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Hsiu-Chen Huang

Sau-Chin Mei

Lee-Ren Yeh

Luo-Ping Ger

I-Ping Liu

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Relationship Between Grip Strength and Radial Bone Mineral Density in Normal Elderly Males

Hsiu-Chen Huang, Sau-Chin Mei,

Lee-Ren Yeh*, Luo-ping Ger**, I-Ping Liu

The purpose of this study is to investigate the relationship between grip strength and bone mineral density (BMD) in normal elderly males who were subject to senile osteoporosis. We examined grip strength and BMD in 49 healthy volunteer males, aged 65-80 years-old (mean age : 71.1 ± 3.9 y/o). Radial BMD was measured in the distal and middle radius by dual energy X-ray absorptiometry (DEXA). Isometric grip strength was assessed with a hand-held dynamometer for both forearms. A significant positive correlation was found between radial BMD and grip strength in both dominant and non-dominant forearms. Meanwhile, no significant correlation existed between body weight and radial BMD. In addition, we also compared the radial BMD between life style active/ sedentary groups, and smoker/ non-smoker groups. The two-tail paired t-test showed significant difference between life style active/sedentary groups, but no significant difference between smoker/non-smoker groups. We conclude that grip strength can be a predictor of radial BMD in elderly men, and habitual physical activity is one of the major determinants of BMD especially for aged male subjects.

Key words : grip strength, bone density, osteoporosis

INTRODUCTION

It is widely acknowledged that muscle strength is significantly correlated with bone mass. The basis of this relationship has not been clearly defined. The previous research has focused on postmenopausal women to explore the relationship between muscle strength and regional bone mineral content[1-6], and positive effect of skeletal loading of stronger muscle to bone mass has been demonstrated, which was valuable in prediction and

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Department of Physical Medicine and Rehabilitation
*Department of Radiology
**Department of Medical Education and Research
Veterans General Hospital- Kaohsiung, Taiwan, R.O.C.
Address correspondence to: Dr. Hsiu-Chen Huang, Department of Physical Medicine and Rehabilitation, Veterans General Hospital- Kaohsiung, 386. Ta-Chung 1st Rd, Kaohsiung 813, Taiwan, R.O.C.
Tel : (07) 3422121

prevention of postmenopausal osteoporosis (i.e. Type I osteoporosis) Fewer study, however, has demonstrated the relationship of muscle strength to regional bone mass in aged male subjects. General speaking, bone mineral density is determined by anthropometric, mechanical, life-style, hereditary, and hormonal factors.[1] We selected the aged male group to minimize the hormonal effect (eg. estrogen) so that our study is focused on the influence of mechanical and life-style factors to bone mineral density. Therefore, we conducted this study to evaluate the relationship between grip strength and radial bone mineral density in normal elderly males who were older than 65 years-old and were confronted with senile osteoporosis to investigate if muscle strength could be a predictor of bone mineral density in this age group.

MATERIALS AND METHODS

Subjects

The subjects were 49 healthy elderly male volunteers, aged 65-80 years-old. Each subject underwent a standardized interview to obtain information on handedness, medical history, and life-style behaviors. Those who had the history of fracture, arthritis, and peripheral nerve injury of upper limbs, stroke, or cervical myelopathy were excluded from this study. Subjects were further categorized by self-report into life-style sedentary/ active groups, and smoker/non-smoker groups. The active group of life style was defined as those who engaged in more than 15 minutes of vigorous activities including strenuous exercise or heavy work that caused subjective rapid heart beats and perspiration three or more times per week. All subjects had a body mass index (BMI = weight/ height^2) of less than 30 and were therefore not obese. This study was conducted from May 1995 to Aug. 1995.

