Original article

Rate of occupational leg swelling is greater in the morning than in the afternoon

C E Q Belczak*, J M P de Godoy†, R N Ramos‡, M A de Oliveira‡, S Q Belczak§ and R A Caffaro**

*Santa Casa Medicine School in Sao Paulo FCMSCSP, Professor of the Lymphovenous Rehabilitation Post-graduation Course of the Medicine School in Sao Jose do Rio Preto (FAMERP) Member of the International Group on Compression (GIC); †*Livre Docente*, Medicine School of São Jose do Rio Preto – FAMERP and CNPq Researcher; ‡João Belczak Vascular Center, Maringá, Paraná; §Fourth Year Resident in Vascular Surgery in the Hospital das ClÍnicas, University of São Paulo USP; **Vascular Surgery Section of the Surgery Department in the Medicine School of the Santa Casa of São Paulo FCMSCSP, Brazil

Abstract

The aim of this study was to investigate the rate of occupational leg swelling depending on the time period of the working day. Volumetric variations of the legs of 70 hospital employees, enrolled in three groups, were evaluated. Group I: 35 morning shift workers; Group II: 35 afternoon shift workers and Group III: 15 individuals randomly selected from Groups I and II and evaluated on the day that they worked 12 hours consecutively. Volumetry was performed before and after each work shift for both legs of the participants in Groups I and II. For Group III volumetry was performed early in the morning, at noon and in the evening. For statistical analysis, the Student's *t*-test and Mann-Whitney test were used with an alpha error of 5% being considered acceptable (P value < 0.05). Significant increases in volume were evidenced for the limbs in all three groups (P value < 0.001). On comparing Groups I and II, the accumulation of fluids was significantly higher in the morning than in the afternoon (P value < 0.003). Asymptomatic workers may present with oedema of the legs during their work with the rate of oedema being different for morning and afternoon shifts. The possibility of wearing compression stockings should be considered for this type of work.

Keywords: Oedema; occupational oedema; leg swelling

Introduction

The presence of evening oedema of the legs of apparently normal individuals after working in a sitting or standing position has been demonstrated by several authors over the last few decades.[1,2] This oedema is mostly asymptomatic and will disappear overnight. Nevertheless, unpleasant subjective feelings of heaviness and tiredness may be reported.[2] Some studies have reported biological variations that occur during the day in healthy individuals and in those submitted to specific medical therapies, as well as alterations that exist on distinct days of dominant and non-dominant limbs.[3–5] The amount of swelling with and without the use of compression stockings of different strength has also been comparatively assessed.[2]

It has been demonstrated that there are venous haemodynamic changes over the day as a consequence of the widening of valve cusps, which causes an increase in venous reflux.[6] Many systems of the human physiology have circadian rhythms that are influenced, for example, by the posture or by alterations in the biochemistry of the blood as is the case of oestrogen levels acting on smooth muscle cells.[7–9]

Correspondence: **C E Q Belczak**, Centro Vascular João Belczak – Av. Tiradentes, 1081 Maringá, Brazil, CEP 87013-260. Email: belczak@wnet.com.br

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It is well known that swelling of the legs, apart from being uncomfortable and causing weariness, thereby reducing professional efficiency, frequently represents one of the first manifestations of decompensation of the venous and/or lymphatic system. Clinical complications of these two systems are a common cause of days lost from work and of a decline in the individual's quality of life. Thus, it is important to understand the clinical and aetiological characteristics of oedema, and to measure and interpret the magnitude of swelling with respect to the time of day, in order to improve our knowledge on the pathophysiology of oedema.

The aim of this study was to investigate whether the rate of occupational leg swelling differs during morning and afternoon shifts in apparently normal individuals.

