Weight-Bearing Versus Non-Weight-Bearing Exercises in Management of Osteoporosis in Geriatrics

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ABSTRACT

Purpose: *The purpose of this study was to compare the effects of weight -bearing exercises with non weight-bearing exercises on elderly patients with osteoporosis.* ***Subjects:*** *Forty elderly osteoporotic patients (13 male and 27 female) "with T- score less than –2.5 in the lumbar spine and right femoral neck" participated in this study, their age ranged from 60 to 70 years old.* ***Methods:*** *The patients were divided randomly into two groups:* ***Group-I:*** *Twenty patients with mean age (65.7±2.9) years old practiced weight-bearing exercises program.* ***Group-II****: Twenty patients with mean age (65.8±3.2) years old practiced non-weight - bearing exercises program. Each patient was trained for 30 to 45 minutes/ session, two times /week for 6 months. The bone mineral density (BMD) of the lumbar spine and right femoral neck were measured by (DXA) for each patient before and after the exercise program in addition to the quality of life by "ECOS-16" questionnaire.* ***Results:*** *Paired and student t-tests proved that the mean values of BMD of the lumbar spine and right femoral neck were significantly increased in both groups with more significant increase in weight-bearing group. The quality of life was significantly improved in both groups without any significant differences between them.* ***Conclusion:*** *The weight -bearing exercises program may increase bone mineral density greater than the non-weight-bearing exercises in elderly subjects with osteoporosis. Weight-bearing or non-weight-bearing exercises could be effective in improving the quality of life of patients with osteoporosis.*
Key words: *Osteoporosis, Bone mineral density, Weight-bearing, exercises, Quality of life and Geriatrics*.

INTRODUCTION

The deterioration of the physiological capacity of human occurs as a consequence of the biological aging process[38]. The reduction in functional capacity consequently decreases the ability to perform the common activities of daily living in the older population[35]. Osteoporosis is a major public health problem in the elderly population in the worldwide[31]. Osteoporosis is described as a systemic skeletal disease characterized by low bone mass, deterioration of the bone tissue, increasing bone fragility and it's susceptibly for recurrent fractures[20,36]. It is a silent disease that causes no symptoms until a fracture occurs[28]. It is a debilitating disease affecting millions of people. It leads to an increased risk of bone fracture in the elderly due to loss of bone mass and strength[19]. The greatest direct expenditures associated with osteoporosis arise from the treatment of fractures and their squeals in elderly[30].

Bone strength depends on bone size, volumetric bone density, micro architecture, and intrinsic bony tissue properties. The risk of osteoporosis depends on the achievement of peak bone mass[27]. Bone mineral density (BMD) was controlled by interaction of many factors. These factors mainly are genetic and non-genetic factors[36]. Hormonal status is one of the major non-genetic factors, so hormone-replacement therapy (HRT) is mainly effective in the prevention of bone loss in early post-menopause[27,31]. Parathyroid hormone (PTH) has been shown to be an anabolic agent for animal and human skeletons. It plays an important role in bone mass homeostasis. The combined PTH administration and exercise training are beneficial in the treatment of osteoporosis[26]. Many investigators support that growth hormone could enhance loading-related bone formation and modulate the responsiveness of bone tissue to mechanical stimuli by changing the mechanical thresholds for bone formation[14].

Several risk factors for osteoporosis have been identified in the literature[20]. Bone mass and prevalence of osteoporotic fracture differ by sex, as the female has more risk[25, 39]. About 80% of osteoporosis occur in women and 20% in men[28]. At the same time both women and men are experiencing an age-related decline in BMD starting in the midlife[27]. Consequently all post-menopausal women and men over 50 years of age should be assessed for the presence of risk of osteoporosis[30]. So if osteoporosis or low BMD is identified, the evaluation of contributing risk factors should be considered e.g. patients on long-term glucocorticoid therapy are at high risk for developing osteoporosis[28,5]. In addition family history of osteoporosis, menopause before age 45 years, diet and inactivity are considered risk factors for developing osteoporosis[9]. In addition sedentary lifestyle and smoking were considered as main risk factors for the bone loss[5].

