalence of Chronic Venous Disorders Among Employees Working in Prolonged Sitting and Standing Postures

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Research was conducted to determine the prevalence and severity of chronic venous disorders (CVD) among people working in prolonged sitting or static standing postures. Clinical examination and duplex Doppler sonography were performed on 126 employees working in a sitting (96 individuals) or a standing posture (30 individuals). Evidence of CVD was found in 59.4% of individuals working in a sitting posture and in 83.4% of those working in a standing posture, and was significantly higher in employees working in a standing posture ($p = .015$). Incompetent perforating veins and vena saphena magna valves, and bilateral changes were the more frequent signs of CVD. The investigation showed that prolonged standing and sitting at work increases risk of developing CVD. Further, people working in a standing posture are at a significantly greater risk for CVD than those working in a prolonged sitting posture. They should thus be the subject of specific prophylaxis interventions.

chronic venous disorders occupational chronic venous insufficiency
duplex Doppler sonography

1. INTRODUCTION

Chronic venous disorders (CVD) occur mainly in developed countries. According to the consensus statement of the American Venous

Forum, the term CVD includes a full spectrum of morphologic and functional abnormalities of the venous system, from teleangiectasies to venous ulcers [1, 2]. CVD affect 33% of the population, including up to 68% of women [3]. Prevalence of

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varicose veins, the most frequent form of CVD, in the adult population is 2–56% in men and 1–60% in women [2, 4].

By affecting one-third of the European population, CVD have a considerable socioeconomic impact, mainly because they affect

- 35% of the occupationally active population,
- 50% of pensioners,
- every other woman [5].

The socioeconomic cost of CVD in Western European countries is very high, due to their high prevalence, cost of research and treatment, and loss of working days [6]. The most serious medical and economic problems in CVD are varicose ulcers of the lower legs, which coexist with CVD in 80% of cases. Their prevalence is estimated at ~1–3% of the adult population [6, 7]. The cost of the treatment is estimated at 1–2% of the healthcare budget in Europe [3, 8]. In the United Kingdom the cost of treatment of crucial ulceration is 400 to 600 million GBP annually, and in the USA ~10¹² USD [6]. In both Germany and France, the total annual social cost of venous disease treatment is estimated at over 10¹² USD.

The following factors are considered most important in the pathogenesis of CVD: prolonged standing, obesity, constipation, pregnancy, family history of varicose veins, and past thrombosis (e.g., almost 30% of fractures lead to thrombosis of the lower extremities and its after-effects) [7, 9]. However, none of these factors was unequivocally proven to play a dominant role in the pathogenesis of CVD [2, 10]. Additionally, data indicate an increase in CVD prevalence with age; however, many factors (e.g., duration of CVD, arterial blood pressure, pregnancies, cardiovascular disease) reduce the statistical significance of that increase [11].

Opinions on the relationship between working in prolonged standing or sitting postures and CVD are equivocal. Some authors confirm such a relationship [4, 10, 12, 13, 14], whereas others do not [15, 16]. The Edinburgh vein study goes even so far as to suggest a reverse relationship between a prolonged sitting posture and prevalence of CVD (i.e., fewer cases of CVD and varicose veins), while confirming the impact of a

prolonged standing posture on the occurrence of CVD and varicose veins [3].

In light of those controversies, an original investigation was undertaken to determine the effect of working in sitting and standing postures on the risk of CVD. The determination was based on a clinical examination of CVD with the CEAP classification and duplex Doppler sonography, which are in practice the most commonly used diagnostic tools in investigating the competence of the venous system [1, 5, 17].

2. PATIENTS AND METHODS

2.1. Occupational Group Under Study

The investigation encompassed 126 workers: 79 women (62.7%) and 47 men (37.3%). Age (at least 40) and posture at work (sitting for office workers and standing for copy shop and laboratory workers) were the inclusion criteria. Exclusion criteria included past thrombosis, history of immobilization (e.g., a long disease), and a family history of varicose veins. Otherwise, participation was voluntary.

The subjects were aged 40–77 ($M 54 \pm 7$ years); the most numerous group was that of people 50–60 years old (56.3%), followed by 40–50 year-olds (26.2%), 60–70 year-olds (15.1%), and those over 70 (2.4%). The mean length of service in the position declared by the subjects (i.e., sitting or standing) was 25 years ($SD 10$). On average, the subjects spent 42.2 h/week ($SD 7.5$) at work.

