# THE RELATION OF FUNCTIONAL INDEPENDENT MEASUREMENT AND AMBULATION WITH BONE MINERAL DENSITY IN PATIENTS WITH STROKE

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### ABSTRACT

**Objective:** *The aim of this study was to investigate the relationship between loss of functions and bone mineral density (BMD) in hemiplegic patients after stroke.*

**Material and Method:** *41 patients were evaluated. The Brunnstrom values, the Functional Independent Measurement (FIM) and the Functional Ambulation Categories (FAC) values were recorded. BMD measurements were evaluated with dual-energy X-ray absorbtiometry (DXA).*

**Results:** *BMD decrease was significantly greater on the*

*paretic side compared with the nonparetic side. Patients who had not ambulated lost of their BMD in the paretic side and the loss was significantly higher than those who had ambulated. There was a positive correlation between FIM score and BMD values in the affected side.*

**Conclusion:** *Our results suggest that the rapidity of the BMD loss is correlated to the functional independent and ambulation categories in poststroke hemiplegic patients.*

**Key Words:** *Stroke, bone mineral density, functional independent measurement, functional ambulation categories.* **Nobel Med 2011; 7(2): 75-80**

## İNMELİ HASTALARDA FONKSİYONEL BAĞIMSIZLIK ÖLÇÜMÜ VE AMBULASYONUN KEMİK MİNERAL YOĞUNLUĞU İLE İLİŞKİSİ

### ÖZET

**Amaç:** Bu çalışmanın amacı, inmeye bağlı hemiplejisi olan hastalarda kemik mineral yoğunluğu (KMY) ile fonksiyon kayıplarının ilişkisini araştırmaktır.

**Materyal ve Metod:** Kırkbir hasta değerlendirildi. Brunnstrom değerleri, Fonksiyonel Bağımsızlık Ölçümü (FBÖ) ve Fonksiyonel Ambulasyon Kategorileri kaydedildi. KMY ölçümleri DXA ile yapıldı.

**Bulgular:** Paretik tarafta KMY değerleri paretik olmayan taraftan önemli ölçüde daha azalmıştı. Ambule olamayan hastaların paretik taraflarındaki KMY kaybı, ambule olanlardan daha fazla düzeyde idi. Etkilenen tarafın KMY değerleri ile FBÖ skorları arasında pozitif korelasyon vardı.

**Sonuç:** Sonuçlarımıza göre; inme sonrası hemiplejik hastalarda kemik kaybının şiddetinin, fonksiyonel bağımsızlık ve ambulasyon düzeyi ile ilişkili olduğunu düşünmekteyiz.

**Anahtar Kelimeler:** İnme, kemik mineral yoğunluğu, fonksiyonel bağımsızlık ölçümü, fonksiyonel ambulasyon kategorisi. **Nobel Med 2011; 7(2): 75-80**

### INTRODUCTION

Disuse osteoporosis is defined as localized or generalized bone loss resulting from reduction of mechanical stress on bones. Low or loss of mechanical stress on bones induces acceleration of osteoclast-mediated bone resorption and inhibition of osteoblast-mediated bone formation leading to bone loss. Therapeutic bed rest, prolonged voluntary bed rest, localized immobilization due to paraplegia or paraparesis due to spinal cord injury, hemiplegia or hemiparesis due to stroke or application of a cast to treat fractures contribute to disuse osteoporosis.[1-6]

Stroke is an important cause of death and morbidity. Many patients will incur significant sensorimotor impairments and disabilities, which will have a significant impact on their level of functional independence.[7,8] The goal of rehabilitation is to enable an individual who has experienced a stroke to reach the highest possible level of independence and be as productive as possible. Hemiplegia is associated with excessive bone loss in the paralyzed side. The pathogenesis of hemiplegic osteoporosis is not well understood but is considered to be related to older age, generalized and local immobilization, circulatory disturbances, and lack of weight-bearing and muscle pull on the affected side. Hemiplegic osteoporosis is thought to be related to an imbalance between bone synthesis and degradation.[9,10]

