# Handgrip Strength is Related to Bone Mineral Density in Male Athletes

## Erkek Sporcularda El Kavrama Gücü Kemik Mineral Yoğunluğu ile İlişkilidir

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## Summary

**Aim:** The aim of this study was to investigate the relationship between handgrip strength and phalangeal bone mineral density (BMD) and to evaluate the confounding factors in highly trained male athletes.
**Material and Methods:** A total of 57 highly trained athletes; with a mean age of 23.5±4.1 (17-37) years were included in the study. Age, smoking status, alcohol consumption, medications, previous fractures, calcium intake, the duration of sports participation, weekly training time, height and weight of the subjects were recorded. Handgrip strength was measured by a hand-held dynamometer and BMD was measured with radiographic absorbtiometry in both hands.
**Results:** Significant positive correlations were found between BMD and handgrip strength, age, weight and height ($p<0.01$). When stepwise regression analysis was performed, two variables were found to be significantly related to BMD: handgrip strength and weight. R2 value was 0.29 ($F=8.71$, $p=0.001$). To eliminate the effect of body weight on BMD we compared BMD and grip strength in the dominant and non-dominant hands. Bone mineral density, t-scores and the handgrip strength were significantly higher in the dominant hand ($p<0.05$).
**Conclusion:** Handgrip strength is an independent predictor of phalangeal bone mineral density in highly trained male athletes. *(From the World of Osteoporosis 2009;15:66-9)*
***Key words:*** Bone mineral density, muscle strength, handgrip strength, male athletes

## Özet

**Amaç:** Bu çalışmanın amacı erkek sporcularda el kavrama gücü ve falangeal kemik mineral yoğunluğu (KMY) arasındaki ilişkinin ve etki eden faktörlerin araştırılmasıdır.
**Gereç ve Yöntemler:** Çalışmaya yaş ortalaması 23,5±4,1 (17-37) olan toplam 57 erkek sporcu dahil edildi. Yaş, sigara va alkol kullanımı, ilaçlar, kırık öyküleri, kalsiyum alımları, spor yapma süreleri, haftalık antreman süreleri, ağırlık ve boyları kaydedildi. Her iki elden el dinamometresi ile el kavrama gücü ve radyografik absorbsiometre ile KMY ölçümü yapıldı.
**Bulgular:** KMY ile el kavrama gücü, yaş, ağırlık ve boy arasında istatistiksel anlamlı korelasyon bulundu (p<0,01). Regresyon analizi yapıldığında iki değişkenin KMY ile ilişkili olduğu görüldü: El kavrama gücü ve ağırlık. R2 değeri 0,29 (F=8,71, p=0,001) olarak bulundu. Vücut ağırlığının KMY üzerine etkisini dışlamak için KMY ve el kavrama gücü dominant ve nondominant elde karşılaştırıldı. Kemik mineral yoğunluğu, t skorları ve el kavrama gücü dominant elde daha yüksek bulundu (p<0,05).
**Sonuç:** El kavrama gücü erkek sporcularda falangeal kemik mineral yoğunluğunun bağımsız bir belirleyicisidir. *(Osteoporoz Dünyasından 2009;15:66-9)*
***Anahtar kelimeler:*** Kemik mineral yoğunluğu, kas gücü, el kavrama gücü, erkek atletler

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## Introduction

Osteoporosis is characterized by a low bone mineral density (BMD) and altered micro-architecture (1). BMD is determined mainly by genetic factors; however, nutrition, physical activity, mechanical loading, and body composition also contribute to a varying extent throughout life (2). A positive correlation has been reported between muscle strength and local BMD (3-7) in some cross-sectional studies, but such a relationship has not been found by some authors (8-11). Although there are some conflicting results, recently, some studies reported a positive relation between bone density sites and the strength of distant muscles that are not attached to these bones (4,6,9,12-14). And it has been suggested that the effect of muscle strength on bone mass is not only site-specific but more likely it is systemic (15). This relationship between muscle strength and BMD is generally reported among sedentary persons and those with low to moderate levels of physical training; however, little or no relationship is seen between BMD and muscle strength among highly trained persons (16-22). In female athletes participating in sports with intense weight bearing loading such as soccer (19) and volleyball (20), no such relationship has been shown. Petterson et al. also could not find such a relationship in male athletes (23).

Conflicting results about the relationship between muscle strength and BMD may be due to confounding variables such as calcium intake, alcohol consumption, cigarette smoking, physical activity, medication, weight, height, and body mass index. To our knowledge, there is no study investigating other factors that may influence the relationship between strength and BMD among highly trained individuals.

The aim of this study was to investigate the relationship between handgrip strength and phalangeal BMD and to evaluate the confounding factors in highly trained male athletes.

## Material and Methods

Twenty-seven second division male soccer players, 25 first division male basketball players and 12 first division male volleyball players were included in the study. Age, smoking status, alcohol consumption, medications, previous fractures, and calcium intake were questioned according to European Vertebral Osteoporosis Study Group (EVOS) form (24) and the duration of sports participation, weekly training time were also recorded. The exclusion criteria were; systemic diseases, a history of hand injury, fractures, or treatment with drugs known to influence bone mass. The study was conducted in accordance with the principles in the Helsinki Declaration and informed consent was obtained from all subjects.