In the analyzed group, 96 out of 126 people (76.2%) performed work in a sitting posture, including 64 women (66.6% of persons working in a sitting posture) and 32 men (33.4% of persons working in a sitting posture). The other 30 out of 126 studied individuals (23.8%) worked in a static standing posture (e.g., laboratory workers, operators of photocopiers).

Most subjects (76%) worked over 6 h a day in a sitting posture. Of the other 24%, 5.2% worked 4–6 h in a sitting posture, 17.7% 2–4 h, and 1% under 1 h. History taken from these workers revealed that 44.8% declared obesity, 21.9% smoked cigarettes, 18.8% of women used contraception or hormone replacement therapy,

81.8% had been pregnant (42.2% of whom had been pregnant more than twice).

The distribution of the amount of time spent at work in the standing posture for the persons from the standing group showed that the largest group (40%) spent over 6 h a day in the declared posture. Of the remaining workers, 30% spent 4–6 h, 20% 2–4 h, and 10% under 2 h standing per day. History taken from this group of workers revealed that obesity was declared by 43.3%, cigarette smoking by 16.7%, 26.7% of women used contraception or hormone replacement therapy, and 80.0% had been pregnant (53.3% of whom more than twice).

2.2. Doppler Examination

The examination was performed with a Philips (The Netherlands) HDI 4000 ultrasound scanner fitted with a broadband, convex C, 2–5 MHz probe, and a linear L 5–12 MHz transducer, with the option of color, power, and spectral Doppler with duplex and triplex Doppler imaging capabilities. To assess patency of the superficial, deep, and perforating venous systems, color and spectral Doppler were used, together with the Valsalva maneuver, and distal and proximal occlusion tests.

The subjects were examined in the lying and standing positions. First, venous morphology was assessed in the lying position, together with venous patency and the presence of possible post-thrombotic changes. Then, valvular competence of the veins was established with the Valsalva maneuver, in particular of the sapheno-femoral junction, the distal segment of the femoral veins (both superficial and deep), and sufficiency of the femoral part of the VSM (vena saphena magna; long saphenous vein). The other vascular sectors were assessed in the standing (VSM, femoral veins) and sitting positions (vessels of the popliteal fossa and the calf) that ensured physiological filling of the vessels and tension of the valvular system present during the subject's normal activity. Finally, the area of the saphenofemoral junction was assessed. Valvular incompetence was evidenced by the reversal of blood flow (reflux) longer than 0.5 s [15, 18]. The probe was moved along

the varicose veins to visualize the perforating ones. In this study a diameter of 3 mm was a preliminary criterion for further assessment of the competence of perforating veins, thus improving the identification of those veins. After a vessel meeting that criterion was visualized, additional color flow imaging or spectral Doppler were started, and then a distal occlusion test was performed. Reflux of over 0.5 s would confirm incompetency of perforating veins.

2.3. Clinical Examination of the Venous System

The clinical examination comprised history and a physical examination with clinical classifications of CVD [6, 7, 19]. The results of the clinical examination were coded in keeping with the CEAP classification of CVD, which includes information on clinical signs (C), etiologic classification (E), anatomic distribution (A), and pathophysiological dysfunction (P). The following CVD classifications were used to collect additional information, e.g., CVD clinical severity, the course of treatment, and CVD-related quality of life:

- patient's status assessment score (PSAS);
- venous clinical severity score (VCSS);
- venous segmental disease score (VSDS);
- venous disability score (VDS).

There were two, independent of each other, prospective studies. A surgeon conducted the clinical examination, whereas a radiologist used duplex Doppler sonography. Both had extensive experience in diagnosing venous diseases. The surgeon used the results of duplex Doppler to clinically classify cases of CVD.

All the procedures followed the ethical standards of the Medical University of Warsaw; all participants gave written consent.

