The effect of a "bent-knee" gait on trabecular orientation: an experiment test of Wolff's Law

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Abstract:
While recent attempts have been made to link trabecular orientation to gait and posture in extinct hominids, there have been few controlled experiments to test the hypothesis that there is a predictable functional relationship between the orientation of trabecular struts within a point and the orientation of loads applied to the joint. We tested the hypothesis (often termed Wolff's Law) by comparing the strut orientation in the spongiosa of the distal femur in two groups of immature guinea fowl that were exercised on treadmills (10 min/day, for 60 days) at 0º versus 20º inclines. Kinematic and force plate analysis found that, a peak ground reaction force, the posture of the knee in the parasagittal plane was approximately 16º more flexed in the 20º incline group. Strut orientation was analyzed from micro-CT scans of the joints using a radon transform analysis that quantifies the orientation of peak trabecular density (OPTD). As predicted by Wolff's Law, the OPTD was approximately 18º more flexed relative to the long axis of the femur in the incline versus horizontal birds ($p<0.05$). These results demonstrate a predictable relationship between the orientations of trabecular struts and compressive loads applied to a joint during growth, supporting Wolff's Law. This technique may be useful for determining gait and posture in fossil species such as Australopithecus afarensis.