It has been well documented that immobility leads to a reduction of bone mineral density (BMD) in the lower extremities, and in an earlier longitudinal study of stroke patients it was demonstrated that the loss of bone mineral in the femoral neck was significantly higher on the paretic side as compared with the nonparetic side.[11,12] The bone loss was dependent on the patient's ambulatory level and functional condition at baseline. The BMD increase was dependant on the patients relearning to walk, increases in mobilitiy and improvement of their ambulatory level in the post stroke recovery period.[13]

For BMD measurement, DXA is now regarded as the standard because of its reliability and the feasibility of multiple site measurements in hemiplegic patients.[9,14]

Thus, we aimed to relate BMD values to the patient's ambulatory level and functional impairment after stroke and to compare BMD of the paretic and nonparetic limbs at multiple sites in stroke patients.

### MATERIAL and METHOD

Patients with left hemiplegia of 3-months and more than 3-months in duration due to a stroke admitted to the University Hospital were considered for this study. All eligible patients (n = 41) (28 men and 13 women) who agreed to participate to our study were hospitalised for rehabilitation for the first time. Exclusion criteria were: right and bilateral hemiplegia, ataxia, dominant left hand using, previous strokes affecting the sensorimotor system, unconsciousness or terminal illness, chronic renal failure, significant liver dysfunction, early oophorectomy, those who had mental, cognitive and speech problems, presence of osteosynthetic material in the femoral neck, a history of hip fracture, unilateral bone diseases such as osteosarcomas and osteomyelitis or systemic bone diseases and medical treatment affecting bone mineral density. The following demographic and stroke-related variables were recorded: age, gender, time post-stroke and previous history of stroke or transient ischemic attack. The diagnosis of stroke was based upon the clinical and neurologic evaluation. →

Motor recovery status in the upper, lower extremities and hands were categorised according to Brunnstrom motor evaluation scale as identified by 7 stages following physical examination.[15]

Ambulatory level and motor function of the lower limbs were assessed immediately before the BMD measurements. Ambulatory level was classified using the scale "Functional Ambulation Category" (FAC),[16] which has been proven to be useful in stroke rehabilitation.[17] The FAC assesses the amount of human assistance rather than devices needed for ambulation, and scores from 1 (chair-bound) to 6 (independent on both level and non-level surfaces). Nonambulatory patients are either wheelchair-bound (FAC 1) or unable to walk unless supported by another person (FAC 2–3), whereas patients categorized as FAC 4–6 are able to walk at least 6 meters on their own.

As measures of impairment and disability, we used and the Functional Independent Measurement (FIM), because their scale qualities have already been well described. The FIM was developed by a joint task force of the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation.[18,19] The FIM is composed of 18 items related to self-care (6 items), sphincter control (2 items), mobility (3 items), locomotion (2 items), communication (2 items) and social cognition (3 items). Each item is scored on a 7-level scale from 1 (total dependence) to 7 (total independence). Even though controversial, scores assigned to each item are added in order to constitute a single overall continuous score varying from 18 to 126 where a high score indicates a higher independence level.[20]

All tests were performed by the same investigator. Bone mineral density (BMD grams) was measured using dual-energy X-ray absorbtiometry (DXA; Norland XR 36, Norland Medical Systems Inc., Fort Atkinson, USA). Total BMD of the lumbar 2nd, 3rd and 4th vertebra, femoral neck, trochanter and each forearm were derived directly from the total body scan using Norland. All measurements were performed in a supine position to enable relaxed and stable positioning of the patients.

To minimize interobserver variation, all scans were done by the same investigator and all were analyzed by the same technician, who, at the time of the analysis, was not aware of the patient's paralyzed side and disability.

**Statistical analysis**

Data were analyzed using the Windows 11.0 version of the Statistical Package for the Social Sciences (SPSS).