Height and weight of the subjects were measured and body mass index (BMI) was calculated. Grip strength of both hands was measured by a Jamar hydraulic hand dynamometer (Sammons Preston, Bolingbrook, IL, USA). During testing, the subjects sat with their shoulder adducted, elbow flexed at $90^0$ and their forearm and wrist in neutral position. They were then instructed to grip the dynamometer as hard as possible for 3 seconds without pressing the instrument against the body. Three measurements were recorded and the mean values were calculated.

BMD of both hands was measured with radiographic absorbtiometry (MetriScan, Alara Inc., Fremont, CA, USA), a method that was validated in one of the largest epidemiological studies in the bone density field (25). MetriScan estimates relative phalangeal bone density of the three middle fingers. With radiographic absorbtiometry, a high resolution radiographic image of a subject's phalanges is taken. A computerized analysis is made comparing the intensity of the image wit h a reference wedge embedded under the hand plate.

Data were analyzed using SPSS 11.0. Analyses included standard descriptive statistics, two-tailed paired t-tests, Pearson's correlation test and multiple regression analysis. Significance was accepted for $p<0.05$. Multiple regression was used to determine BMD-related factors.

## Results

Seven of 64 subjects were excluded from the study. Two had history of fractures, BMD measurements could not be performed in two athletes because of hand anthropometric characteristics, and grip strength could not be measured in three athletes.

The characteristics of the subjects are given in Table 1.

None of the subjects had regular alcohol consumption.

When the correlations between age, weight, height, BMI, calcium intake, cigarette smoking, duration of sports par-

**Table 1.** Characteristics of the subjects

| | Range | Mean | SD |
|---|---|---|---|
| Age (years) | 17-37 | 23.5 | 4.1 |
| BMI (kg/m$^2$) | 21.7-31.1 | 24.4 | 1.9 |
| Weight (kg) | 61.6-125.5 | 83.8 | 13.0 |
| Calcium intake (score) | 1-4 | 2.4 | 1.0 |
| Cigarette smoking (number/day) | 0-20 | 1.1 | 3.5 |
| Duration of sports participation (years) | 4-27 | 11.4 | 4.3 |
| Weekly training time (hours/week) | 8-20 | 13.8 | 2.5 |
| BMD (non-dominant) | 52.8-74.9 | 61.8 | 5.1 |
| BMD (dominant) | 49.3-77.9 | 63.5 | 5.6 |
| t-score (non-dominant) | -0.9-4.34 | 1.18 | 1.22 |
| t-score (dominant) | -1.82-5.07 | 1.59 | 1.35 |
| Non-dominant grip strength (kg) | 37.7-74 | 51.9 | 8.9 |
| Dominant grip strength (kg) | 36.6-82.7 | 53.4 | 9.5 |

BMI: Body mass index
BMD: Bone mineral density (MetriScan units)
SD: Standard deviation

ticipation, weekly training time, handgrip strength, and BMD of the non-dominant hand were investigated; significant positive correlations were found between BMD and handgrip strength (r=0.44, p=0.001), age (r=0.41, p=0.002), weight (r=0.48, p=0.001), and height (r=0.41, p=0.002). Correlation between BMD and grip strength of the non-dominant hand is given in Figure 1.

Stepwise regression analysis was performed to determine BMD-related factors. The independent variables in the model were: handgrip strength, age, body weight and height, calcium dietary intake, cigarette smoking, duration of sports participation, weekly training time. Two variables were found to be significantly related to BMD: handgrip strength and weight. R2 value was 0.29 (F=8.71, p=0.001) (Table 2).

All the other studied variables were not significantly related to BMD when the effects of both handgrip strength and weight were considered (Table 3).

To eliminate the effect of body weight on BMD, we compared BMD and grip strength in the dominant and non-dominant hands. BMD, t-scores and hand grip strength were significantly higher in the dominant hand (p<0.05) (Table 4).

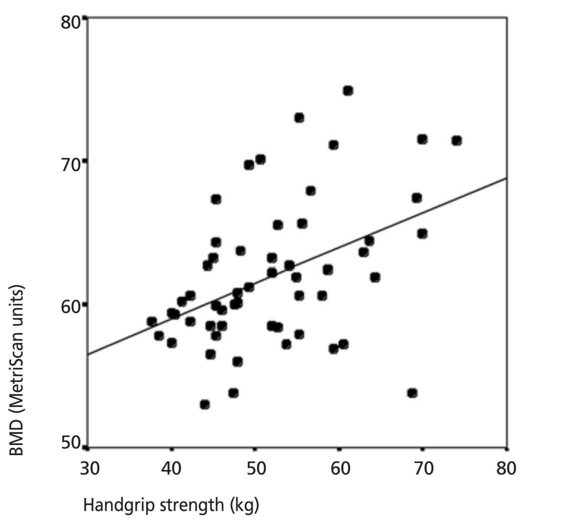


**Figure 1. Correlation between BMD and handgrip strength (r=0.44, p=0.001)**

**Table 2.** Multiple regression analysis results. Only handgrip strength and weight were significantly related to bone mineral density (BMD)