Materials and methods

Volumetric variations of both legs of 70 health-care employees from the São Marcos Hospital in Maringá, Brazil, were evaluated from 10 October 2007 to 10 April 2008 using the water displacement method[10] (Figure 1). The employees were from morning and afternoon shifts, however one day a week the employees were required to work 12 consecutive hours. The morning shift was from 07:00 hours to 13:00 hours and the afternoon shift from 13:00 hours to 19:00 hours. All the healthy volunteers including nurses, cleaners, receptionists, kitchen workers and porters of the surgical centre, performed manual activities combining periods of standing, walking and sitting for similar proportions of time. Individuals who remained predominantly sitting or standing, that is without moving, were not enrolled in this study. An invitation, in which the objectives of the study were explained, was made to all morning and afternoon employees of one sector of the hospital. Individuals were carefully informed of all details and prerequisites of the trial before inclusion and were selected on a consecutive basis from those who accepted to participate and who fulfilled the inclusion criteria. They also signed written consent forms. Inclusion criteria were that the individuals were classified as C0 (no varicose veins) or C1 (only telangiectasias) of the clinical, aetiological, anatomical and pathophysiological classification (CEAP).[11,12] Individuals with ischaemia, hypertension and diabetes were excluded from the study as were those who were taking medicaments, which may affect the formation of oedema such as diuretics, calcium blockers or hormones. In addition, patients with oedema of the legs due to a systemic origin such as congestive heart failure, renal and hepatic diseases, myxoedema or traumatic and rheumatic joint diseases were excluded from the study.

Figure 1 Volumetry by water displacement

Two groups were formed with 35 individuals each: Group I of morning workers and Group II of afternoon workers. Group I was composed of 32 Caucasians and three Negroes and included just one male employee. Their ages ranged from 19 to 53 years old and their weights varied between 53 kg and 103 kg. Group II consisted of 31 women and four men with four Negroes, one Asian and 30 Caucasians with ages varying from 21 to 54 years old and weights ranging from 49 kg to 80 kg. A third group was formed of 15 individuals randomly selected from Groups I and II and evaluated on the day that they worked 12 hours consecutively.

Water displacement volumetry

The measuring instrument consisted of a Plexi-glass container of 45 cm in height (Figure 1) to measure the entire volume of the foot and lower the leg up to just below the knee. It was filled with warm water at 30°C as proposed by Thulesius *et al.*[13] This temperature was used to better exclude cutaneous vasomotor responses.[2] After careful introduction of the lower leg into the device, patients were requested to stand still for five

minutes while the displaced water was collected and weighed using precision weighting scales. One gram of displaced water was assumed to correspond to 1 mL of volume.

Statistics

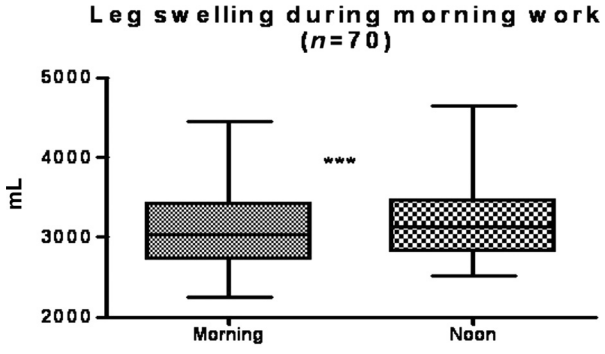
For statistical analysis, the Student's *t*-test and Mann-Whitney test were employed with an alpha error of 5% being considered acceptable. There were no significant differences with respect to gender, age, ethnical background or weight between Groups I and II.

The study was approved by the Research Ethics Committee of University of Maringá (CESUMAR).

Results

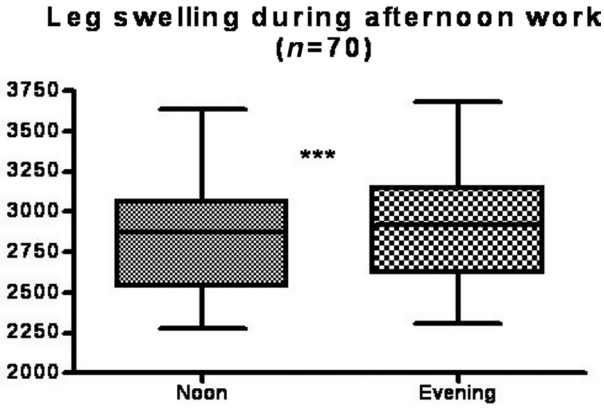
There were significant variations in volume over the day for all three groups. Figures 2 and 3 show a significant increase in the leg volume, both for the morning (Group I) and afternoon workers (Group II) ($P < 0.001$). Figure 4 demonstrates a higher increase of the leg volume in Group I compared with Group II (P value < 0.003 – Mann-Whitney test).