2.4. Analysis of Questionnaire Data and Medical Results

The results of data from the clinical examination and duplex Doppler sonography were analyzed; MS Access and SQL (structured query language) were used. Statistical

analysis was done with Splus version 6.0 for Windows (Insightful Corp., USA) [20]. Sample proportions in both groups (standing and sitting) were used to estimate the true proportions of subjects with CVD. The sample proportion of subjects with standing jobs who had CVD was 25/30 (83.4%), 95% confidence interval (CI; 64.5, 93.7). The sample proportion of subjects with sitting jobs that had CVD was 57/96 (59.4%), 95% CI (48.9, 69.1). To decide if the population proportions of people with CVD differed significantly between the two occupational groups, a 2-proportion χ^2 test was performed. All statistical tests were performed on a 5% level of significance. The χ^2 test statistic was 7.56 with 2 *df* and $p = .023$. To decide which pairs of proportions differed we used 2-sample χ^2 tests. The objective of the analysis was, notably, to find answers to the following questions:

- What is the prevalence and severity of CVD in persons working in a sitting posture?
- What is the prevalence and severity of CVD in persons working in a standing posture?
- Is the difference in CVD prevalence between persons working in prolonged sitting and prolonged standing postures statistically significant?

3. RESULTS

3.1. Duplex Doppler

Several signs were assessed with duplex Doppler in each person, in each leg separately. Thus, there were 252 ultrasound examinations (126 individuals $\times$ 2). CVD was diagnosed if there was at least one of the following signs:

- incompetence of the saphenofemoral junction;
- incompetence of the femoral segment of the VSM;
- incompetence of the popliteal section of the VSM;

- incompetence of the short saphenous vein (vena saphena parva, VSP);
- presence of femoral varices;
- presence of crural varices;
- competence of the perforating veins;
- occurrence of bilateral changes.

3.1.1 Sitting workers

In the pool of the 96 persons working in a sitting posture, 57 (59.4% of the employees working in a sitting posture), of whom 39 were women (40.6% of the sitting persons) and 18 were men (18% of the sitting persons), had Doppler signs of CVD. VSM insufficiency and incompetent perforating veins were the most frequent pathologies in those 57 patients. Sixty-five percent of them had bilateral changes.

3.1.2. Standing workers

In the pool of 30 persons working in a standing posture (15 women and 15 men), 25 subjects (83.4%), of whom 14 were women (46.7%) and 11 were men (36.7%), had Doppler evidence of CVD. Incompetent perforating veins (96% of standing persons with sonographic signs of CVD) and VSM insufficiency, notably in the crural segment (76% of standing persons with sonographic signs of CVD), were most frequent (Figures 1–2, Table 1).

CVD signs analyzed with Doppler were found more frequently in the standing group than in the sitting one. Only incompetent perforating veins and bilateral changes were more frequent in the sitting subjects. Incidence of CVD was statistically greater in standing than in sitting office workers ($p = .015$).

In both groups under study considered together, i.e., in 126 persons examined with Doppler, the prevalence of cases with Doppler evidence in two age groups (under and over 54), increased with age (Figure 3).