Measurements

Bone mineral density (BMD) was measured by means of dual energy X-ray absorptiometry (DEXA) using a Hologic QDR-2000. BMD measurements at the distal radius were taken proximal to the end plate of the radius. (This region contains mostly trabecular bone.) BMD measurements at mid-radius region were taken 20mm wide centered at a distance equal to 1/3 of the forearm length measured from the distal tip of the radius. (This region contains mostly cortical bone.) The coefficient of variation for repeated measurements was 0.45%. Both dominant and non-dominant forearm BMD were measured in all subjects.

Isometric grip strength was assessed with a hand-held dynamometer (JAMAR Models pc 5030J1). The dynamometer was placed in the hand with the participants arms flexed 90° at the elbow and the forearm parallel to the floors. The participant was instructed to squeeze the hand as hard as possible on a 3-second count without pressing the instrument against the body. Three measurements were recorded and the mean values, in pounds, were calculated. There was a 2-minute interval between measures. Grip strength was assessed in both forearms. The test-retest correlation coefficients (r) was between 0.968 and 0.977 in the left hands and between 0.977 and 0.985 in the right hands.

Data was analyzed using SPSS statistic package. Analyses included standard descriptive statistics, simple regression, and stepwise regression. The two-tail paired t test was also performed. Two-tailed p values of 0.05 or less were considered evidence of statistically significant findings.

RESULTS

The 49 subjects were 71.1 ± 3.9 years of age. Body weight and height were 67.0 ± 8.7 Kg and 166.2 ± 4.5 cm respectively. The mean values of grip strength for dominant and non-dominant hands were 79.3 ± 11.3 and 75.6 ± 9.4 pounds respectively. The mean values of mid-radius BMD were 0.723 ± 0.070 g/cm^2 for the dominant forearms and 0.717 ± 0.073 g/cm^2 for the non-dominant forearms; The mean values of distal radius BMD were 0.452 ± 0.069 g/cm^2 for the dominant forearms and 0.424 ± 0.063 g/cm^2 for the non-dominant forearms. (Table I)

Relationship between Radial BMD and Grip Strength

Dominant grip strength was significantly correlated with BMD of the distal radius by simple linear regression analysis ($r= 0.395$, $p<0.01$, Fig.1), and of the mid-radius ($r=0.753$, $p<0.01$, Fig.2).

Non-dominant grip strength was significantly correlated with BMD of the distal radius by simple linear regression analysis ($r=0.364$, $p<0.01$, Fig.3), and of the

Table 1. Subjects Characteristics

Characteristics	No.	Mean (± SD)	Range
Age (y/o)	49	71.1 ± 3.9	65 - 80
Height (cm)	49	166.2 ± 4.5	156.5 - 175.5
Weight (Kg)	49	67.0 ± 8.7	49.0 - 85.0
Life-style (sedentary/ active)	30/19		
Smoking (yes/no)	26/23		
Grip Strength (pounds)			
Dominant forearm	49	79.3 ± 11.3	61.0 - 102.0
Non-dominant forearm	49	75.6 ± 9.4	56.6 - 97.2
Bone Mineral Density (g/cm^2)			
Dominant Mid-radius	49	0.723 ± 0.070	0.561 - 0.844
Dominant Distal Radius	49	0.452 ± 0.069	0.323 - 0.603
Non-dominant Mid-radius	49	0.717 ± 0.073	0.577 - 0.838
Non-dominant Distal Radius	49	0.424 ± 0.063	0.299- 0.574