Figure 5 illustrates the volume increase over the entire day measured in Group III (12-hour shift), which was significant both in the morning and in the afternoon ($P < 0.0001$). There was no significant difference concerning the volume changes between the left and right legs.



	Morning	Noon
Minimum	2240	2510
25% Percentile	2725	2825
Median	3030	3125
75% Percentile	3420	3470
Maximum	4450	4650
Mean	3097	3207
SD	490.7	484.0
SE	58.65	57.85

Figure 2 Variations in volume of the legs during the morning shift (Group I)



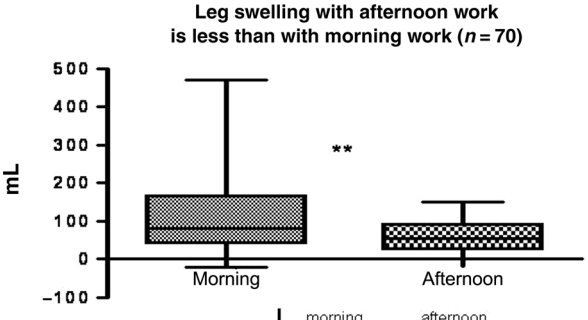
	Noon	Evening
Minimum	2280	2310
25% Percentile	2540	2620
Median	2875	2920
75% Percentile	3065	3145
Maximum	3640	3680
Mean	2843	2902
SD	311.7	316.4
SE	37.26	37.82

Figure 3 Variations in volume of the legs during the afternoon shift (Group II)

The swelling rate per working hour in Group III was about two times as high in the morning compared with the afternoon (Figure 6) ($P < 0.0001$, Mann-Whitney test).

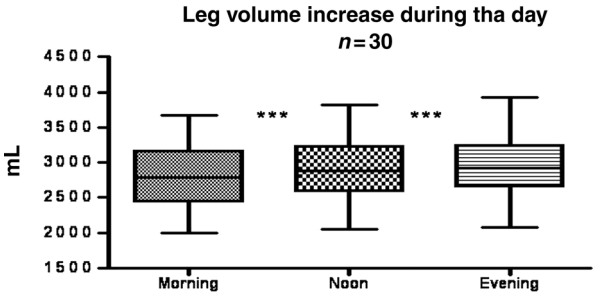
Discussion

This study shows that working in the standing and sitting positions, for varying and intercalated periods of the same day, causes leg swelling due



	morning	afternoon
Minimum	-20.00	0.0
25% Percentile	40.00	25.00
Median	80.00	55.00
75% Percentile	165.0	90.00
Maximum	470.0	150.0
Mean	110.0	59.14
SD	98.97	38.33
SE	11.83	4.581

Figure 4 Comparing Group I (morning) with Group II (afternoon)

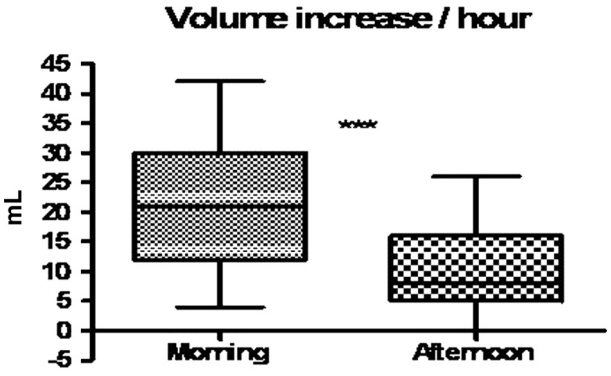


	Morning	Noon	Evening
Minimum	1995	2055	2075
25% Percentile	2440	2585	2650
Median	2790	2880	2920
75% Percentile	3170	3225	3240
Maximum	3675	3825	3925
Mean	2808	2915	2962
SD	439.3	446.2	450.4
SE	80.21	81.47	82.22