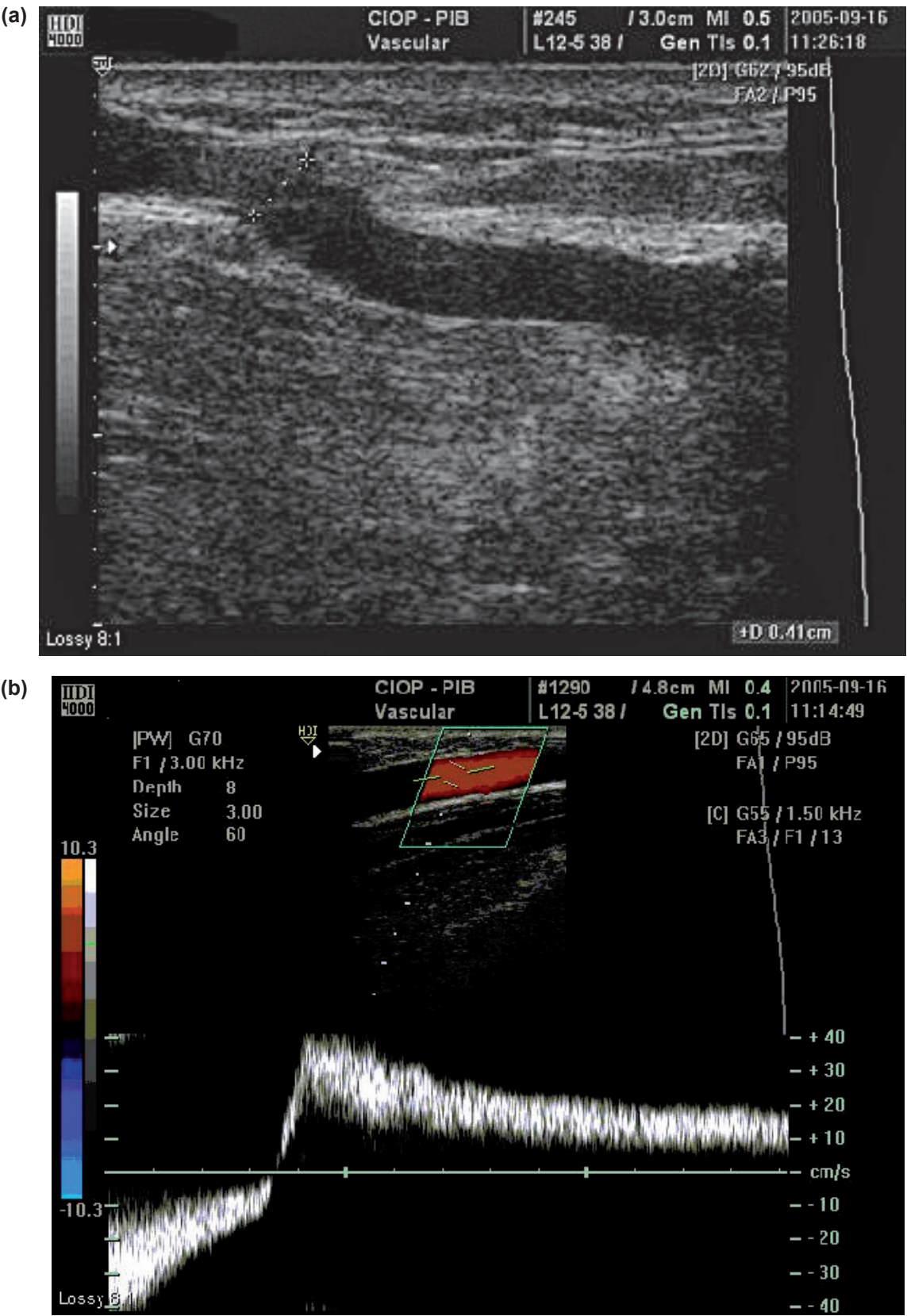


Figure 1. An incompetent perforating vein: (a) dilation up to 4 mm (duplex Doppler); (b) reversal flow during occlusion test (triplex Doppler).

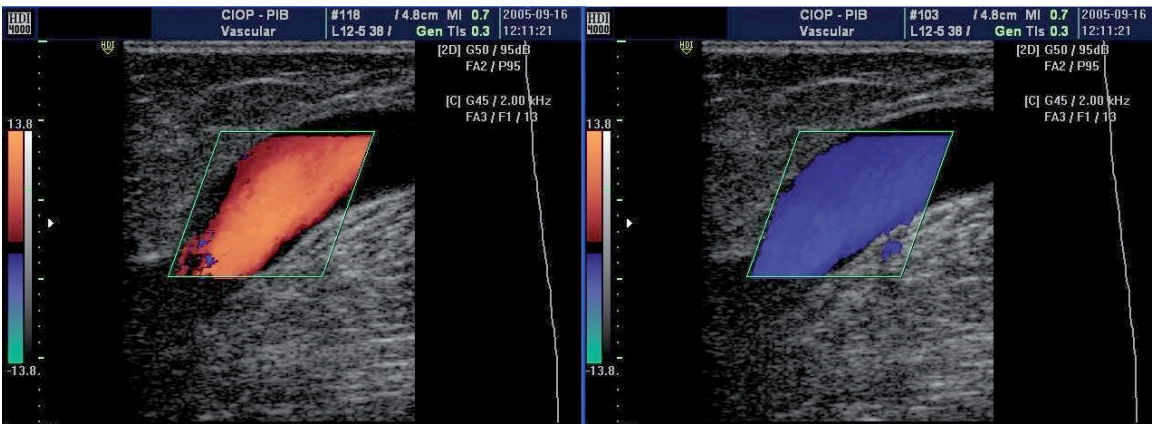


Figure 2. Valvular incompetence of the long saphenous vein (vena saphena magna): reversal flow during the Valsalva maneuver.

