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# BONE STRUCTURE AND FRAGILITY FRACTURE RISK FACTORS: A POPULATION ANALYSIS

F. Cosmi[1,2], A. Nicolosi[2], and G. Zatta[3]

[1] *Department of Engineering and Architecture, University of Trieste, Italy; email: cosmi@units.it*

[2] *M2TEST srl,Area Science Park, Trieste, Italy ; email: alessandra@bestest.it*

[3]*Centro Radiologico Giuliano, Trieste, Italy*

## 1. Introduction

Osteoporosis (OP) is a silent disease, characterized by a decreasing bone strength, which leads to a progressive increase in fracture risk. As mean average human lifespan is growing, a parallel rise in the rate of osteoporosis is observed.

Mechanical properties of bone depend on both its composition and its trabecular component micro-architectural arrangement [1]. OP diagnosis is made on the basis of bone mineral density (BMD), possibly combined with algorithms based on the clinical risk factors, e.g. FRAX®, but about half of those at risk of OP still go undetected, since their OP risk is linked to alterations of the trabecular architecture [2].

The mechanical response of bone structure to the applied loads can be evaluated from 3D reconstructions of the examined tissue, e.g. obtained by micro-CT scans. However, these costly techniques are usually limited to research applications, for example to evaluate the effects on bone structure under microgravity conditions [3] - [5]. The BESTEST® is a test based on the simulated application of loads on a virtual biopsy of the patient. Briefly, the test uses planar X-rays projections to assess the mechanical properties of the patient's trabecular bone tissue, Fig.1. A specific hand-held radiological device acquires the radiographic image (AP projection) of the proximal epiphysis in the finger of the non-dominant hand with a specific protocol [6], [7].

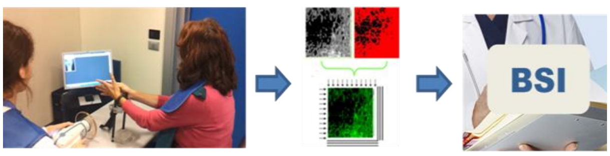


**Fig. 1.** Clinical application: scheme of BSI bone quality analysis

The images are then converted into a Cell Method numerical model [8] and application of compressive loads is simulated [9] - [10]. The results are combined in the Bone Structure Index (BSI) that quantifies the pathological alterations of bone micro-architecture [11] –[12].

## 2. Methods

### *2.1 Experimental design*

The study was structured in 3 phases.

1. During the Trieste NEXT2015 event, contact details of over 400 caucasian female volunteers ≥20 yrs were collected.

2. Volunteers compiled an anonimous anamnestic questionnaire and X-rays for BSI evaluation were acquired. Age, weight, height and, when available, DXA T-score at the femoral neck (BMD_T-score) are considered.

3. The BSI of each volunteer was calculated.

4. Radiographs with insufficiently included trabecular bone, fractures in measurement regions, foreign material or unacceptable positioning were manually excluded.

The reports were delivered anonymously and free of charge to the volonteers. The Ethics Committee of the University of Trieste gave a favorable opinion (No 66 of 11.11.2015).

## 3. Results

Population eligible for the study resulted in Np=336 females, age 20 – 95 yrs. BMD T-score was available for a population subgorup of Ns=65, age 40-85yrs. The age breakdown for population and subgroup is given in Fig.2. The age (mean ± st. dev.) of the subjects is 61±12 yrs in the population and 65±10 yrs in the subgroup.

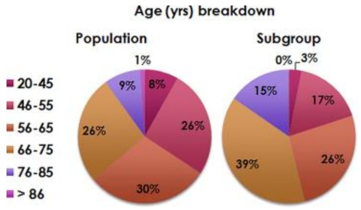


**Fig. 2.** Age in population (left) and subgroup (right).

An hypocaloric diet therapy, while improving cardiovascular risk indexes, decreases total BMD in the arms and legs, both in pre- and post-menopausal women [13], [14]. The majority of our subjects is reports a Body Mass Index (BMI) associated to a moderate risk of fractures and less than 30% falls into the low risk category, Fig.3.

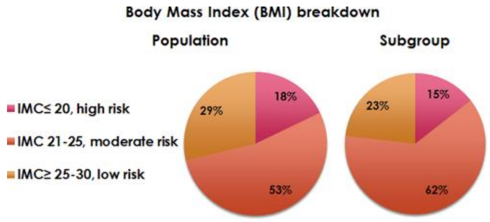


**Fig. 3.** BMI in population (left) and subgroup (right).

The distribution of femoral neck DXA diagnostic categories in the subgroup is shown in Fig.4.

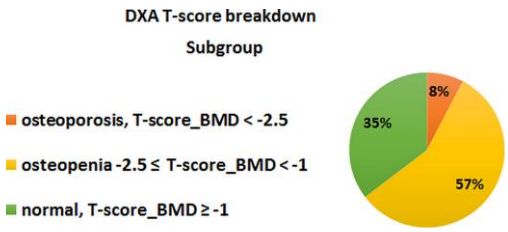


**Fig. 4.** Distribution of femoral neck DXA T-score.

The bone structure quality as measured by the BESTEST® can be again interpreted by T-score concept, Fig.5.

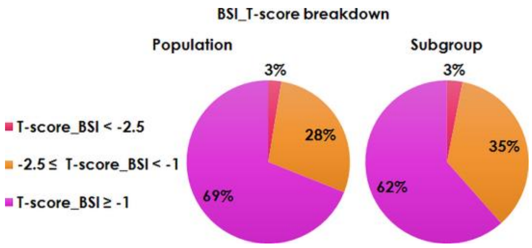


**Fig. 5.** Distribution of BSI T-score.

## 4. Brief discussion

The usefulness of BSI as an add-on to BMD assessment is clearly shown in Fig.6. The BSI and DXA values are independent ($R^2$ = 0.0631). This type of diagram can be very useful in clinical practice since it can drive both the prognosis and the choice of the appropriate treatment, improving diagnostic accuracy. The very low X-ray doses used for BSI assessment imply that the treating physician can monitor the bone changes in response to any therapeutic strategy and quickly introduce any adjustment (treatment tailoring) every few months if necessary, providing patients with a strong motivation to strictly adhere to their therapy and avoid discontinuation. The rapidity and convenience of the test are highly appreciated by both patients and physicians.

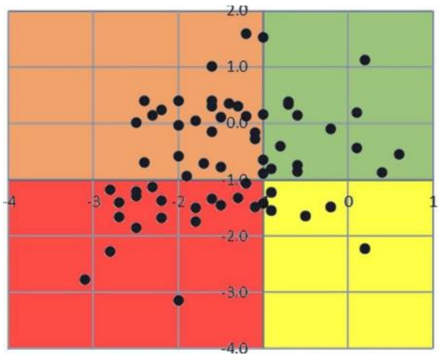


**Fig. 6.** BSI_T-score vs. femoral neck DXA T-score (subgroup).

## 5. References

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