

# TRABECULAR BONE MASS EVALUATION AS RELATED TO CORTICAL MASS IN THE HUMAN LEG. A PQCT STUDY.

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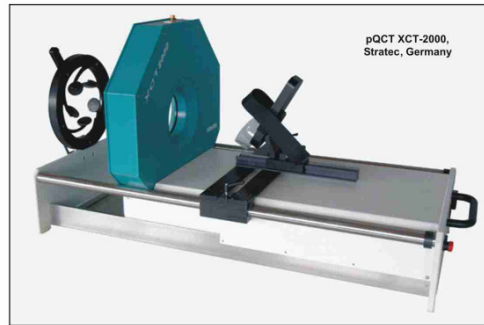


Figure 2

## BIOMECHANICAL BACKGROUND AND AIM OF THE STUDY

In uniaxial compression, the relevant factors to bone strength are the amount and material properties rather than the distribution of bone tissue, and the nature of bone structure.

The distal third of the tibial length undergoes chiefly uniaxial compression, transmitted from the single articular surface of the heel. Toward the mid-diaphysis, an increasing proportion of bending and torsion stress is combined. It can be proposed that the diaphyseal design becomes progressively adapted to support the combined stress coming from the double articular surface of the knee (Fig 1).

pQCT can provide standard scans of sites at 4%, 14%, and 38% of the tibial length taken distally from the heel articular line (Fig 2).

In agreement with the abovementioned description, standard pQCT scans (Fig 1) usually show that

- at the 4% site tibial structure is mostly trabecular;
- at the 14% site it is almost exclusively cortical, the diameter is minimal, and the section is closely rounded, with a relatively thin, fairly homogeneous cortical thickness (i.e. with minimal values of cross-sectional moments of inertia -CSMI's-), and
- From the 38% toward the knee, the sectional shape departs progressively from circularity to a triangular shape until the joint zone, thus increasing dramatically the CSMI.

The working hypothesis of this investigation proposes that the distribution of the mineralized bone mass in cross-sections of the distal tibia at different heights should reflect the above biomechanical considerations, regardless of the gender of the individuals.

If so, then the analysis and Z-scored graphs of the relationships between the total cross-sectional bone mass measured at different tibial levels may provide some original references for comparative diagnosis of bone weakening diseases following biomechanical criteria, based on data taken from the same individuals.

## METHODS

In order to test those proposals, we have determined the total BMC (TC) by pQCT at the 4%, 14% and 38% sites in the leg in voluntary, healthy men and pre- and post-MP women (n = 60,80,120) aged 28-80 yr, in order to determine

1. the proportion between total bone mass (TC) at the 4%, 14% and 38% sites in the different groups (proposedly constant for any couple of regions for all the individuals studied);
2. the functions describing those relationships (proposedly linear and comprising the origin), and
3. whether gender and pre- or post-menopausal status have any impact on these associations (proposedly none).

## RESULTS

The TC at the 4% site (y) correlated linearly and very closely with that at the 14% site (whole group,  $y = -0.45 + 1.54x$ ;  $r = 0.938$ ,  $R^2 = 0.881$ ,  $p < 0.001$ ,  $SEE = 0.25$ ; Fig 3) and at the 38% site (whole group,  $y = -0.31 + 1.08x$ ,  $r = 0.903$ ,  $R^2 = 0.815$ ,  $p < 0.001$ ,  $SEE = 0.33$ ; Fig 5) in all men and pre-MP women, either separately or taken together, with similar intercepts for every group.

The adjusting curves for the whole set of individuals comprised statistically the origin of both graphs.

Data from post-MP women plotted within the normal range of the men and pre-MP women data (Figs 4 & 6).

## INTERPRETATION

Results confirmed the above biomechanical approach. In addition, they indicated that

1. the mechanical efficiency of the combined bone structure at the 4% site in compression would approximate 66% of that of the cortical structure at the 14% site in any individual (b value of the corresponding correlation close to 1.5);
2. the mechanical solicitations of cortical structure at the 38% site (trend to increase the CSMI's) would require to enhance the periosteal diameter and increase cortical mass up to the same amount than that of the combined structure at the 4% site in any individual (b value of the corresponding correlation close to unity), and
3. these relationships were unrelated to the gender and reproductive status of the individuals.

## DIAGNOSTIC APPLICATIONS

Z-scored graphs of both relationships studied (Figs 3-6) provide original references of the biomechanical proportionality between trabecular and cortical masses in normal men, pre-MP women, and post-MP women (single curves for all the three groups in each instance).