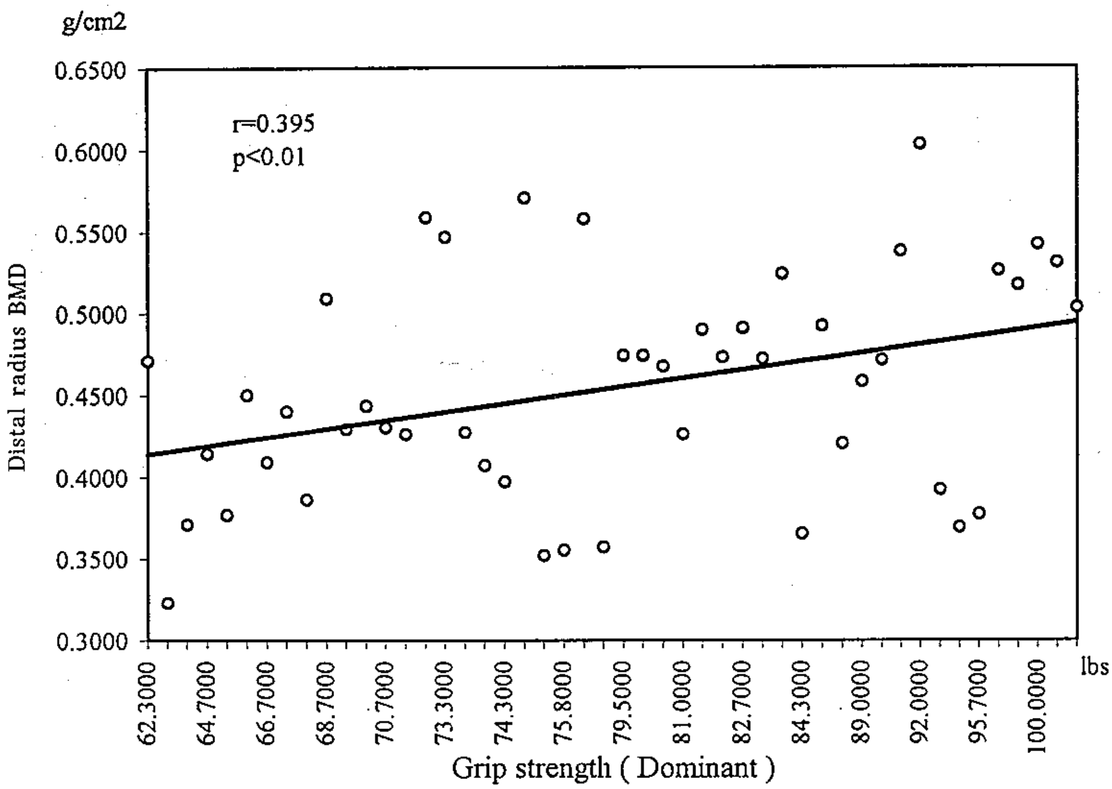

Fig 1. Relationship between grip strength and distal radius BMD of the dominant forearms. Significant correlation was found by simple linear regression analysis. ($r = 0.395$, $p<0.01$)