Figure 5 Variations in volume of Group III over the entire day (12-hour shift) evaluated at the start, at noon and at the end of work

to an overload of the lymphovenous drainage capacity. Physiological variations were observed with a greater accumulation of fluids during the morning compared with the afternoon.

Some studies have shown that oedema formation depends on factors such as circadian alterations, posture, temperature, physical activity, hormonal fluctuations, medications, clothes worn and the intake of salt.[14] In our study the three groups were similar with respect to factors that might influence



	Morning	Afternoon
Minimum	4.000	0.0
25% Percentile	12.00	5.000
Median	21.00	8.000
75% Percentile	30.00	16.00
Maximum	42.00	26.00
Mean	21.40	9.467
SD	11.30	6.169
SE	2.064	1.126

Figure 6 Comparison of leg swelling per hour between morning and afternoon (Group III)

the evolution of oedema such as age, gender, weight and the activities of participants. Another factor that might influence the volumetric variations of legs is the presence of varicose veins causing a higher accumulation of fluids.

The measurement of lower leg volume by water displacement is an accurate method and presents a good reproducibility as described by Partsch *et al.*[2] This method defines segments of the lower extremity including the foot and the leg in the standing position. Vayssairat *et al.* in 1994,[15] on measuring normal individuals and patients with varicose veins, confirmed that even for normal legs there was a significant increase in volume between morning and afternoon measurements. This may correlate with alterations of the venous haemodynamics detected in normal limbs during day-to-day work by other authors, who underline the influence of prolonged standing, activities with limited leg movement and even long periods of sitting.[16] Thus, only apparently normal individuals whose activities did not require remaining in the same position continuously were included in this study.

It is believed that the formation of occupational leg swelling is primarily caused by the effect of gravitational forces over an excessive period. The accumulation of fluids may occur due to an increase in the volume of the interstitial space and in the vascular reservoir itself and so the presence of varicose veins might interfere in volumetric variations. This study demonstrates that patients with varicose veins have a greater variation in the volume of the limb, which may be affected depending on the time that they remain standing before the examination.[17]

During sleep in the recumbent position at night, the diminished gravitational force allows the limb to empty and return to its normal size and stabilizing the pressures at the microcirculation level; balancing the intravascular and extravascular pressures. It may be assumed that the limb in the early morning is free from oedema similar to a dry sponge. When the legs, in the upright position, start to be submitted to the gravitational forces Starling's equilibrium changes and the 'dry sponge' fills up quickly within the first few hours. The filtration into the tissue increases the interstitial pressure, which then diminishes further extravasation in the afternoon. Thus, oedema that occurs during the morning may reduce the speed of swelling during the afternoon.

The fact that legs swell by the end of a working day is probably the result of a physiological phenomenon resulting from an extravasation of fluid from the venules because of steadily increasing

venous pressure in the dependent regions, owing to gravity.[2]

Recognition of these factors should lead to a discussion on the possibility of using protective prophylactic measures such as compression stockings, whenever individuals are required to spend long periods standing or sitting in their daily routine work. Such measures may avoid an overload of tissue fluid, which has to be mastered by the venous and lymphatic systems.

This study stimulates a discussion on the theme of occupational oedema and provides support to a series of doubts with respect to medicine at work in an attempt to find scientific support to establish prophylactic routines that protect the health of workers.

Conclusion

After working in a sitting or standing position for several hours, asymptomatic employees present occupational leg swelling, which is more pronounced in the morning than in the afternoon. Future studies should concentrate on measures to prevent occupational leg swelling, such as compression stockings of different classes adjusted to this diurnal variation.

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