Many devices and techniques are available for measuring BMD[28]. Dual-energy X-ray absorptiometry (DXA) is the method commonly used to diagnose osteoporosis. This technique used for measuring the central skeleton (e.g. spine, proximal femur)[24,10] or measured some part of the peripheral skeleton as ultradistal and proximal radius[2]. Other factors that may alter bone strength "include bone turnover, architecture (size and shape, or bone geometry), micro architecture, damage accumulation, matrix properties, mineralization, and mineral properties" can be detected as bone quality[17]. Quantitative ultrasound (QUS) of the bone by ultrasound bone densitometer is widely reported as a recent technique[3,32]. Calcaneal QUS measurement is becoming increasingly popular for the assessment of skeletal status in children, adults, postmenopausal women and elderly subjects[7,12,29].

Health-related quality of life (HRQOL) assessment plays an increasingly important role in intervention studies for patients with osteoporosis[33]. HRQOL is used as an outcome measure that complements BMD measurement in osteoporosis because the imaging tests don't adequately reflect the extent to which the patient is affected in his or her daily activities[4].

Good nutrition is considered an essential factor for good bone health[8,27]. Calcium is the most important nutrient for attaining peak bone mass. Vitamin D is required for optimal Calcium absorption and thus it is also important for bone health. In addition there is strong evidence that physical activity contributes to bone mass building up [35,15,43]. It was documented that physical activity has positive effect on growing bones[15,16] during childhood , adolescence[18], in adults[43]and in elderly subjects[27]. Many investigations have confirmed that active children have a higher bone mass than non-active children[15,16]. Many trials of exercises intervention are proved to increase physical activity during bone growth[15,16], in adults[43] and to overcome osteoporosis[41].

Physical exercises have a good influence on bone health[23]. Exercises have a benefit on bone mechanical properties by changing the composition of the bone (e.g. water content ratio, collagen formation) in addition to the BMD[22]. There is a positive stress/strain relationship between exercise and bone so it has potential benefits in preventing bone loss. The adaptation of bone to exercise is critically important in designing public health[30,25]. Forces generated through the mechanical loads during exercises promote osteogenesis[21]. Other benefits of exercises in elderly are the improvement of balance, reduction of recurrent falling and the associated risk of fracture[27,11]. At the same time exercises have the ability to improve body composition[43] and muscle strength[13] Which is other predicting factor of bone mass and strength[43]. In the literature there is agreement on that both men and women should be encouraged to participate in exercise program[8,40]. It was suggested that continued training at a reduced frequency and intensity is required to maintain the musculoskeletal benefit from exercise which may lower fracture risk in later life[43].

Different techniques of exercises are recommended in the literature to benefit bone mechanical properties[22]. Resistance exercises (RE) are used to enhance bone mass in form of strength training programs[43] due to the belief that improved strength has been associated with improved muscle and bone mass, balance, and mobility. All of these factors are important in the prevention of fractures and improved quality of life[35]. Swimming exercises produce some beneficial effects on bone structure, turnover, and strength[19,22]. Recently some investigators suggested that whole body training may also increase general BMD[41]. Weight-bearing exercises are the most popular type of exercises used for bone osteogenesis in children, adolescents, adults, and in post-menopausal women[15,41]. This category of exercises mainly include impact as a component[21,40], because this type of exercise load the skeleton in an atypical manner that increased BMD[25,19]. Forces generated through mechanical loads during any exercise promote osteogenesis. These forces are highest during weight-bearing modes of exercises[41]. These modes of exercises are traditionally recommended for improving bone health in post-menopausal women[19]. Weight-bearing exercises are applied in literature with different modes as running[22] or jumping[21,43]. Then recently it was suggested that a relatively light weight bearing exercises may be beneficial and feasible in elderly for the prevention of osteoporosis[8].

So the purpose of this study was to investigate the effect of weight -bearing exercises in elderly patients with osteoporosis and to compare its effect with that of non-weight-bearing exercises on those patients.

