# 明新科技大學　校內專題研究計畫成果報告

以蛋白質體觀點研究運動訓練對攜鈣蛋白質與骨質密度之關係

Proteomic views of the relation between exercise training, calcium binding proteins and bone mineral density

計畫類別： ☐整合型計畫　■個人計畫

計畫編號：MUST-97-自然-01_

執行期間：97 年　3 月　　1 日至　97 年　9 月　　30 日


計畫主持人：陳洸鐘

共同主持人：

計畫參與人員：


處理方式：除涉及專利或其他智慧財產權外得立即公開，
唯必要時本校得展延發表時限。

☐可立即對外提供參考
（請打√）☐一年後可對外提供參考
∨兩年後可對外提供參考


執行單位：明新科技大學 人社科學院 自然科學教育中心


中　華　民　國　　97　年　　10　　月

# 目　錄

英文摘要---------------------------------------- 1

中文摘要---------------------------------------- 3

第一章　　緒論---------------------------------- 4

前言(研究背景與目的)

第二章　　研究方法與步驟------------------------ 6

第三章　　結果與討論---------------------------- 8

參考文獻---------------------------------------- 12

成果自評表-------------------------------------- 15

# Proteomic views of the relation between exercise training, calcium binding proteins and bone mineral density


## Abstract

Background

The physical and financial burden of osteoporosis can substantially diminish quality of life. Clinical evidence indicates that physical activity can prevent osteoporosis by regulating bone maintenance and stimulating bone formation and mineral accumulation. The improved muscle strength and balance achieved by physical activity can reduce the risk of falls and fractures. Regular weight-bearing physical activity is widely recommended for adult women and may help increase bone mineral density (BMD). However, studies of the effects of impact intense training programs (ITP) on BMD and physiological functions have yielded conflicting evidence. This study investigated how intense physical training impacts bone mineral density (BMD) and physiological function in female basketball athletes.

Methods

Twenty-four female subjects aged 18 to 20 years old participated in this study. Twelve subjects were athletes receiving intense training program(ITP) and twelve control subjects were sedentary non-athletes (NON, n=12). Their regional (lumbar spine L2-4 and right hip) bone mineral densities (BMDs) were measured by dual-energy X-ray absorptiometry (DXA).

Body composition, physiological function (including liver function and hormone status) were measured. Student *t*-test, Pearson correlation were performed to determine significant predictors of BMD at right hip and L2-L4 sites.

Results

Sedentary females had lower BMD values in L2-L4 and right hip BMD sites than those undergoing intense basketball training.

Analysis revealed that only training intensity program and seniority were related to

L2-L4 and right hip BMDs.

Conclusions

Female athletes who had undergone long-term(5 years)basketball training had higher BMD values in both the right hip and the lumbar spine (L2-L4). These results suggest that ITP programs weight-bearing physical training improves BMD accretion and bone mass acquisition.

# 以蛋白質體觀點研究運動訓練對攜鈣蛋白質與骨質密度之關係


## 摘　要

目的

由於罹患骨質疏鬆症將造成人們生命財產上的重大損失，因此研究上顯示經由運動可促進骨密度增加並避免罹患骨質疏鬆症。並可增進平衡與體適能的能力避免造成跌倒與骨折的風險。荷重式運動可增進成年女性的骨密度，眾所皆知，但是強力的高度訓練強度對於女性籃球運動員其生理生化功能與骨密度造成的影響是本研究的主要目的。

方法

24 個籃球運動員，分成兩組有 12 位為女性籃球隊員。另外 12 位為對照組，分別用雙光能 X 光測定法測定髖骨(hip)骨密度，體組成與生理生化功能亦一併加以檢測。

結果

經由實驗結果與分析，發現女性籃球運動員擁有較高髖骨骨密度與訓練年資有正相關之效果。

結論

女性籃球隊員經由高強度訓練過程，可以擁有較高的髖骨骨密度。

# 第一章　緒論

## 前言（研究背景與目的）

As a serious health problem, osteoporosis that diminishes quality of life and the associated bone fractures can be a substantial physical and financial burden[1]. Physical activity is known to prevent osteoporosis by regulating bone maintenance, stimulating bone formation and mineral accumulation, strengthening muscles and improving balance, all of which can reduce the overall risk of falls and fractures[2].