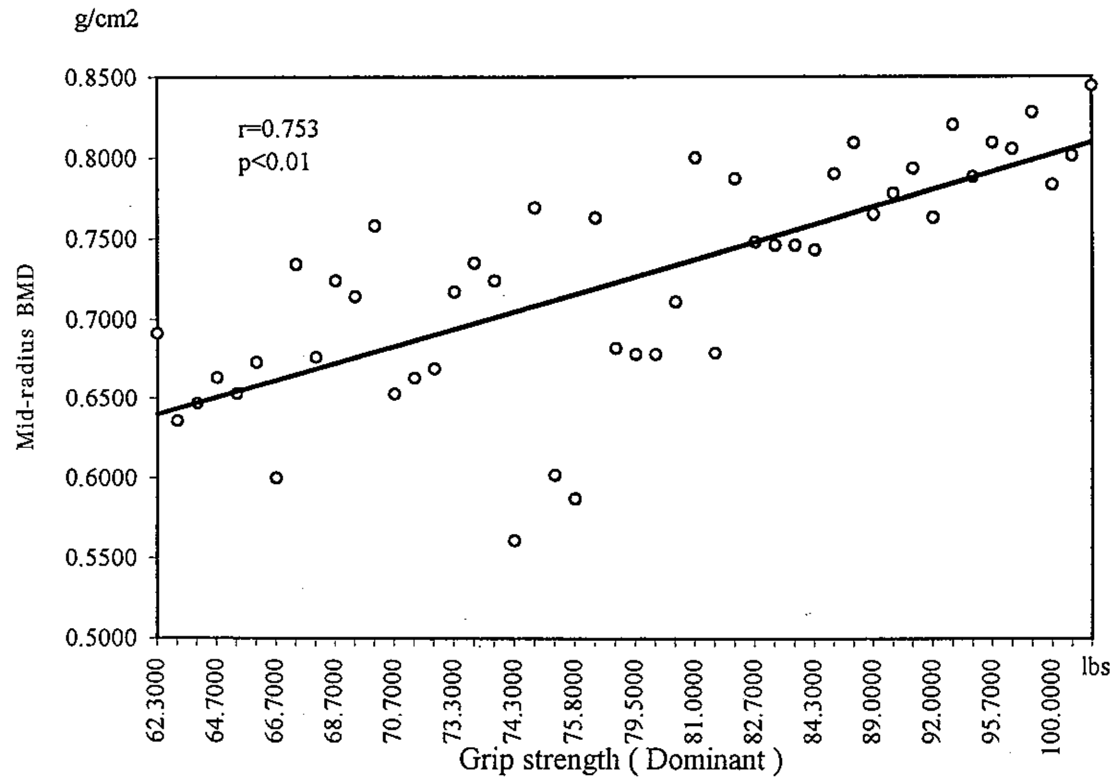

Fig 2. Relationship between grip strength and mid-radial BMD of the dominant forearms. Significant correlation was found by simple linear regression analysis. (r = 0.753, p<0.01)