METHODS AND PROCEDURE

Subjects

Forty patients (13 male and 27 female) ranged in age from 60 to 70 years old. Each patient was diagnosed according to DXA measurement ("T-score," lower than-2.5). The patients were divided randomly into two equal groups. ***Group-I:*** Twenty patients (6 male and 14 female) with mean age (65.7±2.9) years old trained with weight -bearing exercises program. ***Group-II:*** Twenty patients (7 male and 13 female) with mean age (65.8±3.2) years old trained with non-weight-bearing exercises program. Each patient practiced the program for 30 to 45 minutes/ session, two times /week for 6 months (table 1). Each patient was informed with all procedures, and signed a consent form to continue the training program for 6 months. Each patient was evaluated before and after the training program. This study was conducted at the out-clinic of Faculty of Physical Therapy, Cairo

University. The radiographic investigation was conducted in Department of Radio diagnosis, Faculty of Medicine, Cairo University. Elderly patients suffered from uncontrolled hypertension, diabetes, symptomatic cardio respiratory disease, severe renal or hepatic disease, progressive neurological disease, chronic disabling arthritis, significant dementia, anemia and marked obesity with the inability to exercise were excluded from the study.

Instrumentation

1) Dual-energy X-ray absorptiometry (DXA) was used for measuring Bone mineral density (BMD) and detection of "T-score"[10,24,28].
2) ECOS-16 Health related quality of life questionnaire was used to study the effect of the both groups on quality of life[4].

Assessment Procedure

1- Dual-energy X-ray absorptiometry (DXA) used to detect a "T-score," which is the number of standard deviations above or below the mean BMD for normal young adults. "Osteoporosis is defined as a T-score lowers than -2.5". T-score of the lumbar spine, and right femoral neck are calculated to reflect the BMD[24,28]
2- "ECOS-16" questionnaire: It is a self-administered questionnaire. It consists of 16 items "12 items from the Quality of Life Questionnaire of the European Foundation for Osteoporosis (QUALEFFO) and 4 items from the Osteoporosis Quality of Life Questionnaire (QOLQ). ECOS-16 questionnaire includes four dimensions: Physical Function, Pain, Fear of illness and Psychosocial function. The score of each item ranges from 1(best HRQoL) to 5(worst HRQoL). The time frame for the questionnaire was the last week. All items have the same weight on the overall questionnaire score and the overall score is calculated as the mean score of all the response items[4].

Treatment procedure

Each patient was trained for 30 to 45 minutes/session, two times /week for 6 months Each patient performed warming up (brisk walking 10 minutes and gentle stretching of knee flexors, calf muscles, lower back muscles)[12,13,25]. Each patient practiced the weight-bearing or the non-Weight bearing exercises program then followed by cooling down (brisk walking 5 minutes).

Weight-bearing exercises program

These exercises are performed three sets, eight repetitions

1- Double leg press on the wall from 30°, 60°, 90° flexion angles[13,35,41].
2- Unilateral leg press on the wall from 30°, 60°, 90° flexion angles
3- Quarter squats up to right angle knee flexion[43].
4- Wide stance mini squat with arm support on the wall barr[41].
5- Step up exercises with arm support[41].
6- Calf rises with upper limb support[25,43].
7- Wall slides from supine[2].
8- Standing on one limb 20 sec. with arm support[25].

Non-Weight bearing exercises program

These exercises are performed three sets, eight repetitions. The resistance was determined to be 25% of 1 repetition maximum which is re-evaluated after each two months (1RM)[13].

1- Hip exercises (flexion, extension, adduction and abduction)[25].
2- Leg extension exercises "static and dynamic"[41].

3- Quadriceps curl[13,35].
4- Hamstrings curl[13,35].
5- Ankle exercises.
6- Stationary bicycle ergometer was used with high seat "for 5 minutes" at mild intensity[13,25].
7- Back extension exercises from standing and supine position[34].

Statistical analysis

The collected data were statistically analyzed using *Paired t-test* to compare the effect of each training program within each group. *Student t-test* was used to compare the mean differences between weight-bearing exercises and non-weight bearing exercises programs in both treatment groups.

RESULTS

1- Physical characteristics of elderly subjects in both treatment groups

There were non-significant differences between both groups in the physical characteristics of elderly subjects. Their age ranged from 60 to 70 years old with mean value (65.7 ± 2.9) in group-I and (65.8 ± 3.2) in group-II. The range of height was (150 to 186cm.) with mean value (169.9 ± 8.4) in group-I and (165.2 ± 8.7) in group-II. The range of weight was (65 to 88) Kg. with mean values (69 ± 5.6) in group-I and (71.7 ± 7.4) in group-II. The range of BMI (Body mass index) was (20-30) Kg/cm with mean values (25.1 ± 2.9) in group-I and (24.4 ± 3.1) in group-II. (Table 1).

