# Effects of Short-Term Vitamin D Supplementation on Musculoskeletal and Body Balance for Prevention of Falling in Postmenopausal Women

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***Objective:*** *The objective of this research was to examine the effects of the short-duration (4 weeks) vitamin D supplementation on biochemical bone markers, muscle strength and balance of the postmenopausal females.*

***Material and Method:*** *The participants consisted of 52 female participants from Chulalongkorn University, aged between 45-55 years old. They were divided into two groups: 26 females in the vitamin D supplementation (VID) and 26 females in the control group (CON) by the simple random sampling method. The experimental group received 20,000 IU of vitamin D2 per week, for a period of 4 weeks. The control group did not receive vitamin D2. The collected data before and after the experiment were the results of the physiology test, the biochemical bone markers, the muscle strength and the balance ability. The collected data were compared and analyzed by the mean and standard deviation. The differences of the tests are statistically significant at the 0.05 level.*

***Results:*** *After the 4-week experiment, the vitamin D2 supplementation group had significantly improved balance ability on normal stability surfaces when being compared with the pretest and the control group ($p<0.05$).*

***Conclusion:*** *A short-term vitamin D2 supplementation had positive effect on balance. This is, therefore, a good alternative for postmenopausal people and may reduce the risks of falling in women in particular.*

***Keywords:*** *Short-duration vitamin D supplementation, Biochemical bone marker, Balance, Fall postmenopausal women*

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Increased bone fractures and increased number of falls caused by impaired neuromuscular coordination function are known risk factors for bone fractures[1,2]. The factors concerning age-related condition lead to the deterioration of the muscle system and physical structure; they result in body stability[2,3]. Postmenopausal women really have a high risk of developing osteoporosis as the growth rate of bone mass is gradually reduced[4]. It is due to the changing biochemical mechanism especially the decrease of estrogen levels. The multiple risks of osteoporosis are identified by estrogen deficiency[5], lack of proper exercises[6], and dietary vitamin D intake[7]. It is obviously accepted that many postmenopausal women have broken bone according to their bone accumulation[8]. The main objective of avoiding bone fractures at present, therefore, focuses on the reduction of falls[9], the maintenance of bone condition or the development of bones by strengthening the body muscles and improving the balance which seems to be the best solution[10].

Some previous studies[3,11] revealed that long-term vitamin D and calcium supplementation could reduce fractures in elderly people. However, there has been no research on a short-term (4 weeks) vitamin D supplementation on the multiple risk factors for fractures (biochemical bone markers, lower extremity strength and stability) in postmenopausal women. This research placed an emphasis on the short duration (4 weeks) of using Vitamin D supplementation on musculoskeletal and body stability.

The present study aimed to examine the effects of a short-term vitamin D supplementation on biochemical bone markers, muscle strength and balance in the postmenopausal women. The results achieved would encourage better understanding of how vitamin D supplementation could interact with the physiological

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systems associated with body stability. The findings from this study could also serve as guidelines for women to maintain good health and prevent osteoporosis, develop body stability, and reduce the risks of falling.

## Material and Method

### *Subjects selection and criterion*

The research design of this study was an experimental research. The population of this study was the female Chulalongkorn University staff. The selection instruments were a subject selection form and the SAHARAR BMD to measure the heel bone density (BMD). All participants were required to have heel bone density of not lower than -2.5 of the standard deviation by using SAHARAR BMD to measure the heel bone density. The potential participants were excluded if they suffered from osteoporosis, if they were smokers, alcoholic consumers, taking medications or hormones affecting the bones at the time of the experiment, or if they drank more than 2 standard-sized cups (250 cc cup) of tea or black coffee per day. Moreover, they had to have a BMI not over 30. The subjects were divided into 2 groups by simple random sampling method. Twenty-six subjects were in the VID group and 26 subjects in the control group (CON).