**Table 1:** Mean bone mineral density of all the region (n=41)

| BMD (gr/cm²) | Min | Max | Mean ± SD |
|---|---|---|---|
| L2 | 0.323 | 1.648 | 0.884 ± 0.276 |
| L3 | 0.323 | 1.558 | 0.890 ± 0.265 |
| L4 | 0.274 | 1.472 | 0.885 ± 0.270 |
| Femoral neck (paretic) | 0.344 | 1.215 | 0.668 ± 0.179 |
| Femoral neck | 0.451 | 1.319 | 0.786 ± 0.187 |
| Trochanter (paretic) | 0.321 | 1.274 | 0.720 ± 0.230 |
| Trochanter | 0.314 | 1.360 | 0.747 ± 0.233 |
| Distal radius (paretic) | 0.150 | 0.571 | 0.367 ± 0.120 |
| Distal radius | 0.230 | 0.655 | 0.420 ± 0.120 |

**Table 2:** The correlation among the BMD values at all regions, the BR values, FAC and FIM in the paretic side
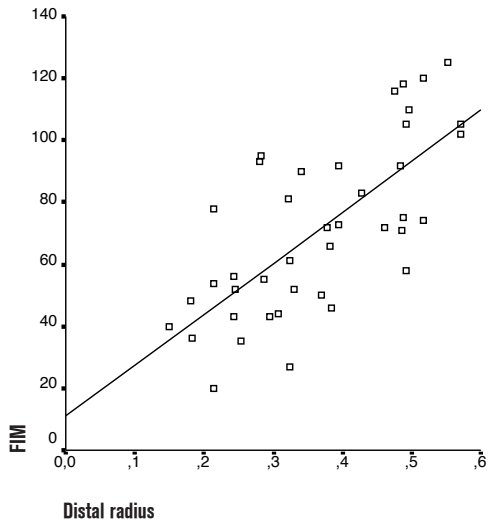
| | FAC | | FIM | |
|---|---|---|---|---|
| | r | p | r | p |
| L2 | -0.071 | 0.659 | -0.121 | 0.451 |
| L3 | -0.069 | 0.670 | -0.142 | 0.376 |
| L4 | -0.067 | 0.676 | -0.164 | 0.306 |
| Femoral neck | 0.482 | 0.001 | 0.355 | 0.023 |
| Trochanter | 0.679 | 0.000 | 0.479 | 0.002 |
| Distal radius | 0.738 | 0.000 | 0.713 | 0.000 |
| Hand BR | 0.751 | 0.000 | 0.718 | 0.000 |
| Upper extremity BR | 0.782 | 0.000 | 0.811 | 0.000 |
| Lower extremity BR | 0.921 | 0.000 | 0.749 | 0.000 |

Descriptive statistics were expressed as mean ± SD. All variables were tested for normal distribution by the Kolmogorov-Smirnov test. All variables were found normally distributed. Student's *t*-test was used for continuous variables. Statistical correlations among BMD and the Brunnstrom values, FAC and FIM were evaluated using Pearson correlation coefficient. P value less than 0.05 was considered statistically significant.
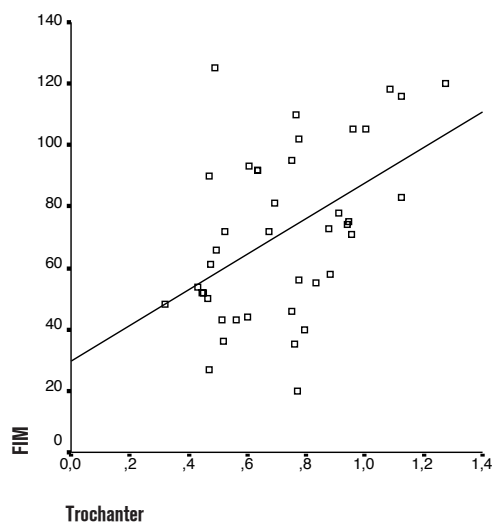
Informed consent was obtained from each participant according to the Second Helsinki Declaration, and the research protocol was approved by the Ethical Committee of the Trakya University Medical Faculty.

