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ASYMMETRY OF PLANTAR FLEXION STRENGTH IN THE FOOT

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A study of plantar flexion strength and calf circumference in 30 conscripts is submitted. It showed an asymmetry of strength amounting to 6–11 per cent (95 per cent confidence limits). The right leg was significantly stronger than the left, but there was no difference in strength between the dominant and non-dominant leg. There was little correlation between circumference and strength.

Key words: foot; laterality; leg circumference; muscle contraction; muscular asymmetry; plantar flexion

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If posttraumatic reduction of strength is to be assessed, the degree of difference in strength between symmetrical muscle groups must be known (Heebøll-Nielsen 1964), and it must be known also whether dominant and non-dominant muscle groups differ in strength (Gillies & Chalmers 1970). Ergometric studies on normal limbs have demonstrated a relationship between maximum power and volume of effective muscle tissue (Davies & Sargeant 1975). On clinical examination and in follow-up studies, muscle strength has often been assessed by measuring circumference. According to theoretical considerations, however, there may be qualitative differences between normal muscles (Asmussen & Christensen 1975), and little correlation has been demonstrated between circumference and isometric strength and dynamic endurance in previously injured limbs (Damholt & Zdravkovic 1972).

MATERIAL

To elucidate these aspects we studied the strength of plantar flexion in 30 new conscripts without previous injuries to the lower limbs and with a fairly equal distribution of side dominance. The dominant leg is taken to mean the leg which the person prefers for jumping and/or for a forceful, accurate kick at a ball.

Table 1 presents age, height, and weight.

Table 1. Age, height, and weight distribution of 30 conscripts

	Max	Min	Mean
Age (years)	26	19	21.1
Height (cm)	193.5	166.0	179.3
Weight (kg)	94.2	60.1	72.7

As the dominant leg 20 stated the right and 10 the left leg.

METHOD

For measuring the plantar flexion strength of the foot we used an electronic strain-gauge dynamometer designed by Darcus (1953). The device for fastening the leg to it was designed by the present authors (Figure 1). When the leg is fastened in the unyielding apparatus, contraction of the calf muscles must be considered isometric. In the measurements the set-up was as reported by Asmussen & Heebøll-Nielsen (1961). The scale is