### *Study design and supplements*

During the 4 weeks, the subjects were randomly assigned to either the control group or the vitamin D group. At the study entry, a complete physical examination and assessment of the subjects' medical history, diets, and physical activity were performed. In addition, biological bone markers were analyzed and body balance was measured. The subjects were advised to maintain their usual diets and to avoid taking supplemental vitamin D and calcium on their own. The subjects in the CON group were instructed to remain sedentary while the vitamin D supplementation group started receiving 20,000 IU of vitamin D2 supplementation per week. The collected data before and after the experiment were the results of the physiology test, the biochemical bone markers, the muscle strength and the balance ability. However, both vitamin D supplementation and control groups had to control their daily food and drink consumption appropriately that may effect on bone such as tea, coffee, and alcohol.

### *Measurements*

To measure biochemical bone markers after 8 hours of overnight fasting, the venous blood sample was collected. Blood sampling was performed at the same time of day for the pre and post-tests in order to avoid diurnal changes in blood chemistry variables. Two hours after having breakfast, the participants were asked to perform balance and muscle strength assessment.

#### *General physical fitness measures*

Before joining the project, the participants were tested for general physiological status, namely weight and height, resting heart rate, and blood pressure-both systolic and diastolic ("Tanita" "UM-052" model Japan, Mercury sphygmomanometer, and stethoscope).

#### *Muscle strength and balance performance measure*

To assess the participants' muscle strength, the measurement was performed with Nautilus-type back and leg dynamometer. For static balancing ability, they were tested on both normal and soft surfaces on balance plates (Force plate AM, Bertec, Columbus, OH) with eyes open, head erected, and arms by the side of the trunk. The signal from force platform was sampled at 500 Hz. The personal computer was used to collect the data with the customized BalanceCheck-based software (BalanceCheck TM Screener and Trainer 3.3.2 by BERTEC Columbus, OH-) (Fig. 1). Bertec's 3-component balance plates measure vertical force and the Center of Pressure (CoP).

#### *Measurement of biochemical bone markers*

To measure biochemical bone markers, the blood samples were drawn and tested for β-CrossLaps and P1NP both before and after the experiment. After fasting for 8 hours, nine milliliters of fasting blood was collected between 8:00-10:00 AM. The PINP (Bone formation marker) and β-CrossLaps (Bone resorption marker) were measured by the electrochemiluminescence immunoassay (ECLIA) method following the direction of Elecsys PINP and β-CrossLaps immunoassay (Roche Diagnostics, Switzerland).

### *Statistical analysis*

All statistical analyses were performed by using SPSS statistical software for Windows (version 19.0, SPSS Inc., Chicago, IL, USA) to find the mean and standard deviation of the data, and to compare the mean of the general physiological variables, biochemical bone markers, muscle strength and balance taking place at before and after the 4-week program. The before and after experiment data were analyzed by paired samples t-test and independent samples t-test. The significant level was set at 0.05 level.

## Results

There were fifty-two women participating in this study. The subjects were divided into 2 groups: 26 in the vitamin D group and the other 26 in the control group by the simple random sampling method (Table1). After the 4-week experiment, the findings indicated that the mean scores on muscle strength and biochemical bone markers of the vitamin D group and the control group were not significantly different at 0.05 level (Table 2). The balance of the vitamin D subjects had significantly improved balance ability on normal stable surfaces when being compared with the pretest and the control group ($p<0.05$) (Table 2).

**Fig. 1** Balance checker, AM Bertec, Columbus, a static balancing ability on both normal and soft surfaces on force plate. The balance is checked by a software balance check TM screener and trainer 3.3.2 by BERTEC Columbus.

**Table 1.** Subject characteristics

| Group | Control (CON; n = 26) | Vitamin D (VID; n = 26) |
|---|---|---|
| Age (year) | 50.74±3.13 | 51.03±2.97 |
| Weight (kg) | 59.15±4.1 | 59.64±3.0 |
| BMI (kg/m$^2$) | 23.63±2.6 | 23.57±2.3 |
| BMD of the right heel (SD) | 0.217±0.887 | 0.205±0.817 |
| BMD of the left heel (SD) | 0.203±0.905 | 0.199±0.915 |

## Discussion

The results indicated that a short-term vitamin D supplementation helped improve balance ability of the postmenopausal women. These results suggested that the VID group had positive effect on balance stability. This, therefore, is a good alternative supplementation choice for postmenopausal people and can help reduce falling in women in particular.