| Selected variables | Dependent variable | R | $R^2$ | F | p |
|---|---|---|---|---|---|
| Handgrip strength weight | BMD | 0.54 | 0.29 | 8.71 | 0.001 |
| | B | Std error | β | t | p |
| (constant) | 42.59 | 4.56 | | 9.34 | 0.000 |
| Handgrip strength | 0.17 | 0.08 | 0.30 | 2.02 | 0.05 |
| Weight | 0.12 | 0.05 | 0.33 | 2.22 | 0.03 |

## Discussion

A positive correlation was shown between phalangeal BMD, handgrip strength and weight in highly trained male athletes in the present study. This significant association between phalangeal BMD and grip strength was consistent with the results of previous studies that showed a significant association between grip strength and forearm BMD or bone mineral content or metacarpal BMD in non-athletes; (3,5,6,26) however, conflicting results were reported in athletes. Muscle strength and BMD values of athletes have been found to be higher than those of non-athletic controls in several studies. The association between muscle strength and BMD; however, seems to be strongest in those with low to moderate levels of physical training (16,18,19,22). But little or no relationship is seen between muscle strength and BMD among highly trained individuals. In female athletes participating in sports with intense weight bearing loading such as soccer (19) and volleyball (20), no such relationship has been shown. Petterson et al also could not find such a relationship in male athletes (ice hockey players) (23). From these studies it is concluded that high physical activity seems to weaken this relationship. In our study, the duration of sports participitation and weekly training time were similar to these studies that could not find such a relationship; however, we found a significant correlation between handgrip strength and local BMD in our highly trained athletes. It seems that high physical activity did not weaken this relationship in our study. These conflicting results may be due to different sites of the measurements and various measurement techniques of BMD. In most of the studies the measurements were taken from lumbar spine and femoral neck where the trabecular bone is more prominent. In

**Table 3.** Independent variables excluded by stepwise multiple regression analysis

| | β | t | p |
|---|---|---|---|
| Age | 0.25 | 1.84 | 0.07 |
| Height | -0.15 | -0.60 | 0.55 |
| Calcium intake | -0.82 | -0.61 | 0.55 |
| Cigarette smoking | 0.24 | 1.96 | 0.06 |
| Duration of sports participation | 0.09 | 0.69 | 0.49 |
| Weekly training time | -0.29 | -1.84 | 0.07 |

**Table 4.** Comparison of the dominant and non-dominant hand bone mineral densities (BMD), t-scores and handgrip strength measurements

| | Dominant hand (Meant±SD) | Non-dominant hand (Meant±SD) | p |
|---|---|---|---|
| BMD (MetriScan units) | 63.5±5.6 | 61.8±5.1 | 0.001 |
| t-score | 1.6±1.4 | 1.2±1.2 | 0.001 |
| Handgrip strength (kg) | 53.4±9.5 | 51.9±8.9 | 0.02 |
| SD: Standard deviation | | | |

the present study we measured the BMD of phalanges where cortical bone predominates. And also due to different anatomic localization and different trabecular or cortical bone contents where the measurements were taken, the response of skeleton to compressive, bending, and shear forces may differ (19). Tsuji et al showed that there was a higher correlation coefficient between grip strength and mid-radial BMD than between grip strength and distal radial-which was shown to be composed of trabecular bone- BMD of the dominant forearm in young athletes (7). Controversies in the literature about the relationship between strength and BMD may also, be due to confounding variables. BMD is influenced by many factors that may influence one another. We investigated the effect of other variables together with the relationship between strength and BMD to elucidate the independent role of each variable in highly trained athletes. We evaluated phalangeal BMD, handgrip strength, age, body height and weight, BMI, calcium intake, cigarette smoking, duration of sports participation, weekly training time in each subject. Multiple regression analysis showed that handgrip strength and weight were the strongest independent predictors of phalangeal BMD. To eliminate the effect of body weight on BMD, we compared BMD and handgrip strength in the dominant and non-dominant hands of the male athletes. Grip strength of the dominant hand was significantly greater than that of the non-dominant hand in these subjects. The BMD was also significantly higher on the dominant side than on the non-dominant side. These findings indicate that handgrip strength is an independent predictor of phalangeal BMD in highly trained male athletes.

Recently, it has been suggested that the effect of muscle strength on bone mass is more systemic than site specific because of the conflicting results about the relation between muscle strength and other bone density sites rather than adjacent bones (6,15). However, in our study, grip strength and phalangeal BMD of the dominant hands were significantly greater than those of the non-dominant hands. These findings emphasize the site specific effect of exercise and muscle strength on bone mass in highly trained male athletes.

## Conclusion

Handgrip strength is an independent predictor of phalangeal BMD in highly trained male athletes.

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