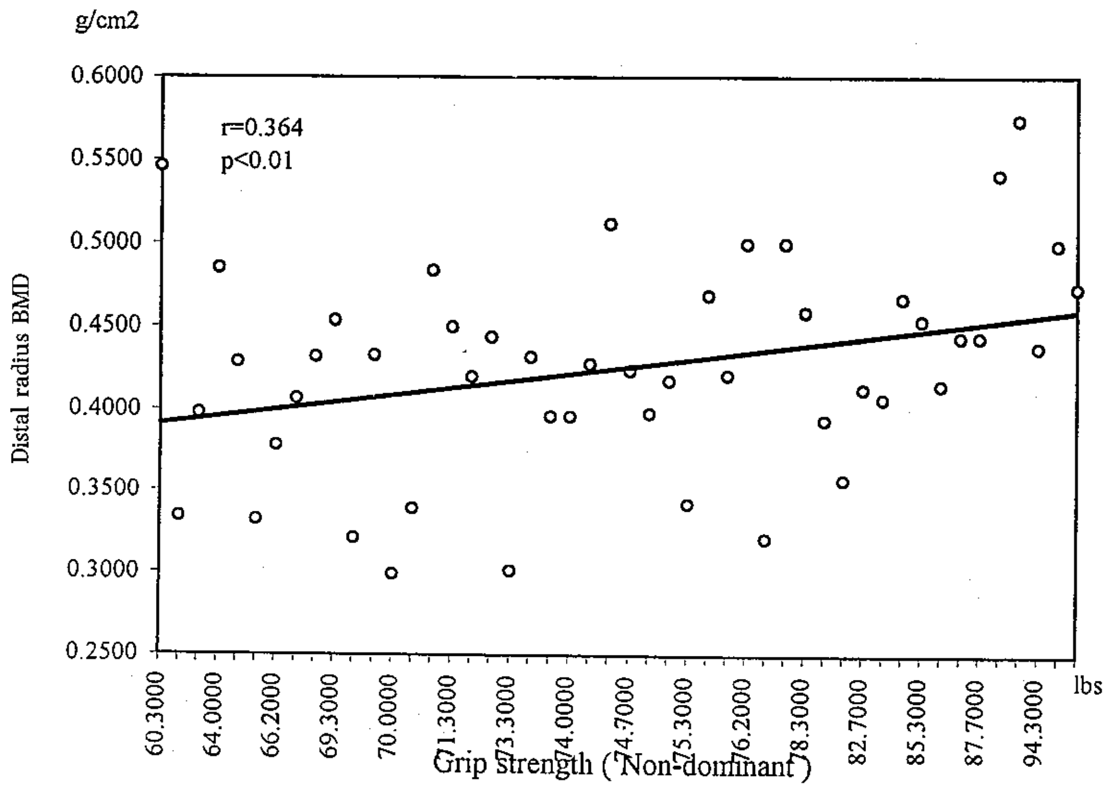

Fig 3. Relationship between grip strength and distal radius BMD of the non-dominant forearms. Significant correlation was found by simple linear regression analysis. (r = 0.364, p<0.01)

mid-radius. (r=0.709, p<0.01, Fig.4)

Relationship between Radial BMD and Other Confounders — Body Weight, Life-style, and Smoking

In our study, no significant correlation between body weight and both BMD of the distal radius (r=0.262, p>0.05), and of the midradius (r=0.215, p>0.05) in the dominant forearms was found.

The average values of mid-radius BMD and distal radius BMD were higher in the active group than in the sedentary group. The two-tail paired t-test showed a significant difference. (p<0.05, Table II)

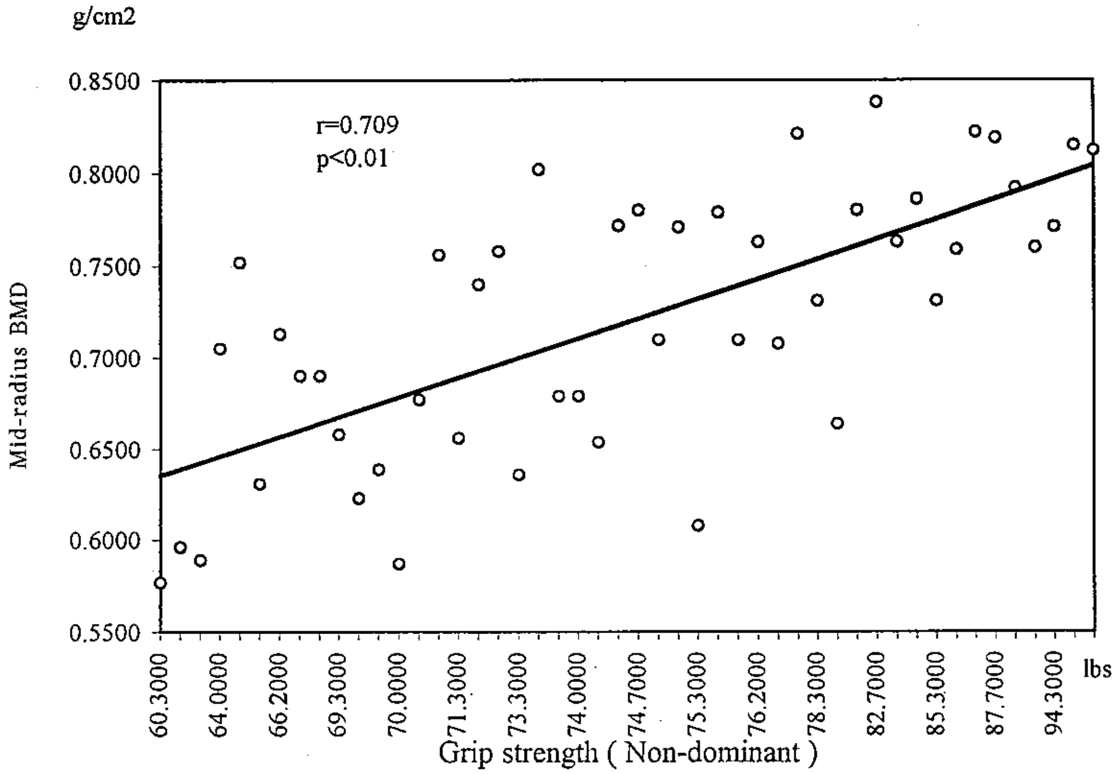

Fig 4. Relationship between grip strength and mid-radial BMD of the non-dominant forearms. Significant correlation was found by simple linear regression analysis. (r = 0.709, p<0.01)