Table (1): Physical characteristics of elderly subjects in both groups.

Variables	Age		Height		Weight		BMI	
Group	G I	G II	G I	G II	G I	G II	G I	G II
Range (min-max)	(60-70)		(150-186)		(65-88)		(20-30)	
Mean	65.7	65.8	169.9	165.2	69	71.1	25.1	24.4
SD	2.9	3.2	8.4	8.7	5.6	7.4	2.9	3.1
T-value	0.05†		1.7†		1.3†		0.61†	

† Non significant P>0.05 GI: group-I G II group-II

2- Bone density after training program in both treatments groups

In group-I (weight-bearing exercises program) the mean values of "T-score" in lumbar spine significantly reduced from (-4.1 ± 0.8) to (-3.9 ± 0.9) and the "T-score" of the right femoral neck significantly reduced from (-4.1 ± 0.73) to (-3.6 ± 0.76), (Table 2, fig.1).

Table (2): The mean values of "T-score" in lumbar spine, and femoral neck, in-group (I).

Variables	lumbar Spine		Femoral Neck	
	Pre	Post	Pre	Post
Mean	-4.1	-3.9	-4.1	-3.6
SD	0.8	0.9	0.73	0.76
T-value	6.1*		9.44*	

*Significant P<0.05

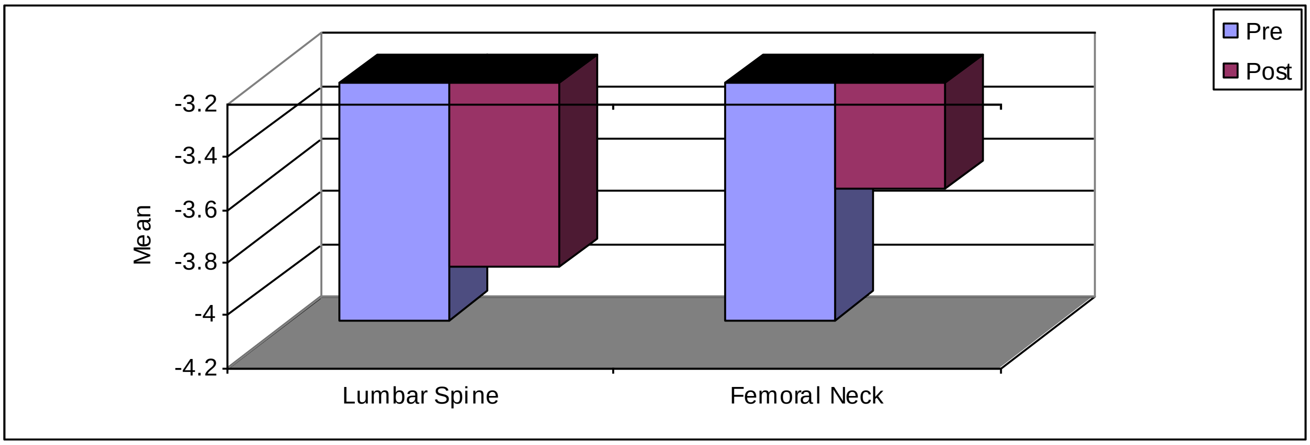

Fig. (1): The mean values of "T-score" in lumbar spine, and femoral neck, in-group (I).

In group-II (Non-weight bearing exercises program) the mean values of "T-score" in lumbar spine significantly reduced from (-4.4 ± 0.7) to (-4.3 ± 0.8) and the "T-score" of right femoral neck significantly decreased from (-4.3 ± 0.71) to (-4.1 ± 0.72) (table 3, fig. 2)

Table (3): the mean values of "T-score" in lumbar spine, and femoral neck, in group (II).