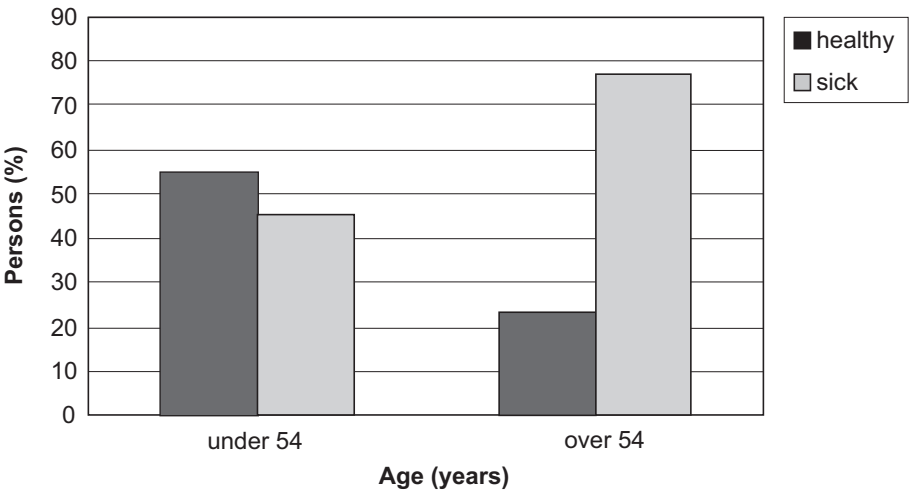


Figure 3. Pathological changes in persons under and over 54 years old (duplex Doppler).

TABLE 1. Frequency of Signs of Chronic Venous Disorders in Doppler Sonography in Standing and Sitting Workers

Lesions	Posture (%)	
	Standing	Sitting
Incompetence of saphenofemoral junction	48.0	38.6
Incompetence of femoral segment of VSM	72.0	59.6
Incompetence of popliteal section of VSM	76.0	64.9
Incompetence of VSP–popliteal vein junction	24.0	15.8
Incompetence of VSP	32.0	24.6
Presence of femoral varices	28.0	26.3
Presence of crural varices	64.0	63.2
Incompetence of perforating veins	96.0	98.2
Bilateral changes	52.0	64.9

Notes. VSM—vena saphena magna (long saphenous vein), VSP—vena saphena parva (short saphenous vein).

3.2. Clinical Examination

Of the 126 participants who had duplex Doppler examinations, 84 applied and had their lower extremities clinically examined. That group comprised 65 individuals who worked in the sitting posture and 19 who worked in the standing posture. Due to the low number of employees in the standing group, the results of the clinical investigation were analyzed for the entire group of 84 subjects.

3.2.1. CEAP

According to CEAP, CVD severity was none or mild (i.e., there were no visible or palpable signs; teleangiectasis and reticular veins) in 65% of the examined legs (class 0–1 out of 7). Only 6% of cases had severe skin changes including lipodermatosclerosis and pigmentation (class 4–5); with no cases of the most severe CVD-related complication, i.e., varicose ulcers of the lower leg. The medical history indicated the primary character of CVD in all the subjects. In 33.3% of cases (in 56 of the 168 limbs) there were no pathologies in the venous system, in the superficial, deep and perforating veins. In the other cases CVD was mainly located in the perforating venous system and in superficial veins. The deep venous system was affected in 5 limbs only. Reflux was the pathophysiological factor in all cases.

3.2.2. Chronic venous insufficiency expressed with PSAS

The maximum occurrence and severity of CVD clinical signs (pain, edema, claudication, pigmentation, and lipodermatosclerosis) assessed with PSAS on a 0–18 scale was 4, which confirmed low CVD severity in the occupational groups under study. Seventy-seven percent of the examined limbs had the score of 0–2; 7% had 3–4 points.

3.2.3. VCSS

The results of clinical examination with VCSS confirmed low severity of CVD in the subjects. The highest score on a 0–30 scale was 10. There

were no changes (0) or they were mild/moderate (1) in 67% of right limbs and 63% of left ones.