Table 2. Comparison of radial BMD between life-style active/sedentary groups and smoker/non-smoker groups

Characteristics	No.	Distal radius BMD (Mean ± SD)	Mid-radius BMD (Mean ± SD)
Life-style			
Sedentary	30	0.435 ± 0.071✱	0.702 ± 0.065✦
Active	19	0.479 ± 0.058✱	0.755 ± 0.067✦
Smoking (yes/ no)			
Smoker	26	0.437 ± 0.067❖	0.711 ± 0.068★
Non-smoker	23	0.469 ± 0.069❖	0.735 ± 0.072★

✱✦Two-tail paired t-test showed significant difference. p<0.05

❖★Two-tail paired t-test showed no significant difference. p>0.05

The average values of mid-radius and distal radius BMD were higher in the non-smoker group than in the smoker group, but two-tail paired t-test showed no significant difference. (p>0.05, Table II)

Results of Stepwise Regression Analysis

We used stepwise regression to assess the independent contributions of the above-mentioned variables (including grip strength, body weight, age, life-style, and smoking) to bone density. In stepwise regression analysis, grip strength was the only independent predictor of distal radius BMD and of mid-radius BMD.

DISCUSSION

We conducted this study to evaluate the relationships between muscle strength and bone mineral density in normal elderly men. Recent articles have reported muscle strength, in particular, is a determinant factor of BMD.[1,2,5,7-11] Significant associations between grip strength and bone density of the radius have been reported for postmenopausal women[1,5,10,11] and for young women.[7,9] Our data shows a significant positive correlation between radial BMD and grip strength of both the dominant and non-dominant forearms in elderly male subjects. It appears that at least part of the increased bone mass of stronger individuals can be attributes to increased skeletal loading by stronger muscle. According to Jonsson et al,[2] the relationship between physical activity and bone mass seems to be more complicated in females than in males, since the former has the additional confounder of hormonal factor. In fact, in our study, grip strength is the only independent predictor of radial bone density by stepwise regression analysis, indicating that physical fitness is more important in male subjects to preserve bone mass.

Body weight has been frequently observed to correlate with bone mineral density especially for postmenopausal women ,[10,12,13] which was regarded as the influence of skeletal loading of body mass to skeleton and promotion of bone mass by adiposity, which aromatizes circulating androgens into estrogen.[10,16] However, in our study, no significant relationship exists between body weight and radial bone density in this elderly male group, which concurs with the finding of Bevier et al 1989.[10] We speculate the reasons as follows : 1) Men who achieved higher physical fitness and had significantly greater bone density frequently weighted less. 2) The influence of skeletal loading of body mass acts majorly on weight-bearing skeleton, such as spine and hip; its effects on appendicular bone (radius) may be minimal. 3) The range of body weight of our subjects is too narrow to show its effects since all our subjects have BMI less than 30 and all are non-obese. 4) The influence of adipose tissue may be less in men than in women since hormonal effect is not so important in men as in women. It shows, in short, muscle strength may be a more important determinant of bone mass than body weight.

As expected, the active group in life-style has significantly higher radial BMD than the sedentary group, which reveals the positive effect of physical activity in daily life again, and reflects the habitual loading of the skeleton by routine physical activity may preserve bone mass.

