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Research Article

Quantitative Changes in Bone Mineral Density and Lean and Fat Mass in Patients with Osteoporotic Vertebral Compression Fractures Treated by Three Weeks of Bed Rest

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Abstract

The purpose of this study was to clarify the effects of 3 weeks of bed rest on bone mineral density, lean and fat mass, and the complication rate in elderly patients with osteoporotic vertebral compression fracture. The study included 27 female patients (mean age 75 years) with a mean body mass index of 22.2 kg/m^2. The patients were kept in bed in a horizontal position for 24 h a day and allowed to raise the headrest of the bed by no more than 30^0 when eating and drinking. Bone mineral density and amounts of lean and fatty tissue were measured by dual-energy X-ray absorptiometry before and after 3 weeks of horizontal bed rest. Compared with baseline, mean bone mineral density of the pelvis decreased significantly by 7.3% and mean lean body mass decreased significantly by 5.0%. Complications occurring during the study period included delirium (4 patients), urinary tract infection (4 patients), a gastric ulcer (1 patient), and dizziness (1 patient), as well as a femoral neck fracture due to a fall after 3 weeks of bed rest. These results suggest that patients with osteoporotic vertebral compression fracture should be encouraged to ambulate as soon as possible.

Keywords: *Osteoporosis; Vertebral compression fracture; Bed rest; Bone mineral density; Lean mass; Fat mass*

Abbreviations: OVCF: Osteoporotic Vertebral Compression Fracture; BMD: Bone Mineral Density

Introduction

It is estimated that over 12.8 million people in Japan have osteoporosis [1]. Cases of osteoporotic vertebral compression fracture (OVCF) have been steadily increasing as the number of patients with osteoporosis increases. Some patients with OVCF are managed with balloon kyphoplasty [2,3] or vertebroplasty [4,5], but most are managed conservatively. However, there are no evidence-based guidelines for conservative treatment of OVCF that define the optimal duration of bed rest, the most appropriate rehabilitation programme, and the most effective brace. Therefore, the methods used vary widely between institutions. Patient with OVCF experience severe back pain [6] and need to rest in bed. An aggressive rehabilitation programme is likely to fail because of low motivation levels in the elderly. Many bed rest studies in young healthy volunteers have demonstrated that bone loss and muscle atrophy occur as a result of prolonged immobilisation and skeletal unloading [7-10]. However, there have been no reports on the changes in bone mineral density (BMD), changes in lean and fat mass, or the complications that occur in elderly patients with OVCF during bed rest. The purpose of this study was to clarify the changes in BMD and lean and fat mass as well as complication rates during 3 weeks of bed rest in elderly patients with OVCF.

Patients and Methods

Study population

Patients with OVCF were entered into this study. Patients were excluded if they had a vertebral fracture associated with high-energy trauma or a pathological fracture due to spinal metastasis of a malignant tumour, were on haemodialysis or suffering from dementia, had palsy following a cerebrovascular accident, were on corticosteroid therapy, or had infectious or tuberculous spondylitis. The study group comprised 27 female patients with mean age of 75 years, mean body weight of 53.4 kg, mean height of 155.0 cm, and mean body mass index of 22.2 kg/m^2. Two, 15 and 10 patients had OVCF at the thoracic spine, thoracolumbar junction, and lumbar spine, respectively. All patients were hospitalised. The study was approved by the Committee for Medical Ethics at Mitoyo General Hospital. Written informed consent was obtained from all patients, who were informed that they could withdraw from the study at any time.

Bed rest protocol

During the 3 weeks of bed rest, the patients were kept horizontal in bed 24h a day and allowed to raise the headrest of the bed no more than 30^0 when eating and drinking. Patients used a bedpan with the assistance of nurses. All patients received physiotherapy in bed for 30mins, 5 times a week from a qualified physical therapist who understood the principal aims of the study. The physical training programme consisted of passive joint movement and isometric exercise of the muscles of the trunk and extremities. The maximum energy intake provided was 1600 kcal/day, but patients could also request snacks between meals. All patients were allowed to sit or stand depending on their physical status after 3 weeks of bed rest.