Borer reported that after 9-12 months of regular exercise, young adult women often show limited improvement in bone health, possibly because of high subject attrition rates, inadequate exercise intensity, duration or frequency or because the accumulation of bone mass may be at its natural peak at this stage of physical growth[3]. The important influence of hormones and diet on bone growth and health are well known. For example, recent reports described premature bone loss associated with dietary restriction and estradiol($E_2$) withdrawal in exercise-induced amenorrhoea[4-6].

Skeletal integrity in young females depends largely on menstrual function and impact exercise, and female athletes should be evaluated for possible negative effects of amenorrhea on bone health[7,8]. In a recent study, a 16-week weight training protocol to develop upper arm strength proved effective for increasing bone density at the proximal phalanges in healthy young males [9].

The bone health in basketball players and the effects of intense training program(ITP) on bone metabolism have not been investigated previously. The optimal physical activity level (intensity, frequency, duration and rate of progression) for enhancing BMD in females is still unknown. Weight-bearing exercise is important for increasing BMD, and such activities should be dynamic, variable, performed rapidly and intermittently, and they should require relatively few loading cycles[6]. Although several effective interventions have been designed for improving bone mass, further research is needed to define specific exercise programs for optimizing bone structure and strength during growth. Further work is also needed to determine whether ITP exercise-induced alterations in bone mass and structure during growth are maintained into old age when fractures occur.

Regular weight-bearing physical activity has been widely recommended for adult women and may be beneficial for increasing BMD. However, studies have produced conflicting evidence as to the effects of impact ITP on BMD and physiological functions in female athletes. This study therefore examined the effects of long term high impact ITP training on BMD in female basketball players. Our aims are to compare female athletes BMD between GS and Back-up players and to evaluate the factors that contribute to bone mass when in compliance with ITP practices.

# 第二章　研究方法與步驟

Subjects

This study analyzed twenty-four females aged 18 to 20 years. The sample group included high school athletes (n=12) while the control group was comprised of non-athletic females (n=12). Inclusion criteria were that the female basketball athletes had participated in high-intensity activities(over 5 years of athletic activities). The measured parameters included body composition, L2- L4 BMD, right hip BMD, renal function, liver function and hormone status. The protocol was approved by human subject committee, Chinese Cultural University. All subjects signed a written consent after the procedure and possible risks had been clearly explained.

Anthropometric measurement of body composition

Anthropometric measurements were based on conventional criteria. Body weight (Wt) and height (Ht) were estimated to the nearest 0.1 kg and 0.5cm, respectively. Finally, body mass index (BMI) was calculated as body weight(kg)/body height(m)$^2$.

ITP program activity

During the five years period, all subjects performed running activity fast walking 1h/d , jumping program 1h/d and weight-bear running activity 1h/d.　The three hours of intense training was performed 5d or 6d per week . Female basketball athletes had participated in over five years high intensity activities.

Renal and liver function

From each subject, twenty-four blood samples were drawn from the antecubital vein while in the seated position. Routine complete blood counts (CBC) were taken using a Sysmex-E9000 (TOA Electronic, Inc., Tokyo, Japan), and renal and liver function tests were performed using a Hitachi 7170 instrument (Hitachi Electronic, Inc., Tokyo, Japan) by clinical chemistry laboratory staff at Cardinal Tien Hospital, Taipei County, Taiwan.

Hormone status

In each subject, triiodothyronine (T3), thyroxine (T4) were assayed in basal conditions using commercial enzymeimmunoassay(EIA) kits (CIS Diagnostics, Tronzano Vercellese-Tonino; RADIM, Pomezia-Roma, Italy; ICN Biomedicals, Inc., Costa Mesa, CA, USA).

BMD determination

The L2-L4 and right hip (at femoral neck site) BMD were measured via DXA (Norland, Norland excell, Norland Corp., WI, USA) for bone mineral densitometry, and all BMD values were also expressed as a T-score accurately reflecting BMD. The scanners were calibrated daily against the standard manufacturer-supplied calibration block to control baseline drift.