Cigarette-smoking is cited as having a detrimental effect on bone mineral density[14-16], but studies investigating the association between smoking and osteoporosis has reported conflicting results[15,17-19]. Our data shows no significant difference of BMD between smokers and non-smokers in this aged male subjects, which was consistent with the findings of May et al 1994 in older men[18], and Hollenach et al 1993 in older men and women[17]. Since the mechanism by which smoking influences bone mass remains unclear, the relationsip between smoking and radial BMD is hard to define, which could be confounded by 1) dose-response relationship 2) body weight 3) hormonal factors 4) diet (calcium absorption) 5) amount of exercise. It seems that dose-response relationship (the level of smoking) and hormonal factors (less influence of anti-estrogenic effect of smoking in males) account for the major confounding factors in our study. Further survey must be conducted for defining the influence of cigarette-smoking to bone mineral density.

Age, previously regarded as an important contributing factor of BMD, does not significantly correlate with BMD in our study, while the grip strength and life-style factor do. It implies that an old male (no matter how old he is) may have " strong bone " (low risk of fracture) as far as he is active and has strong muscles. In other words, keeping a regular exercise program and active life style may retard the evolutional loss of bone mass caused by age. Meanwhile, it should be noted that our age distribution (between 65 y/o and 80 y/o) was set at narrow range and within the end extreme of life that it is hard to show the relative contribution of aging for the whole life - time.

The measurement site at distal radius in our study was majorly composed of trabecular bone and the mid-radius was cortical bone.[20] Our data revealed the correlation coefficient was higher between mid-radial BMD and grip strength (r=0.753 for the dominant forearms; and r=0.709 for the non-dominant forearms) than between distal radius and grip strength (r=0.395 for the dominant forearms, and r=0.364 for the non-dominant forearms) This result corresponds to the findings of Tsuji et al [9] 1995 for young atheletes, and Jonsson et al [2] 1992 for perimenopausal women, which implies that the cortical bone appears to be more sensitive to physical activity than trabecular bone in the peripheral skeleton. Should the speculation be accurate, it may determine what type of fracture the elderly males will sustain in the future. That is, physical activity may not necessarily prevent all fragility fractures, but might be more effective in preventing fractures of the cortical bone such as femoral neck fracture.[14,21] Besides, it may also be explained that the midportion of the radius was more affected by environmental stress like grip strength than the distal portion of radius. Anatomically, the muscles used in gripping are attached to the midradius[5]. Thus, grip strength affected by environmental physical stress presumably has a direct beneficial effect for increasing mid-radial BMD.[9]

In conclusion, grip strength can be a predictor of bone mineral density in elderly men and physical activity is one of the major determinants of BMD especially for elderly male subjects. Aged people should be educated to exercise themselves regularly and to keep body active in daily-life performance for preserving bone mass and further preventing traumatic complications.

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正常老年男性的握力與橈骨骨質密度之關係

黃秀珍　梅紹京　葉力仁*　葛魯蘋**　劉憶平

影響骨質密度的眾多因子之中，肌力被認為是呈正相關的影響因子。本研究目的乃探討握力與橈骨骨質密度的關係，對象是65歲以上的正常老年男性。共蒐集49位平均年齡 71.1歲的自願受測者。分別以手握式測力器（hand-held dynamometer）測量其雙手的等長性握力(isometric grip strength)；及以 Dual Energy X-ray Absorptiometry（DEXA）測量雙手的橈骨中段及橈骨遠端的骨質密度。統計結果顯示在慣用手及非慣用手的橈骨骨質密度與握力呈有意義的正相關。而體重與橈骨骨質密度則沒有顯著相關。另外，我們比較生活型態好動型/文靜型（life-style active/sedentary group)及抽煙/不抽煙者的橈骨骨質密度。統計結果顯示生活型態好動型/文靜型兩組的橈骨骨質密度有統計意義的差異，而抽煙/不抽煙者的橈骨骨質密度則無統計意義的差異。我們的結論是：握力可為正常老年男性橈骨骨質密度的預測因子，且日常生活的活動度多寡是為決定骨質密度的重要因素之一。

高雄榮民總醫院　復健科　*放射線部　**醫學研究部
抽印本索取地址：黃秀珍，高雄榮民總醫院復健科，高雄市左營區大中一路386號
聯絡電話：(07)342-2121