Measurements

BMD and amounts of lean and fatty tissue were measured by dual-energy X-ray absorptiometry (Prodigy for Bone Health, GE Healthcare, Norwalk, CT, USA) before and after 3 weeks of horizontal bed rest. BMD was measured at the thoracic spine, lumbar spine, pelvis, both arms and legs, and total body. Lean mass and fat mass were measured in the trunk, arms and legs, and total body. All patients underwent plain radiography on initial presentation and 12 months after the injury. The wedge ratio for each fractured vertebra was calculated (height of anterior wall of the involved vertebra × 100/height of posterior wall of the involved vertebra [%]) at the initial presentation and final follow-up at 12 months. Complications that occurred during the 3 weeks of bed rest were also documented.

Statistical analysis

In order to establish whether significant changes had occurred, BMD and lean and fat mass were compared before and after 3 weeks of bed rest using the paired Student's t-test. Changes in the wedge ratio was also compared between baseline and final follow-up using the paired Student's t-test. A p-value less than 0.05 was considered statistically significant.

Results

	On Admission	After 3 Weeks of Bed Rest	p value	% Baseline
Right Arm	0.531 ± 0.048	0.535 ± 0.048	0.2748	0.75
Left Arm	0.506 ± 0.033	0.51 ± 0.030	0.6781	0.79
Thoracic Spine	0.549 ± 0.018	0.549 ± 0.068	N/A	0
Lumbar Spine	0.547 ± 0.089	0.557 ± 0.082	0.4776	1.83
Pelvis	0.758 ± 0.159	0.703 ± 0.127	0.0321	-7.3
Right Leg	0.798 ±0.054	0.795 ± 0.082	0.8666	-0.4
Left Leg	0.858 ± 0.136	0.86 ± 0.149	0.9371	0.23
Total Body	0.782 ± 0.057	0.781 ± 0.064	0.826	-0.1

Table 1: *Changes of BMD at before and after 3 weeks bed rest.*

There was a significant (7.3%) decrease in mean BMD of the pelvis after 3 weeks of bed rest.

(± SD g/cm^2)

There was a significant (7.3%) decrease in mean BMD of the pelvis from 0.758 g/cm^2 at baseline to 0.703 g/cm2 after 3 weeks of bed rest. There were no significant changes in mean BMD of the thoracic or lumbar spine, right or left arm leg, or total body.

There was a significant (8%) decrease in lean mass in the right arm from 1,488g at baseline to 1,369g and a significant (5%) decrease in mean total lean body mass from 30,168 g at baseline to 28,649 g after 3 weeks of bed rest.

	On Admission	After 3 Weeks of Bed Rest	p value	% Baseline
Right Arm	1488 ± 175	1369 ± 164	0.0204	-8.0
Left Arm	1426 ± 154	1068 ± 344	0.0835	-25.0
Trunk	15612 ± 1319	15082 ± 11260	0.0956	-3.4
Right Leg	4346 ± 363	4110 ± 475	0.0912	-5.4
Left Leg	4177 ± 422	3870 ± 566	0.0575	-7.3
Total Body	30168 ± 1967	28649 ± 2232	0.0075	-5.0

Table 2: *Changes of amount of lean at before and after 3 weeks bed rest.*

There was a significant (8%) decrease in lean mass in the right arm and a significant (5%) decrease in mean total lean body mass after 3 weeks of bed rest.

(± SD g)

There was no significant change in mean fat mass during the study.

	On Admission	After 3 Weeks of Bed Rest	p value	% Baseline
Right Arm	1128 ± 288	1106 ± 418	0.8162	-1.9
Left Arm	1072 ± 2851	1028 ± 365	0.6169	-4.1
Trunk	6703 ± 2563	7083 ± 2016	0.3877	5.7
Right Leg	2641 ± 11461	2650 ±984	0.9232	0.3
Left Leg	2368 ±1028	2479 ±973	0.2636	4.7
Total Body	14726 ± 4287	15122 ± 3993	0.1935	2.7

Table 3: *Changes of amount of fat at before and after 3 weeks bed rest.*

There was no significant change in mean fat mass during the study.

(± SD g)

The mean wedge ratio decreased significantly from 68.4% at baseline to 55.0% at 12 months after the OVCF. Complications occurring during the study period included delirium (4 patients), urinary tract infection (4 patients), a gastric ulcer (1 patient), and dizziness (1 patient), as well as a femoral neck fracture in a patient who fell from a standing position during a walking exercise after 3 weeks of bed rest. No cardiovascular events or cerebrovascular accidents were recorded during the 3-week study.