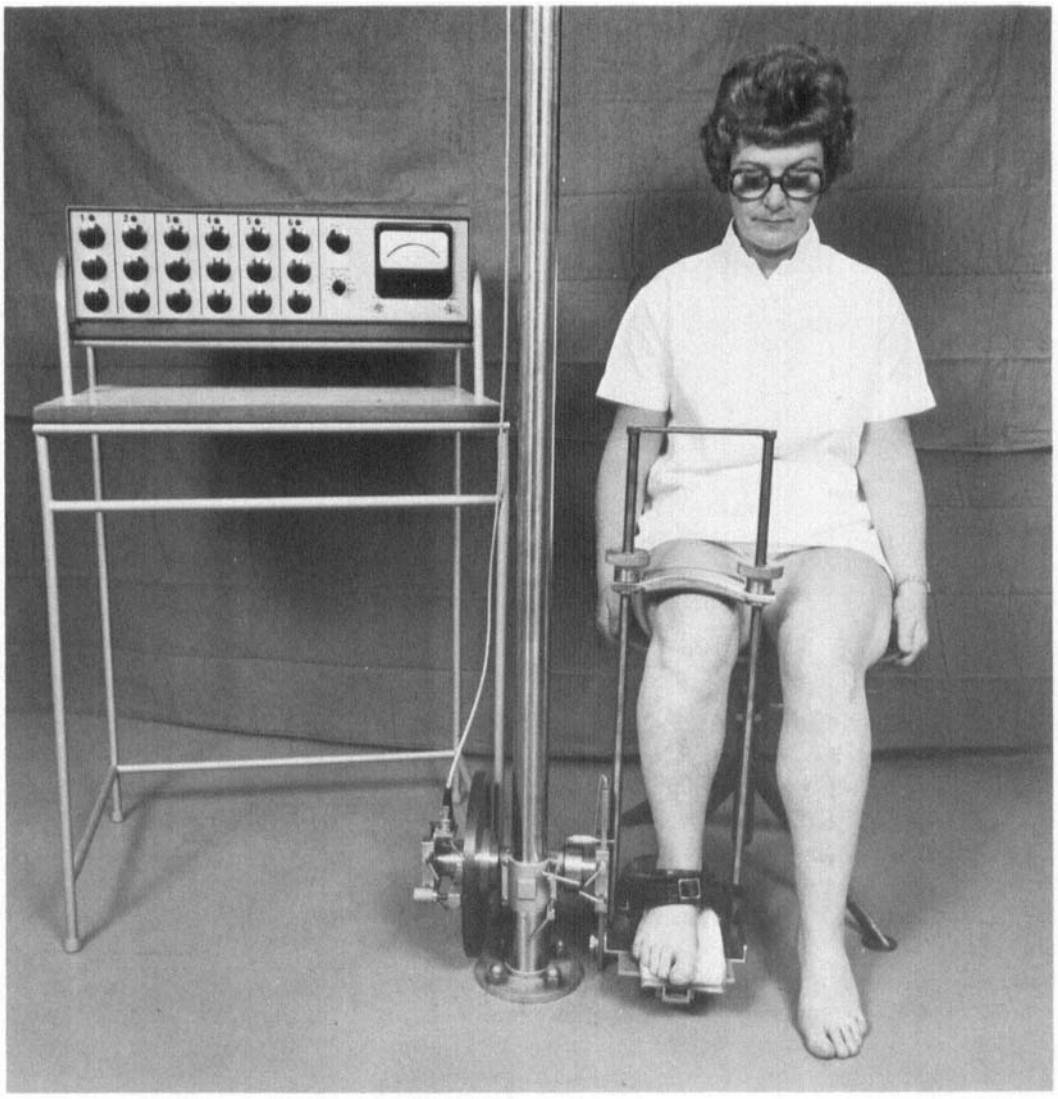

Figure 1. Darcus' strain-gauge dynamometer combined with the present authors' device for fastening the limb.

calibrated so that the strength can be read directly in kp × cm.

The plantar flexion strength recorded was the maximum excursion on the scale that the subject could achieve at repeated measurements. The recorded circumference refers to greatest calf circumference.

RESULTS

The ratio between strength in the right and left legs is apparent from Table 2. In 22 out of 30 persons (73.3 per cent), the right leg was stronger than the left. The mean strength in the right leg was 1728 kp × cm and in the left leg 1630, i.e. a difference of 5.7 per cent. This difference is significant ($0.005 < P < 0.01$).

Figure 2 gives the correlation between the plantar flexion strength in the right and left leg. The correlation coefficient is 0.68 and the correlation is significant ($P < 0.001$).

Similarly, Table 3 and Figure 3 present the

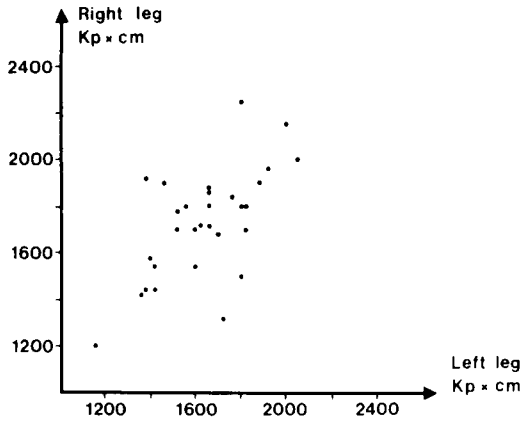

Figure 2. Correlation between plantar flexion strength in the right and left leg in 30 conscripts (r = 0.68).

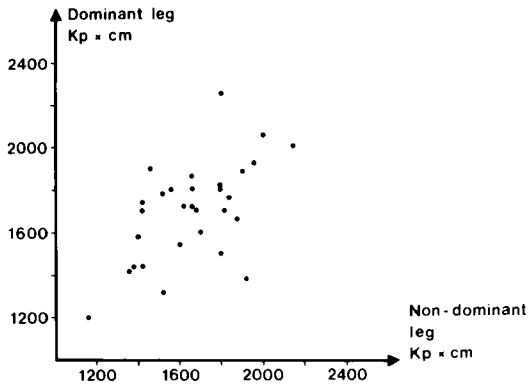

Figure 3. Correlation between plantar flexion strength of the dominant and non-dominant leg in 30 conscripts (r = 0.60).

ratio between the dominant and non-dominant leg. The dominant leg had a mean strength of 1693 kp × cm as compared with 1666 kp × cm in the non-dominant leg, a difference of 1.6 per cent which is not significant ($0.4 < P < 0.5$). The correlation between the strength in the dominant and non-dominant leg is significant ($r = 0.60$, $P < 0.001$).

The correlation between strength in the stronger and weaker leg is illustrated in Figure 4. The correlation is significant ($P < 0.001$) and the correlation coefficient 0.80. The mean difference in strength between the weaker and stronger leg was 149 kp × cm or 8 per cent. The 95 per cent confidence limits were 97–201 kp × cm (or 6–11 per cent).

Figure 5 shows the relationship between

Table 2. Plantar flexion strength in the right and left leg of 30 conscripts

	Mean strength kp × cm	S.D.	Range	Per cent of persons in whom the right leg was stronger	R–L in per cent of R
Right leg	1728	235	1200–2250	73.3 (22/30)	5.7
Left leg	1630	210	1160–2050		

Paired t test: $t = 2.989$, degrees of freedom 29, $0.005 < P < 0.01$.