Variables	Lumbar spine		femoral neck	
	Pre	Post	Pre	Post
Mean	-4.4	-4.3	-4.3	-4.1
SD	0.7	0.8	0.71	0.72
T-value	4.8*		7.8*	

*Significant P < 0.05

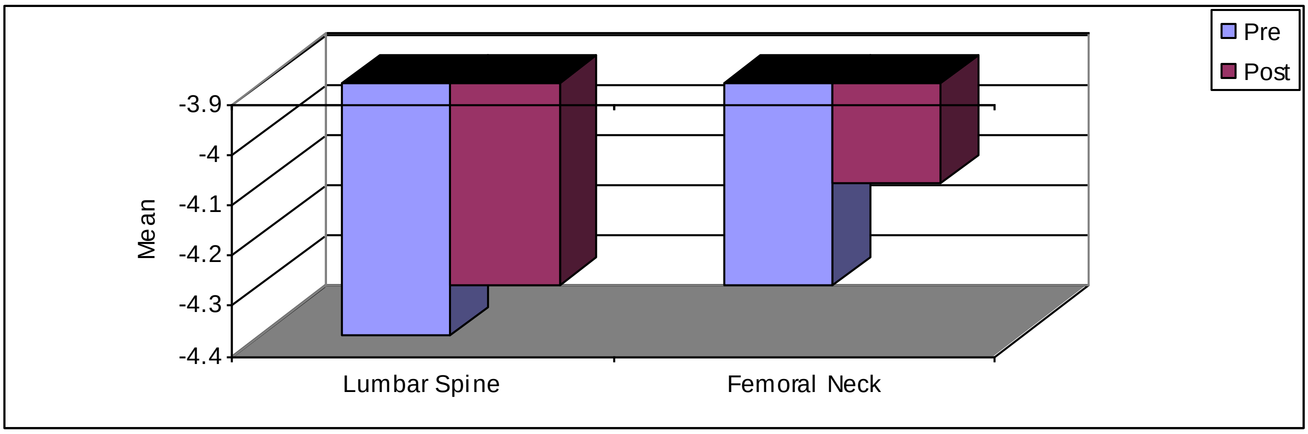

Fig. (2): The mean values of "T-score" in lumbar spine, and femoral neck, in group (II).

With comparison of "T-score" in lumbar spine, and femoral neck, between both groups there was a significant reduction of "T-score" in lumbar spine in group-I with the mean difference (-0.32 ± 0.25) which is greater than that of group-II (-0.12 ± 6.3). "T-score" in femoral neck significantly reduced in group-I with the mean difference (-0.49 ± 0.22) more than that of group-II (-0.12 ± 7.1), (Table 4, fig.3).

Table 4: the mean difference of "T-score" in lumbar spine, and femoral neck, in both training groups

Variables	Lumbar spine		femoral neck	
	Group I	Group II	Group I	Group II
Mean	-0.32	-0.12	-0.49	-0.12
SD	0.25	6.3	0.22	7.1
T-value	18.8*		17.1*	

*Significant P<0.05 GI : Group I GII: Group II

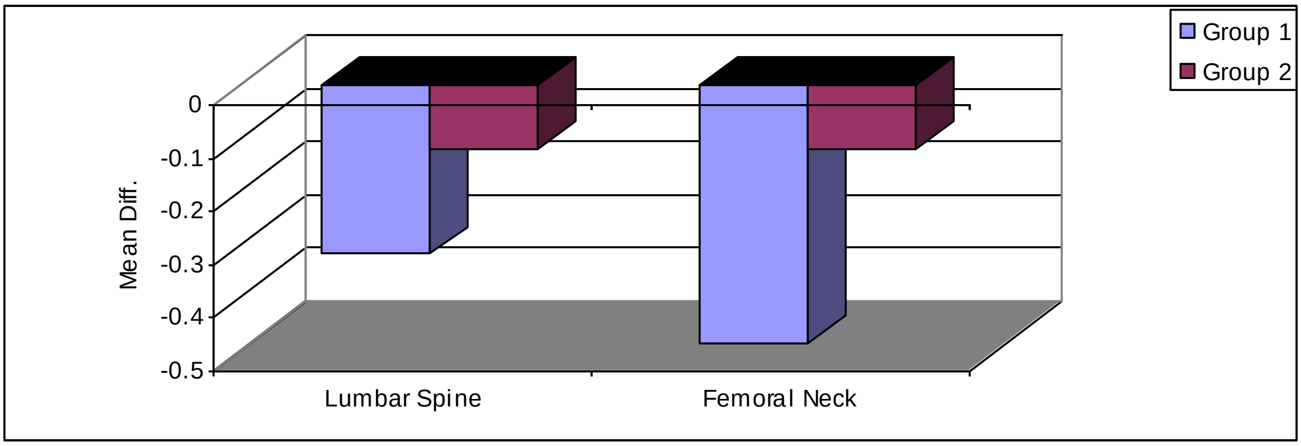

Fig. (3): The mean difference of "T-score" in lumbar spine, and femoral neck in both training groups.