Discussion

A number of bed rest studies have investigated the effects of immobilisation and/or unloading on BMD, muscle mass, and calcium kinetics [11] in young healthy volunteers. In a 17-week bed rest study, Leblanc et al reported significant bone loss at the lumbar spine, total spine, pelvis, trunk, and legs in 6 healthy volunteers [12]. Similarly, Hides et al evaluated changes in the cross-sectional area (CSA) of the trunk muscles on magnetic resonance imaging in 10 healthy male subjects after 8 weeks of bed rest [13]. They reported that bed rest led to preferential atrophy of the multifidus muscle and an increased CSA in the flexor musculature of the abdomen. They also reported that the CSA of the multifidus and anterolateral abdominal muscles returned to baseline values after 4 days of re-ambulation; however, the CSA of the psoas major muscle did not return to the baseline level until day 28 of follow-up. Further, Schneider et al reported that calcium was lost at a rate of 200 mg/day in healthy male subjects during a 5-36 weeks bed rest study and observed a negative calcium balance when calcium levels were measured at 2 weeks and at 1 month of bed rest [14].

In the present study, there was a significant (7.3%) decrease in mean BMD of the pelvis after 3 weeks of bed rest. The authors of another study of prolonged bed rest (for 5-30 weeks) that included histomorphology suggested that the significant levels of bone resorption observed in their patients could be the result of increased numbers of osteoclasts and decreased numbers of osteoblasts [15]. However, the mechanism of bone resorption observed over a relatively shorter period of unloading is not fully understood. Fukuoka et al demonstrated that bone resorption could occur during 20 days of bed rest without any activation of osteoclasts [16]. Osteocytes are found in osteocytic lacunae at a density of 25,000 cells per 1 mm^3 of compact bone [17]. Osteocytes contain actin filaments that act as mechanoreceptors. Osteocytes communicate with each other through a network consisting of dendrites that extend through the tubular canaliculi. Unloading or immobilisation is detected by osteocytes and sclerostin, a glycoprotein secreted predominantly by osteocytes under physiological conditions. Sclerostin is an important negative regulator of bone mass that acts by inhibiting bone formation by osteoblasts [18]. Microgravity and decreased mechanical loading experiments have shown that sclerostin becomes upregulated and BMD decreases [19]. The amount of calcium released from bone via osteoclasts is thought to account for only 0.1% of total calcium elution. It is well known that the osteocytic-osteoblastic network has a significant role in calcium metabolism in bone [17]. Osteocytes may have played an important part in bone resorption during the present relatively short bed rest study.

Patients with OVCF have low BMD, poor bone quality, and occasionally sarcopenia. Elderly patients with OVCF tend not to want to move because of severe back pain. It is widely accepted that the best initial treatment for these patients comprises pain relief and prescription of an adequate brace and rehabilitation to prevent disuse syndrome [20]. This study clearly demonstrated that BMD of the pelvis decreased significantly by 7.3% from baseline and total lean body mass decreased significantly by 5.0% from baseline. In a 90-day bed rest study reported by Rittweger., *et al.* bone loss of -6.0% was observed at the tibial epiphysis in 25 young healthy participants in the absence of any exercise or medication. Complete recovery of diaphyseal bone loss was observed 1 year after re-ambulation [21]. Recovery of bone loss is possible but time-consuming, even in young healthy individuals. Unloading or immobilisation might affect elderly patients with OVCF even more profoundly and complete recovery is unlikely.

In this study, a number of adverse events were documented during 3 weeks of bed rest, including delirium, urinary tract infection, gastric ulcer, and dizziness, as well as a femoral neck fracture due to a fall during the re-ambulation period. Although no cardiovascular events were observed in the present study, prolonged bed rest has been associated with increased levels of cystatin C, which is a marker of increased cardiovascular risk [22]. The findings of this study suggest that patients with OVCF should be encouraged to ambulate as soon as possible.

Conclusion

Mean BMD at the pelvis and mean total lean body mass decreased significantly from baseline during this 3-week bed rest study. Bed rest for this relatively short length of time was associated with a number of adverse events. Patients with OVCF should be encouraged to ambulate as soon as possible to minimise bone loss, muscle atrophy, and the risk of complications during immobilisation.

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