Statistical analysis

All data were analyzed by Student t-test, Pearson correlation analysis to determine the significant predictors of BMD at right hip and L2-L4 sites.

# 第三章　結果與討論

## Results

General Characteristics

Anthropometric variables did not significantly differ between the ITP and NON groups. The ITP group underwent weight-bearing training consisting primarily of running, fast walking, jumping, maneuvering on hard surfaces and uphill running (15-18 h/wk). The duration of training over five years. Summarises the participant characteristics for all variables. No significant relationships ($p>0.05$) were found between two groups. Shows the BMD measurements for L2-L4 and right hip sites, , indicating that the ITP group had significantly higher BMD at both sites than the NON group.

Evaluation of physiological parameters

Further, the twenty-four females enrolled in this cross-sectional study did not significantly differ in terms of T3, T4, Alk-P, total protien or γ-GTP (Table 2).

Evaluation of BMD

Confounding factors were identified by using a stepwise linear regression procedure.　Therefore, for correlation analysis, found to affect BMD at two sites were included in the subsequent analysis.

## Discussion & Conclusions

Increasing BMD and preventing osteoporosis is vital for stopping or decelerating bone loss during future postmenopause[5-8]. This article describes the results of long-term intense training (ITP) in female college basketball athletes. The exercise program for these athletes emphasized low-volume weight-bearing training over five years period.

Twelve fully compliant female athletes with no medications or illnesses affecting bone metabolism were assigned to the intense training program(ITP) group; twelve college females served as sedentary non-athletic controls (NON). In summary, all athletes who participated in the 5-year ITP program achieved BMD gains at the

L2-L4($p<0.05$ ) and hip sites($p<0.05$). ITP-1 had higher BMD than ITP-2 groups.

Most BMD benefits achieved by intense training or exercise during growth periods are lost when physical activity ceases[10, 11]. Intense training five years, after this period of high intense activity (five years of ITP), may retain higher BMD benefits into old age. [10, 13]. A reduced rate of fragility fracture in the athlete group may have been achieved because the participants had physically active lifestyles and high activity levels during training and competition, which would then increase BMD and reduce fractures[14, 15, 16].

A previous report demonstrated that multipurpose ITP programs significantly affect relevant menopausal risk factors and may therefore provide an alternative to hormone replacement therapy[16, 21].

According to the data in this study, female athletes who undergo intense training generate mechanical constraints on the body which can causes changes in bone metabolism such as increased BMD (both L2-L4 and right hip sites). The findings of similar studies elsewhere are heterogenous and depend on exercise intensity, duration and frequency[22, 27].

The two groups in this study did not differ in hormone status (in terms of T3, T4, alkaline phosphatase, total protein and r-GTP). Resistance exercise had a positive treatment effect and may help prevent skeletal change[23]. No significant relationships were observed between physiological function parameters and any measured BMD parameters in weight-bearing high impact training athletes and sedentary controls.

Study by Soot also had found that sedentary females of normal weight had lower ($p<0.05$ ) BMDs in sites L2-L4 and the femoral neck in comparison to females who had undergone weight-bearing ITP. This observation suggests that intense training, type of mechanical load and higher BMD have positive effects in female college basketball athletes compared to sedentary controls[12, 13]. The data for BMDs in sites L2-L4, femoral neck and total BMD of sedentary subjects in comparison to females who had undergone strength training, correlated with the results reported here.

However, the biological explanation for the reduced incidence of fracture is unclear. Proposed explanations include residual benefits to bone structural properties, muscle strength, coordination and balance[22, 27].

Each of these traits can be maintained in formally trained athletes after their active career and may help to reduce the number of fractures later in life. Therefore, based on the current evidence, a physically active lifestyle during growth stage prevents fragility fractures in old age[12, 16].