3.2.4. VSIDS

The anatomic distribution of the disease was assessed with VSIDS. On a scale of 0–10, the highest score was 1.5 (77% of limbs). The score of 0 was acquired in 2%, 0.5 in 40%, and 1.5 in 35% of cases. As changes were studied in the superficial and perforator vein systems only, scores were low. Deep venous incompetence was found in 5 cases (cf. section 3.2.1.)

3.2.5. VDS

According to VDS, almost all participants (97% of the limbs) declared either no CVD-specific symptoms (56%) or mild ones (41%) that did not significantly affect their quality of life (0–1 on a 0–3 scale). The highest level of venous disability was established in one case only; there were changes in the left limb, which affected day-to-day activities despite compression therapy or lifting the limb.

4. DISCUSSION AND CONCLUSION

The influence of working conditions on the development of CVD has not been unequivocally determined. In Switzerland, varicose veins were found in 56% of men and 55% of women working in chemical industry [3, 12]. Varicose veins in the VSM and VSP drainage area occurred in 20% of men and 11% of women, and reticular vein or teleangiectasias or both in 36% of men and 44% of women. A study carried out in Czechoslovakia in women working in a supermarket demonstrated the occurrence of reticular veins in 15.4%, teleangiectasias in 30.7%, varicose in VSM and VSP branches in 14.4% of women [15]. In a study carried out in Scotland, both reticular veins and teleangiectasias were found in 18% of women [3].

Opinions on the relationship between working in prolonged standing or sitting postures and CVD are equivocal. Several authors confirmed such a relationship [4, 10, 12, 13, 14], although there were also indications to the

contrary [15, 16]. In their cross-sectional study, Jawien, Grzela, and Ochwat did not find any relationship between CVD and work in a sitting posture, whereas there was a significantly higher CVD prevalence in women and men working in a prolonged standing posture [9].

Our study, based in part on Doppler, revealed CVD evidence in 59.4% individuals working in a sitting posture, and in 83.4% of individuals working in a standing posture. Women were more often affected than men; however, the difference in CVD prevalence between women and men was less clear in the former group: the women-to-men ratio was 1:2 in the standing group and 2:1 in the sitting one (it is important that there were only 30 persons in the standing group). The study also confirmed that CVD increased with age. Doppler ultrasound showed that both general CVD prevalence and prevalence of individual CVD signs was higher in the standing group, compared to the group of individuals working in a sitting posture. A statistical analysis performed to find out if the population proportions of persons with CVD signs diagnosed with Doppler sonography differed significantly between the two groups confirmed a significant difference ($p = .05$). The true proportion of workers with CVD was significantly lower among the sitting group than among the standing one ($p = .015$). Incompetent perforators were the most frequent sign in both groups. Duplex Doppler clearly showed the location of incompetent perforating veins. The standing posture generated more signs of CVD presumably due to a larger load on the venous system. This, however, may not be a case, because ambulatory venous pressure during sitting is ~60–80 mm of water, as opposed to 20 mm during walking, and the number is only slightly higher (~100 mm) during standing [16].

Concluding, our investigation showed that a standing posture at work is a significantly greater risk for CVD development than prolonged sitting. The clinical examination carried out in the two groups of workers revealed mild clinical severity of CVD, despite a frequent diagnosis of the disease with Doppler. That is why workers

should be made aware of CVD prophylaxis. It should cover modified behavior (e.g., watching body weight, not smoking, wearing compression socks or stockings to reduce discomfort and edema), workplace ergonomics (e.g., an adjustable seat, regular exercise to activate the muscular pump of the calf, breaks to rest and stretch legs). Moreover, it is necessary to monitor the course of the disease which, due to competent compensation mechanisms might not particularly manifest itself clinically [14, 21, 22]. This is especially important if a Doppler examination reveals a more advanced form of CVD localized in the deep system. Labropoulos, Delis, Nicolaides, et al. demonstrated that in such a situation the risk of skin changes and ulcers is much higher than of other changes, localized in the superficial system and perforating veins [23]. On the other hand, it is generally agreed today that hydrostatic pressure alone is not enough to create CVD. Muscle pump failure, obesity, and inflammatory mechanisms are considered as important contributors as increased venous pressure [16]. Hence, blaming working conditions as the primary cause in the development of this disease might be arguable [16]. Longitudinal studies conducted with standardized methods of evaluation are required before the true association between working conditions and incidence of CVD can be determined.

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