As far as trabecular bone mass is usually more sensitive than cortical mass to changes in bone turnover, these graphs may provide an original description of the skeletal impact of high-turnover bone diseases following biomechanical criteria.

Based on the presented evidence, it can be proposed that an enhanced bone turnover would lower the Z-score of the relationship between BMC at 4% vs 14% or at 4% vs 38% sites. As long as these relationships are calculated from data obtained from the same individuals, this diagnostic procedure would obviate any comparison with references taken from different populations (as usually made with the T-scores of DXA BMD data).

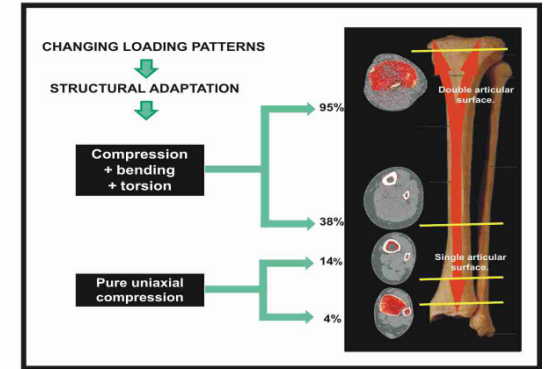


Figure 1

## ADAPTIVE DISTRIBUTION OF BONE MASS Tibial total BMC at 4% vs 14% sites

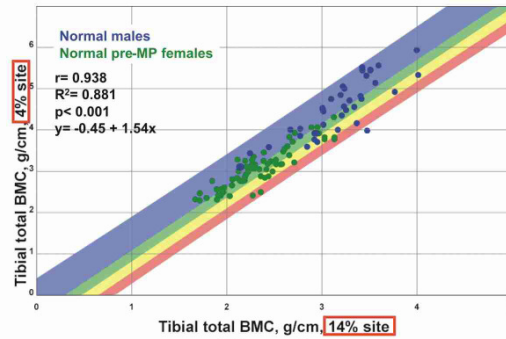


Figure 3

## ADAPTIVE DISTRIBUTION OF BONE MASS Tibial total BMC at 4% vs 38% sites

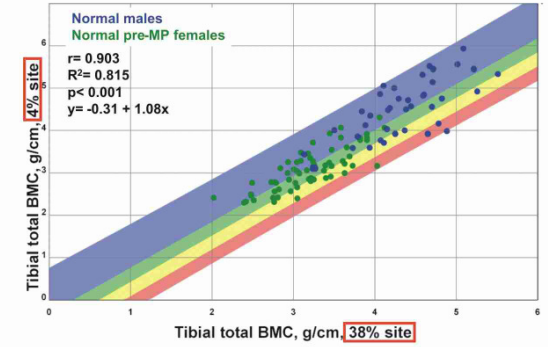


Figure 5

## ADAPTIVE DISTRIBUTION OF BONE MASS Tibial total BMC at 4% vs 14% sites

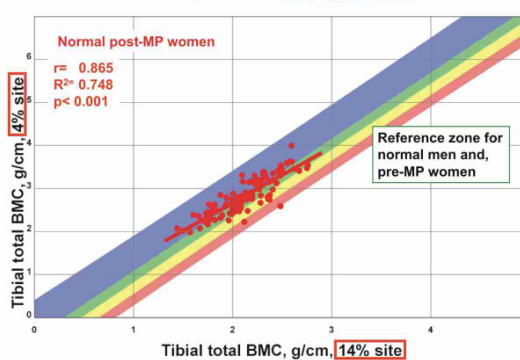


Figure 4

## ADAPTIVE DISTRIBUTION OF BONE MASS Tibial total BMC at 4% vs 38% sites

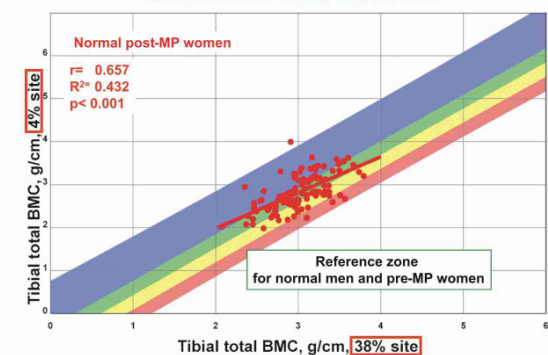


Figure 6