**RESULTS**

A total of 41 patients of whom were 28 male (68.3%) and 13 female (31.7%), with an average age of 59.46±14.18 (16-78) were prospectively included in to the study. Mean age is 63.31±7.2 (49-75) for female and 57.68± 16.26 (16-78) for male. BMD values of the spine, legs and forearms in the patients are presented in Table 1. →

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**Figure 1.** The correlation FIM and BMD at the distal radius on the paretic side



**Figure 2.** The correlation FIM and BMD at the trochanter on the paretic side
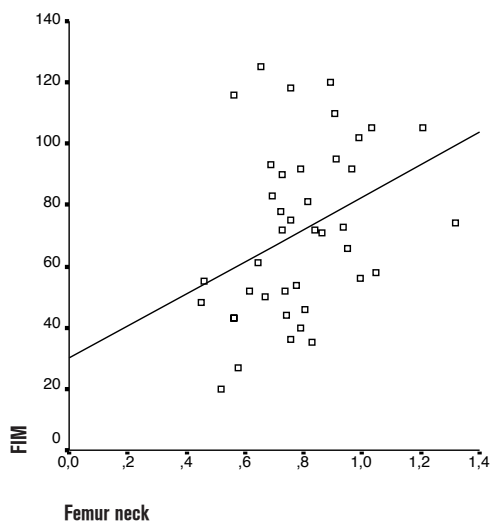


**Figure 3.** The correlation FIM and BMD at the femoral neck on the paretic side

There was only statistically significant negative correlation between the age of the patients and BMD at the nonparetic femoral neck region in stroke patients (r=-0.442, p=0.004). Moreover there was no relationship (p>0.05) between the patients' weight, height and BMI and BMD at the nonparetic regions in stroke patients.

All sites BMD of the paretic compared with the nonparetic differed (femoral neck t=-10.280, p=0.000; trochanter t=-2.048, p=0.047; distal radius t=-8.620, p=0.000). In addition, the BMD loss was significantly greater on the paretic side compared with the nonparetic side.

A statistically significant positive correlation was found between the Brunnstrom values of hand and upper extremity and the BMD at the distal radius (r=0.728, p=0.000; r=0.726, p=0.000 respectively). In addition, significant positive correlations were found between the Brunnstrom values of lower extremity and the BMD at the femoral neck (r=0.483, p=0.001) and trochanter (r=0.738, p=0.000). When the BMD values for spine and the Brunnstrom values were considered, no significant correlation was found (p>0.05).

The mean value of FIM was found to be 71.41 ± 1.69 (min:20, max:119). An average FAC is 2.70 ± 1.69 (min=0, max=5). A significant positive correlation was found between BMD at the paretic femoral neck, trochanter and distal radius and FAC. A significant positive correlation was found between BMD at the paretic trochanter, femoral neck and distal radius and FIM (Figure 1-3). No significant correlation was found among the BMD values for spine and the FAC, FIM (p>0.05). There were statistically significant positive correlation between the BR values and FAC and FIM (Table 2). In addition, we found significant positive correlation between the FAC and FIM (r=0.782, p=0.000).

**DISCUSSION**

This study shows that patients who had functional impairment after a stroke lose bone mass in the paretic side during this period. In contrast, patients who maintained high levels of ambulation and functional level may have lower bone mass loss.

The functional independent level was affected from both muscle activity and cognitive function. To exclude this condition, we noticed that patients who had mental, cognitive function and left hemiparesic were considered for this study. The sufficiency of upper and lower extremity function is important to functional independence. Disability can be a result of functional impairment. After stroke, forces exerted on the weight bearing bones in the legs may be→