**Table 1 Summarises the participant characteristics for all variables.**
**No significant relationships (p>0.05) were found between two groups. Hematologic parameters of the tested individuals. Parameters related to hemogram and no significantly were found in two groups. BMD in athletes with significance by independent t-test as compared with control group.The athletes group also had a significantly increased level of right hip and lumbar spine, P<0.05.**

| Goup | Athlete (ITP, n=12) | Control (NON,n=12) |
|---|---|---|
| Height(cm) | 163.88±7.09 | 163.75±4.20 |
| Weight(kg) | 56.00±6.78 | 56.96±8.69 |
| BMI($kg/m^2$) | 20.81±1.80 | 21.22±3.09 |
| S. pressure (mmHg) | 111.67 ±12.01 | 106.17 ±10.90 |
| D. pressure (mmHg) | 67.17 ± 5.34 | 67.17 ± 7.00 |
| RBC($10^6$/ul) | 4.53±0.37 | 4.37±0.24 |
| Hb(mg/dl) | 13.16±0.67 | 12.84±0.82 |
| Hct(%) | 40.50±2.51 | 39.60±2.09 |
| platelet($10^3$/ul) | 263.25±61.48 | 222.58±38.41 |
| MCV(fl) | 89.76±6.03 | 90.76±3.55 |
| MCHC(g/dl) | 32.54±1.13 | 32.42±1.31 |
| Right hip (at femoral neck)(T-score) | 1.49±1.69* | -0.14 ±0.56 |
| Lumbar spine L2-4 (T-score) | 0.78±1.36* | -0.33±0.85 |

**Table 2 Description of the serum measurements of athlete and control groups.**
**No significance were found compare athlete group than control group. Evaluation of physiological parameters and hormone status. The twenty-four female athletes enrolled in this cross- sectional study did not differ significantly in terms of glutamate pyruvate transaminase(GPT), blood urea nitrogen (BUN),creatinine (CRN), cholesterol(CHO), total cholesterol (TG), T3, T4, alkaline phosphatase(ALP) total protein (T-p) and gamma-glutamyl transferase (r-GTP) .**

| | Athlete (ITP, n=12) | Control (NON,n=12) |
|---|---|---|
| GPT(ALT)(IU/L) | 15.83±4.41 | 15.42±4.23 |
| BUN(mg/dl) | 14.00±2.73 | 13.25±2.38 |
| CRE(mg/dl) | 1.01±0.07 | 1.03±0.08 |
| CHO(mg/dl) | 168.00±20.80 | 176.75±23.33 |
| TG(mg/dl) | 69.17±29.98 | 77.50±21.22 |
| T3(ng/dl) | 104.25±18.41 | 99.58±23.74 |
| T4(ug/dl) | 8.63±0.85 | 8.56±1.06 |
| ALK-p(IU/L) | 82.25±12.93 | 78.25±11.55 |
| T-p(g/dl) | 7.45±0.22 | 7.36±0.31 |
| r-GTP(IU/L) | 14.33±2.27 | 16.67±3.37 |

**Table3 Correlation of Right hip, Lumbar Spine and Seniority.**

**The Lumbar spine L2-4(T-score) was significantly with Right hip BMD(T-score) in positive relation(r=0.576, p<0.05) and Seniority (r=0.781, p<0.05).**

**[a] $P < 0.05$, correlation of Lumbar spine L2-4 with Right hip.**

**[b] $P < 0.05$, correlation of Lumbar spine L2-4 with Seniority.**

| | | Lumbar spine L2-4 | Rright hip | Seniority |
|---|---|---|---|---|
| Pearson correlations | Lumbar spine L2-4 (T-score) | 1 | 0.576* | 0.781* |
| | Right hip (femoral neck) (T-score) | .576 [a]* | 1 | 0.442 |
| | seniority | .781 [b]* | 0.442 | 1 |