In this study, a short-term supplementation with vitamin D improved body balance in postmenopausal women. However, there were no significant changes when evaluating the muscle strength and biochemical bone markers values. One previous study[11] reported that vitamin D supplementation helped improve balance ability in older women assessed by questionnaire. On the other hand, there was only little evidence from the literature concerning duration to improve stability by vitamin D. The clinical relevance of this duration is still unclear. Grady et al[12] found no effect of vitamin D supplementation on muscle strength in postmenopausal women. However, deficiency in vitamin D leads to disorder of neuromuscular coordination and balance ability[13]. The major finding of the present study was that short-term vitamin D2 supplementation with 20,000 IU per week was definitely effective in increasing balance ability. This surprising result could be explained that short-term supplementation with vitamin D (4 weeks) was able to cause the development of neuromuscular coordination[1]. This study showed that the VID regime improved the participants' body balance when they had their eyes open on normal stability surface (Normal stability, i.e. eyes open and Anterior-posterior normal stability) showing that they used visual and other neuromuscular coordination data to stabilize the body. It is believed that this leads to improving awareness of body position caused by increased neuromuscular coordination from vitamin D supplementation[13]. The improvement in neuromuscular coordination is defects of nerve growth factor synthesis by vitamin D derivatives as shown in vitro in

**Table 2.** Response of physiological data, muscle strength and balance

| | CON; (n = 26) | | VID; (n = 26) | |
|---|---|---|---|---|
| | Pre | Post | Pre | Post |
| Physiological data | | | | |
| Weight (kg) | 59.15±4.1 | 60.13±4.1 | 59.64±3.0 | 59.81±3.63 |
| BMI (kg/m$^2$) | 23.63±2.6 | 23.97±2.5 | 23.57±2.3 | 23.60±2.5 |
| HR rest (bpm) | 79.41±2.7 | 79.83±2.5 | 79.36±3.0 | 78.85±2.9 |
| SBP (mmHg) | 128.3±2.1 | 128.1±2.3 | 128.2±3.1 | 127.7±2.7 |
| DBP (mmHg) | 80.63±3.5 | 80.55±4.1 | 80.83±3.6 | 81.16±4.3 |
| Muscle strength | | | | |
| Leg strength (kg/bw) | 0.92±0.04 | 0.92±0.05 | 0.91±0.07 | 0.95±0.09 |
| Back strength (kg/bw) | 0.64±0.06 | 0.65±0.07 | 0.65±0.08 | 0.66±0.08 |
| Balance | | | | |
| Normal stability-eyes open (%) | 85.83±2.10 | 85.72±2.23 | 85.40±2.0 | 88.23±2.7*$^+$ |
| Perturbed stability-eyes open (%) | 81.33±2.1 | 81.10±2.2 | 82.87±1.5 | 83.14±1.4 |
| Anterior-posterior normal stability (cm) | 1.45±0.05 | 1.42±0.04 | 1.45±0.05 | 1.10±0.05*$^+$ |
| Anterior-posterior perturbed stability (cm) | 1.79±0.06 | 1.78±0.05 | 1.75±0.04 | 1.65±0.05 |
| Lateral normal stability (cm) | 0.61±0.06 | 0.60±0.05 | 0.60±0.05 | 0.49±0.05* |
| Lateral perturbed stability (cm) | 0.77±0.03 | 0.78±0.04 | 0.77±0.04 | 0.75±0.05 |
| Biochemical bone markers | | | | |
| β-CrossLaps (ng/ml) | 0.467±0.061 | 0.455±0.041 | 0.445±0.065 | 0.433±0.079 |
| P1NP (ng/ml) | 50.13±4.10 | 50.34±3.85 | 50.15±2.30 | 49.85+2.35 |
| Bone formation {(P1NP)/(β-CrossLaps)}x0.31 | 33.27±3.35 | 34.29±3.77 | 34.93±3.12 | 35.68±3.24 |

* Different from the pretest, significant at the 0.05 level; $^+$ Different from the control group, significant at the 0.05 level

fibroblasts in rat brain[14]. This supports the concept that vitamin D affects more coordinative muscle function more than strength. It can be concluded that when the nervous system functions better, balance also improves. This can help reduce risks of fractures from falling especially in postmenopausal women[1,15].

