LENGTH AND TORSION OF THE LOWER LIMB

W. STRECKER, P. KEPPLER, F. GEBHARD, L. KINZL

From the University of Ulm, Germany

Corrective osteotomies are often planned and performed on the basis of normal anatomical proportions. We have evaluated the length and torsion of the segments of the lower limb in normal individuals, to analyse the differences between left and right sides, and to provide tolerance figures for both length and torsion.

We used CT on 355 adult patients and measured length and torsion by the Ulm method. We excluded all patients with evidence of trauma, infection, tumour or any congenital disorder.

The mean length of 511 femora was 46.3 ± 6.4 cm (±2SD) and of 513 tibiae 36.9 ± 5.6 cm; the mean total length of 378 lower limbs was 83.2 ± 11.4 cm with a tibiofemoral ratio of 1 to 1.26 ± 0.1. The 99th percentile level for length difference in 178 paired femora was 1.2 cm, in 171 paired tibiae 1.0 cm and in 60 paired lower limbs 1.4 cm.

In 505 femora the mean internal torsion was 24.1 ± 17.4°, and in 504 tibiae the mean external torsion was 34.9 ± 15.9°. For 352 lower limbs the mean external torsion was 9.8 ± 11.4°. The mean torsion angle of right and left femora in individuals did not differ significantly, but mean tibial torsion showed a significant difference between right (36.46° of external torsion) and left sides (33.07° of external torsion). For the whole legs torsion on the left was 7.5 ± 18.2° and 11.8 ± 18.8°, respectively ($p < 0.001$). There was a trend to greater internal torsion in femora in association with an increased external torsion in tibiae, but we found no correlation. The 99th percentile value for the difference in 172 paired femora was 13°; in 176 pairs of tibiae it was 14.3° and for 60 paired lower limbs 15.6°.

These results will help to plan corrective osteotomies in the lower limbs, and we have re-evaluated the mathematical limits of differences in length and torsion.

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W. Strecker, MD
P. Keppler, MD
F. Gebhard, MD
L. Kinzl, MD, Professor
Department of Traumatology Hand and Reconstructive Surgery, University of Ulm, Steinhovelstrasse 9, D-89070 Ulm, Germany.

Correspondence should be sent to Dr W. Strecker.

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Anatomical studies[1] of the lower limb have established the regularity of the mechanical axis as proved by clinical and radiological studies.[2] The ideal mechanical axis is defined by a line between the centre of the femoral head, the knee and the centre of the ankle. Any deviation from this optimal axis is considered to be pathological.[3]

The geometry of the leg is difficult to define, partly because of the variable terms used to describe rotation. Torsion is the rotation within a bone segment, and varies according to the method of measurement. Rotation is used to describe the range of movement of joints between the segments.

We could find no clear evaluation or definition of the normal values for length and torsion in adults, and therefore aimed to measure and define them.

MATERIALS AND METHODS

From 1991 to 1995 we used CT on 355 patients to determine the length and torsion of the femur and tibia in healthy volunteers and the normal limbs of patients with unilateral fractures of the femur or tibia. All the limbs were asymptomatic in subjects with no history of trauma, tumour or any congenital disorder. There were 231 men and 124 women. All the women were over 16 years of age (mean 35.8; range 16 to 73) and the men were over 18 years of age (mean 32.3 years; range 18 to 78). We have used CT measurement of length and torsion since 1989. Since the radiation exposure by the Ulm method is less than that for corresponding radiological techniques no ethical approval was necessary.

Informed consent of all patients was obtained as for standard radiographic examinations.

We used a GE 9800 Quick CT (General Electric, Milwaukee, Oregon) with highlight detector. The limbs were fixed by a foot-rest mounted on the table, to provide a reproducible position. A scout view allowed the use of standard planes; angles were measured by a standard software program. The technical details and the radiation doses have been reported by Waidelich, Strecker and Schneider.[4] We use standard CT to show the centre of femoral head, the centre of the greater trochanter, the dorsal tangent of the femoral condyles and the tibial head and a line across the ankle. Pfeifer et al[5] have reported the reproducibility of the method. Internal torsion is shown by a minus sign (-) and external torsion by a plus sign (+).

Statistical analysis. We used the Winstat V 3.1 program