Table 3. Plantar flexion strength in the dominant leg (D) and non-dominant leg (d) in 30 conscripts

	Mean strength kp × cm	S.D.	Range	Per cent persons stronger in D	D–d in per cent of D
Dominant leg	1693	231	1200–2250	60.0 (18/30)	1.6
Non-dominant leg	1666	225	1160–2150		

Paired t test: $t = 0.7291$, degrees of freedom 29, $0.4 < P < 0.5$.

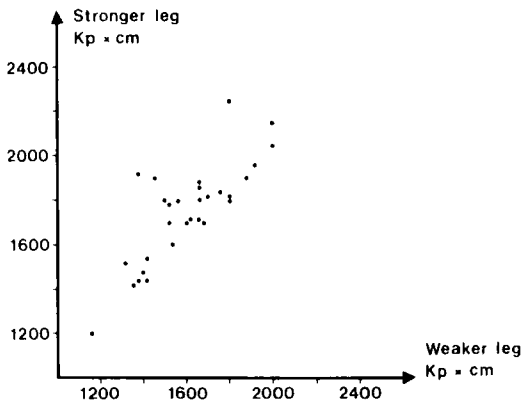

Figure 4. Correlation between plantar flexion strength in the stronger and weaker leg of 30 conscripts (r = 0.80).

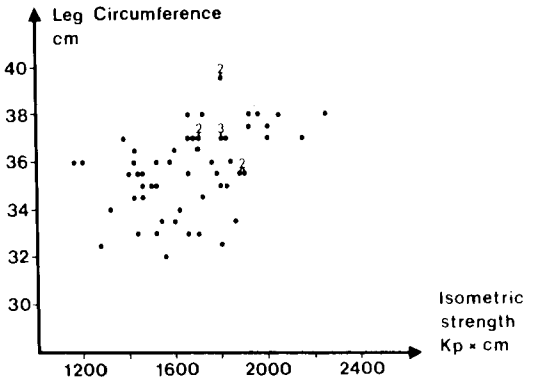

Figure 5. Correlation between calf circumference and plantar flexion strength in 30 conscripts (r = 0.41).

strength and circumference. There is a wide dispersion of the values, indicating little relationship between the two parameters. The correlation coefficient, r = 0.41, is correspondingly low, but the correlation is significant ($0.001 < P < 0.01$).

DISCUSSION

In a study of 96 conscripts Heebøll-Nielsen (1964) found that a difference in strength between symmetrical muscle groups of 10 per cent was not significant, but a difference of 20 per cent was. The present results of this investigation of plantar flexion strength in the feet of 30 conscripts confirm this finding, as there was a mean difference in strength between the weaker and stronger leg of 149 kp × cm or 8 per cent. The 95 per cent confidence limits were 97–201 kp × cm (or 6–11 per cent). Therefore, in dealing with sequelae to traumas affecting the lower limbs it is reasonable to interpret a difference in strength in calf muscles exceeding 15 per cent as pathological.

Gillies & Chalmers (1970), studying plantar flexion strength in eight normal persons, found that the dominant leg was an average of 15.8 per cent stronger than the non-dominant leg. With this background they introduced a corresponding correction of strength measurement in the follow-up of patients treated for rupture of the Achilles tendon. In our study the dominant leg was stronger in 60 per cent of the subjects, it is true, but the difference in strength was slight, averaging 27 kp × cm or 1.6 per cent. This difference is not significant ($0.4 < P < 0.5$).

On the other hand, the right leg was, on average, 5.7 per cent stronger than the left leg. This difference is significant. Even in the group in which the left leg was dominant, the right leg was, on average, 5.6 per cent stronger than the left. In a follow-up study using measurements of strength following trauma to the limbs, in series with a marked difference in the number of right-sided and left-sided injuries, the difference in strength between the right and left leg demonstrated in the present investigation might afford a basis for correcting the results of measurements.

In two series of patients with a history of femoral fractures Damholt & Zdravkovic (1972, 1974) found low correlation values (r = 0.23 and 0.27) for the relationship between circumference of the thigh and isometric quadriceps strength.

In the present study of normal persons there was a somewhat higher correlation coefficient (r = 0.41) for the relationship

between calf circumference and isometric plantar flexion strength in the foot. Nevertheless, the circumference is a poor expression of muscle strength, as the coefficient of determination r^2 is only 0.17, meaning that a variation in one parameter explains only 17 per cent of the variation in the other parameter around the mean value.

Conclusion

A study of calf circumference and plantar flexion strength in a series of normal persons showed:

(1) A variation of 6–11 per cent between the strength of symmetrical muscle groups (95 per cent confidence limits).
(2) No statistically significant difference in strength between the dominant and non-dominant leg.
(3) A significantly greater strength of the right than the left leg.
(4) Little correlation between circumference and strength.

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