After the 4-week experiment, the vitamin D supplementation group had no statistically significant changes in biochemical bone marker. It is possible that the duration of program was too short to detect a significant change by vitamin D supplementation[16-19]. Future research should substantiate this assumption.

A limitation of this pilot study was the short duration of experiment resulting in no changes in biochemical bone markers. A prolonged study is warranted to explore its implication of vitamin D supplementation in the enhancement of bone health. Furthermore, the generalization of this study was limited as the subjects were women only. A future study should strive to include men in order to be able assess the effects of the intervention. This issue should be addressed in a future study.

It can be concluded that the 4-week supplementation with vitamin D improves body balance and, therefore, may eventually prevent falling in postmenopausal women.

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**Potential conflicts of interest**

None.

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## ผลของการรับประทานวิตามินดีเสริมในช่วงระยะเวลาสั้นที่มีต่อระบบโครงสร้างกระดูกและกล้ามเนื้อ และความสามารถในการทรงตัวเพื่อป้องกันการหกล้มในสตรีวัยหมดประจำเดือน

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***วัตถุประสงค์:*** *เพื่อศึกษาผลของการรับประทานวิตามินดีเสริมในช่วงระยะเวลา 4 สัปดาห์ที่มีต่อสารชีวเคมีของกระดูก ความแข็งแรงของกล้ามเนื้อและความสามารถในการทรงตัวในสตรีวัยหมดประจำเดือน*

***วัสดุและวิธีการ:*** *กลุ่มตัวอย่างเป็นสตรีวัยหมดประจำเดือนจำนวน 52 คน ซึ่งเป็นบุคลากรของจุฬาลงกรณ์มหาวิทยาลัยที่มีอายุระหว่าง 45-55 ปี มีการเลือกกลุ่มตัวอย่างโดยแบ่งออกเป็น 2 กลุ่มๆ ละ 26 คน โดยแบ่งออกเป็นกลุ่มการรับประทานวิตามินดีเสริมจำนวน 26 คน และกลุ่มควบคุม 26 คน ด้วยวิธีสุ่มอย่างง่ายโดยกลุ่มการทดลองรับประทานวิตามินดีสองเสริมปริมาณ 20,000 IU ต่อสัปดาห์โดยมีระยะเวลา 4 สัปดาห์ และกลุ่มควบคุมใช้ชีวิตประจำวันตามปกติไม่ได้รับวิตามินดีสองเสริม แล้วดำเนินการเก็บข้อมูลทั้งก่อนการทดลองและหลังการทดลองคือ ทดสอบทางสรีรวิทยา สารชีวเคมีของกระดูก ความแข็งแรงของกล้ามเนื้อและความสามารถในการทรงตัว และนำข้อมูลนำมาเปรียบเทียบและวิเคราะห์โดยหาค่าเฉลี่ย และส่วนเบี่ยงเบนมาตรฐานที่ระดับความนัยสำคัญทางสถิติที่ 0.05*

***ผลการศึกษา:*** *ภายหลังการฝึก 4 สัปดาห์ พบว่ากลุ่มรับประทานวิตามินดีสองเสริมมีค่าความสามารถในการทรงตัวบนพื้นที่มีลักษณะปกติพัฒนาขึ้นเมื่อเทียบกับก่อนการทดลองและกับกลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05*

***สรุป:*** *การรับประทานวิตามินดีสองเสริมในช่วงระยะเวลาสั้น มีผลต่อการพัฒนาความสามารถในการทรงตัวที่ดี ซึ่งจะเป็นทางเลือกที่ดีสำหรับสตรีวัยหมดประจำเดือนและอาจจะช่วยลดการหกล้มในสตรีได้อีกด้วย*