altered due to both changes in ambulatory level and changes in motor function of the lower limbs. It would have been of interest to evaluate the separate effects of these variables on the changes in BMD, but as FAC and FIM are closely related this was not possible. Both variables show the effect of stroke on the musculoskeletal system. The local loss of bone mineral in the femoral neck on the paretic side may be a result of both diminished muscle activity and decreased weight bearing.[21] In our study, a significant positive correlation was found between BMD at the paretic femoral neck, trochanter and distal radius and FIM. This correlation of upper extremity was stronger. Therefore, this condition in patients whose hand functions are intact may be related with the improvement of FIM, which means increase of level of independence even if walking function is insufficient. Reaching at sitting position can create enough loading and mechanic stresses on lumbar spine. Thus this condition helps to prevent BMD at the lumbar spine. Therefore, it was not surprising that a correlation with FIM and BMD at the lumbar spine was not found. Bone mass decrease on the hemiplegic limb corresponds to the degree of palsy.[22,23] To evaluate short-term immobilization effects, Sato[24] assessed calcium metabolism and functional level in 89 patients one week after the hemiplegic stroke. They found negatively correlation between patients' serum concentrations of ionized calcium and functional independence rate.

The affected-side BMDs were lower for the upper and lower limbs. The affected/unaffected ratio was the lowest for humeral BMD. This finding is in agreement with Iversen[25] and Hamdy,[26] who noted more pronounced demineralization in the upper limbs as compared with the lower. Hamdy[26] measured BMDs in 30 hemiplegic subjects with dual-photon absorbtiometry and reported that the mean percentage side difference was 7.95% for arms and 3.42% for legs. This finding may be partly explained by the more pronounced weakness in the upper limbs. It could also reflect the mechanical stress on the lower limbs when the patient stands up and attempts to walk, which is well known to promote bone mineralization. In their study Jorgensen[13] showed that the loss of bone mineral in the femoral neck was related to when the stroke patients relearned to walk.

In our study, it was accounted that a statistically significant positive correlation was found between FIM and BR scores because of correlation with FIM and upper/lower extremity activity. Moreover the correlation between BR scores and the degree of bone loss also depended this condition. Prince[9] suggest that a reduction in function is associated with significant
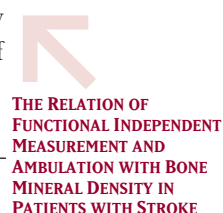
bone loss occurring over prolonged periods that may account, for the significant osteoporosis seen in elderly people and in subjects with conditions resulting in reduced mobility such as arthritis, obstructive airways disease, and neurological disease.

Immobilization is a major cause of osteopenia in post-stroke patients. The severity of osteopenia on the hemiplegic side relative to that of the intact side might have resulted from disuse of the hand. Del Puente[10] studied the determinants of immobilization osteoporosis in hemiplegic subjects, measuring bone mineral density in the paralyzed lower limb as compared with the non-paralyzed one. This study demonstrated degree of bone loss depends significantly and directly on the length of immobilization and functional impairment, irrespective of gender. The present study demonstrated that immobilization in long-standing stroke patients can cause bilateral bone loss as evidenced by the close correlations between the FIM score and the BMD.

Naftchi,[27] 7 in a study of 42 hemiplegic subjects using single-photon absorbtiometry, noted that BMD was 5% to 7% lower on the affected side and the tendency was more marked in females and with longer duration of illness. In addition, they indicate that right-dominant left-paralyzed patients showed a greater loss of bone density than right-dominant right-paralyzed subjects. All patients in this study was right-dominant left-paralyzed for standardization.

In our study, BMD values at the upper extremity were significantly lower than those at the femur on the paretic side. Sato[28] investigated how mineral stores and endocrine factors affect bone mass in poststroke patients immobilized by hemiparesis. In this study, bone loss for the affected side after stroke differed between the upper and lower extremity, and BMD values at the lower extremity were significantly greater than those at the upper extremity on the paretic side. In our study we found, in addition to the degree of immobilization, the correlation among FIM, BR, FAC and the observed changes in bone density in hemiplegic patients. We consider that bone mass may be positive effect by rehabilitation program including increase of muscle strength and improvement in functional independency level, and may prevent secondary complication due to decreased BMD.

In conclusion, hemiplegic patients with a long-standing stroke may develop bone loss, if not treated during the early stage of the stroke. Therefore, it is important to continuously evaluate and treat any bone changes, which occur during the early stages of a hemiplegic stroke.

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