We studied the effect of full and partial weight-bearing on venous peak velocity in the legs of 73 subjects. We used colourflow Duplex ultrasound to determine the minimal amount of weight-bearing required to produce the same venous peak velocity as full weight-bearing.

We found that the venous peak velocity remains the same in the femoral vein during partial weight-bearing (196 N and above). This is important for postoperative physiotherapy and thromboprophylaxis. The median peak velocity was 30 cm/s. This corresponds to an amplification factor of four in relation to the individual resting level (peak velocity).

In addition, we found that partial weight-bearing at 196 N can reliably be reproduced. The median value of partial weight-bearing after a three-day training programme was 206 N.

**Subjects and Methods**

We measured venous peak velocity in the leg during partial and full weight-bearing in 73 volunteers (40 men and 33 women) with a median age of 49 years and a median body mass index of 24.5.

**Method 1.** We used a simple bathroom scale to measure load during partial weight-bearing. The subjects were studied using a Quantum 2000 linear array ultrasound transducer of 5MHz (Siemens, New York). The resting venous velocity in each leg was measured in the supine and standing positions (Fig. 1), with the subjects standing either on their right or left leg, using two crutches. On request, they undertook partial weight-bearing on the right or left leg. A Doppler flow transducer was placed above the corresponding common femoral vein covering the full width of the vessel (common femoral vein, sample volume) at an angle of 45° to the vessel wall.

Repeated weight-bearing studies were performed at a frequency of 20 per minute. After the first ten repetitions the next five were recorded. The individual median peak velocity was taken from these five repetitions, and all readings from the 73 limbs were used to calculate the overall median, minimum, maximum, first and third quartile values for each corresponding level of weight-bearing (Fig. 2). We repeated this procedure at 98 N, 196 N, 294 N, 392 N, 490 N and at full weight-bearing. All investigations were compared with each individual's ipsilateral peak velocity resting level (standing position). The results were analysed using the Wilcoxon signed-rank test.

**Method 2.** We attempted to show that partial weight-bearing of 196 N is reliably reproducible within a three-day training programme. A bathroom scale embedded in a platform was used. During the first day the subjects learned the 'partial weight-bearing feeling' of 196 N by visual contact with the scale. They stood on their right or left leg, using two crutches. With the ‘free’ leg they performed partial weight-bearing of 196 N at a frequency of 20 repetitions per minute.

On the second and third days, the same programme was performed without visual contact. The bathroom scale had the option to record the highest value of the force applied to its surface. The subjects repeated the weight-bearing ten times (within 30 seconds) and the highest value obtained...
Method 1. Ultrasound traces showing venous peak velocity in the common femoral vein at a) resting level and supine position, b) resting level and standing position and c) during partial weight-bearing (196 N).

Method 1. Graph showing combined readings of venous peak velocity in the common femoral vein (median, minimum, maximum and first and third quartile values shown) for the 73 subjects.
was recorded. A confidence interval (CI) for partial weight-bearing (expected value 196 N) was calculated \((p = 0.05)\) from the sample of 73 volunteers (Figs 3 and 4).

**Results**

**Method 1.** In individual subjects, there was no significant difference in venous outflow between the right and left legs at the resting level and during weight-bearing exercises \((p > 0.95)\). Therefore all the results and conclusions are drawn from a sample of the 73 investigations. Because the cross-section in the femoral vein in the standing position was not reproducible, the blood flow was not calculated. The median peak velocity in the femoral vein increased during weight-bearing from 7.50 cm/s in the standing position at the resting level (min, 8 cm/s; max, 20 cm/s; first quartile, 11, 3 cm/s; third quartile 15 cm/s) to 15.00 cm/s at 98 N (min, 3 cm/s; max, 13 cm/s; first quartile, 5 cm/s; third quartile, 10 cm/s) to 30 cm/s at just over 196 N (min, 22 cm/s; max, 45 cm/s; first quartile, 26 cm/s; third quartile, 37 cm/s) and 31 cm/s at full weight-bearing (min, 22 cm/s; max, 46 cm/s; first quartile, 29 cm/s; third quartile, 40 cm/s). For comparison, in the supine position the median peak velocity was 14 cm/s (Figs 1 and 2).

The peak venous velocity did not differ significantly between partial (98 N) and full weight-bearing (Wilcoxon signed-rank test, \(p = 0.05\), test value 170).

**Method 2.** On day 2 the same subjects reproduced partial weight-bearing (without visual contact) with a mean value of 205 N (standard deviation 43.8, confidence interval 205 ± 19.2). On day 3 the mean value was 208.3 N (standard deviation 41.5, confidence interval 208.3 ± 17.4, probability 95%; Figs 3 and 4).

**Discussion**

Venous stasis is one of the most important risk factors in thromboembolism. Early mobilisation after trauma or elective surgery can decrease the venous stasis which occurs during bed-rest.\(^9\)\(^-\)\(^11\) On partial weight-bearing at a load of 196 N, venous return is close to that at full weight-bearing. Partial weight-bearing is reproducible within a tolerable deviation (190.9 N and 225.6 N on day 3). The lower limit of the confidence interval remains very slightly below the required value of 98 N. Reports in the literature show that both passive and active movements of the ankle also improve venous return.\(^12\)\(^,\)\(^13\)

The need for continuing outpatient chemical prophylaxis after surgery remains controversial.\(^14\) It is probable that whenever postoperative mobilisation is not possible or incomplete, chemical prophylaxis will reduce postoperative thromboembolism. The efficacy of this treatment, however, has yet to be studied in randomised, controlled trials.\(^15\)
In our hospital, the incidence of deep-vein thrombosis (DVT) is 3% to 4% in a total of 4000 operations a year, prospectively determined over two years by Duplex colour-coded ultrasound, in patients who received routine chemical prophylaxis with certoparin 3000 anti Xa IU, once daily, and immediate postoperative mobilisation. After discharge at a mean time of seven days, we do not give further chemical prophylaxis if the patient is mobile, has normal movement of the ankle and is at least partially weight-bearing (196 N).\textsuperscript{16,17}

Prophylaxis for DVT in orthopaedic surgery should include functional aftercare, with movement of the ankle and some weight-bearing. In postoperative rehabilitation, partial weight-bearing of 196 N is nearly always possible, even after the fixation of most fractures.

Additional mechanical measures may be used if there are no local contraindications, and although these methods are clearly free from haemorrhagic complications, their value in prophylaxis has yet to be evaluated by prospective randomised studies.\textsuperscript{18,19}

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