参考文獻


1. Kemmler W, Engelke K, von Stengel S, Weineck J, Lauber D, Kalender WA: **Long-term four-year exercise has a positive effect on menopausal risk factors: the Erlangen Fitness Osteoporosis Prevention Study.** J Strength Cond Res. 2007;**21**(1):232-9.
2. Karlsson MK: **Does exercise during growth prevent fractures in later life?** Med Sport Sci. 2007;**51**:121-36.
3. Borer KT: **Physical activity in the prevention and amelioration of osteoporosis in women : interaction of mechanical, hormonal and dietary factors.** Sports Med. 2005;**35**(9):779-830.
4. Martyn-St James M, Carroll S: **Progressive high-intensity resistance training and bone mineral density changes among premenopausal women: evidence of discordant site-specific skeletal effects.** Sports Med. 2006;**36**(8):683-704.
5. Kemmler W, Engelke K, Lauber D, Weineck J, Hensen J, Kalender WA: **Exercise effects on fitness and bone mineral density in early postmenopausal women: 1-year EFOPS results**. Med Sci Sports Exerc. 2002;**34**(12):2115-23.
6. Engelke K, Kemmler W, Lauber D, Beeskow C, Pintag R, Kalender WA: **Exercise maintains bone density at spine and hip EFOPS: a 3-year longitudinal study in early postmenopausal women.** Osteoporos Int. 2006 ;**17**(1):133-42.
7. Kemmler W, Lauber D, Weineck J, Hensen J, Kalender W, Engelke K: **Benefits of 2 years of intense exercise on bone density, physical fitness, and blood lipids in early postmenopausal osteopenic women: results of the Erlangen Fitness Osteoporosis Prevention Study (EFOPS).** Arch Intern Med. 2004.
8. Nichols JF, Rauh MJ, Barrack MT, Barkai HS: **Bone mineral density in female high school athletes: interactions of menstrual function and type of mechanical loading.** Bone.2007;**41**(3):371-7
9. Bagrichevsky M, Martins-Filho J, Guerra-Junior G: **Bone density gain at proximal phalanges in healthy males aged 18-25 years after 16 weeks of upper-arm muscle weight training.** J Sports Med Phys Fitness. 2007 ;**47**(4):437-42.
10. Muraki S, Yamamoto S, Ishibashi H, Oka H, Yoshimura N, Kawaguchi H, Nakamura K: **Diet and lifestyle associated with increased bone mineral density: cross-sectional study of Japanese elderly women at an osteoporosis outpatient clinic.** J Orthop Sci. 2007 ;**12**(4):317-20.
11. Martyn-St James M, Carroll S: **High-intensity resistance training and postmenopausal bone loss: a meta-analysis.** Osteoporos Int. 2006 Jun 1[Epub ahead of print]

12. Nordström A, Karlsson C, Nyquist F, Olsson T, Nordström P, Karlsson M: **Bone loss and fracture risk after reduced physical activity.** J Bone Miner Res. 2005;**20**(2):202-7.
13. Valdimarsson O, Alborg HG, Düppe H, Nyquist F, Karlsson M: **Reduced training is associated with increased loss of BMD.** J Bone Miner Res. 2005 ;**20**(6):906-12.
14. Sööt T, Jürimäe T, Jürimäe J: **Areal bone density in young females with different physical activity patterns: relationships with plasma leptin and body composition.** J Sports Med Phys Fitness. 2007;**47**(1):65-9.
15. Sööt T, Jürimäe T, Jürimäe J: **Relationships between bone mineral density, insulin-like growth factor-1 and sex hormones in young females with different physical activity.** J Sports Med Phys Fitness. 2006;**46**(2):293-7.
16. Yahata Y, Aoyagi K, Okano K, Yoshimi I, Kusano Y, Kobayashi M, Moji K, Takemoto T: **Metacarpal bone mineral density, body mass index and lifestyle among postmenopausal Japanese women: relationship of body mass index, physical activity, calcium intake, alcohol and smoking to bone mineral density: the Hizen-Oshima study.** Tohoku J Exp Med. 2002;**196**(3):123-9.
17. Twiss JJ, Gross GJ, Waltman NL, Ott CD, Lindsey AM: **Health behaviors in breast cancer survivors experiencing bone loss.** J Am Acad Nurse Pract. 2006;**18**(10):471-81.
18. Muraki S, Yamamoto S, Ishibashi H, Oka H, Yoshimura N, Kawaguchi H, Nakamura K: **Diet and lifestyle associated with increased bone mineral density: cross-sectional study of Japanese elderly women at an osteoporosis outpatient clinic.** J Orthop Sci. 2007;**12**(4):317-20.
19. Schulzke SM, Trachsel D, Patole SK: **Physical activity programs for promoting bone mineralization and growth in preterm infants. Cochrane Database Syst Rev.** 2007;**18**;(2):CD005387.
20. Martyn-St James M, Carroll S: **High-intensity resistance training and postmenopausal bone loss: a meta-analysis. Osteoporos Int.** 2006 Jun 1[Epub ahead of print]
21. Daly RM: **The effect of exercise on bone mass and structural geometry during growth.** Med Sport Sci. 2007;**51**:33-49.
22. Karlsson MK: **Physical activity, skeletal health and fractures in a long term perspective.** J Musculoskelet Neuronal Interact. 2004;**4**(1):12-21.
23. Karlsson M: **Has exercise an antifracture efficacy in women?** Scand J Med Sci Sports. 2004;**14**(1):2-15.
24. Karlsson M: **Exercise increases bone mass in children but only insignificantly in adults.** Lakartidningen. 2002;**99**(35):3400-5.

25. Shackelford LC, LeBlanc AD, Driscoll TB, Evans HJ, Rianon NJ, Smith SM, Spector E, Feeback DL, Lai D: **Resistance exercise as a countermeasure to disuse-induced bone loss.** J Appl Physiol. 2004;**97**(1):119-29.
26. Layne JE, Nelson ME: **The effects of progressive resistance training on bone density: a review.** Med Sci Sports Exerc. 1999;**31**(1):25-30.
27. Kontulainen S, Sievänen H, Kannus P, Pasanen M, Vuori I: **Effect of long-term impact-loading on mass, size, and estimated strength of humerus and radius of female racquet-sports players: a peripheral quantitative computed tomography study between young and old starters and controls.** J Bone Miner Res. 2003;**18**(2):352-9.
28. Maïmoun L, Coste O, Puech AM, Peruchon E, Jaussent A, Paris F, Rossi M, Sultan C, Mariano-Goulart D: **No negative impact of reduced leptin secretion on bone metabolism in male decathletes.** Eur J Appl Physiol. 2008;**102**(3): 343-51.
29. Rector RS, Rogers R, Ruebel M, Hinton PS: **Participation in road cycling vs running is associated with lower bone mineral density in men.** Metabolism. 2008;**57**(2):226-32.

# 明新科技大學 ____年度 研究計畫執行成果自評表

計畫類別：□任務導向計畫 □整合型計畫 ■個人計畫
所屬院(部)：□工學院 □管理學院 □服務學院 ■通識教育部
執行系別：自然科學教育(中心)
計畫主持人：陳洸艟　　職稱：副教授
計畫名稱：以蛋白質體觀點研究運動訓練對攜鈣蛋白質與骨質密度之關係
計畫編號：MUST-97-自然-01_
計畫執行時間：97 年 3 月 1 日 至 97 年 9 月 30 日

| | | |
|---|---|---|
| 計畫執行成效 | 教學方面 | 1. 對於改進教學成果方面之具體成效：<br>佳<br>2. 對於提昇學生論文/專題研究能力之具體成效：<br>佳<br>3. 其他方面之具體成效：<br>佳 |
| | 學術研究方面 | 1. 該計畫是否有衍生出其他計畫案 ■是 □否<br>計畫名稱：<br>2. 該計畫是否有產生論文並發表 □已發表 ■預定投稿/ □否<br>發表期刊(研討會)名稱：<br>發表期刊(研討會)日期：____年___月___日<br>3. 該計畫是否有要衍生產學合作案、專利、技術移轉 □是 □否<br>請說明衍生項目： 無 |
| 成果自評 | | 計畫預期目標：已達到<br>計畫執行結果：可達預期目標<br>預期目標達成率：100 % |
| | | 其它具體成效：<br>書寫其他衍生計畫中。<br>(若不敷使用請另加附頁繕寫) |