3- Quality of life after both training programs

The mean values of quality of life significantly increased after both training programs. The ECOS 16 questionnaire significantly reduced from (48 ± 6.6) to (37 ± 6.5) in group-I, and from (47.3 ± 5.4) to (34.8 ± 4.9) in group-II. There were non-significant differences between both treatment groups (Table 5, Fig.4).

Table (5): Quality of life "ECOS 16 questionnaire" after training program in both training groups.

Variables	Group I		Group II		Mean diff.	
	Pre	Post	Pre	Post	G I	G II
Mean	48	37	47.3	34.8	10.9	13.5
SD	6.6	6.5	5.4	4.9	3.9	3.3
T-value	10.5*		15.3*		0.35†	

* Significant P<0.05 † Non significant P>0.05 GI: group-I G II group-II

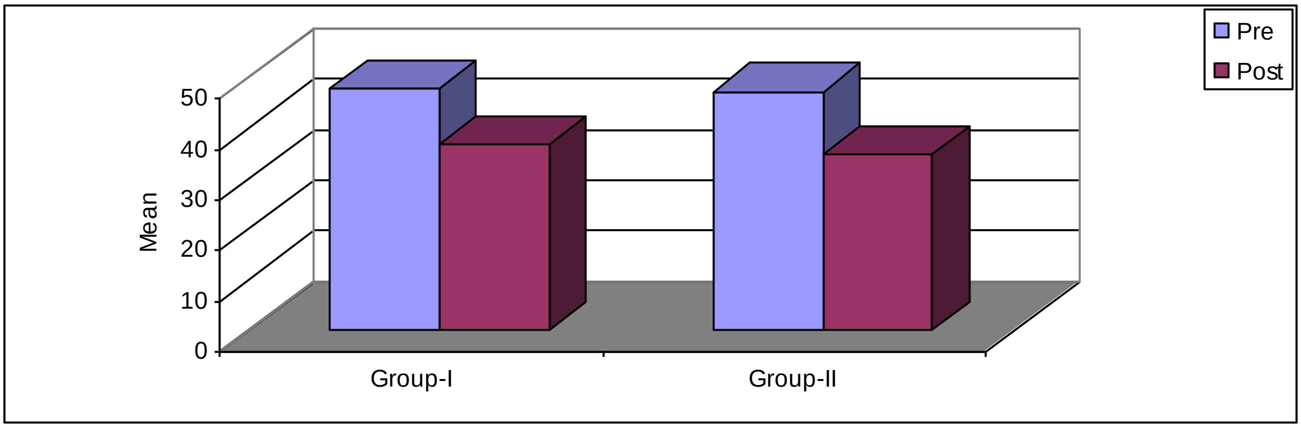

Fig. (4): Quality of life "ECOS 16 questionnaire" after training programs in both groups.

DISCUSSION

The results of this study showed that there were significant reductions of "T-score" of the lumbar spine, and right femoral neck, after either weight-bearing or non-weight-bearing exercise programs. The "T-score" is calculated by DXA which is the most common radiological method used to diagnose osteoporosis and to reflect the improvement of BMD in subjects with osteoporosis[2,10,24].

This result came in agreement with the literature[34,35]. Pfeifer et al 2004[34] reported in their article review that patients with low bone mineral density would benefit most from specific exercise programs. This can be explained by that muscle strength "which is the main out put of exercises" influence bone density[6,25,42]. It is considered as a predictor of bone density in elderly subjects[35,39], because during muscular contraction the force exerted by the muscle pull on the bone has a strong osteogenic stimulus[9]. In support of this idea some investigators found that the combination of progressive impact (jump) and resistance training can increase bone mineral density in pre-menopausal women[43].

In contrast to the result of the current work Adami et al 1999[2] found that strength training has very little effect on bone mass at the femoral neck, lumbar spine, ultradistal and proximal radius. The program in Adami et al 1999[2] study was moderate physical exercise and designed to maximize the stress on the wrist only, while in the this study the exercises cover weight bearing parts of the body as much as possible. In addition the program of this study continued to 6 months in a progressive mode.

There was more significant reduction of "T-score" in lumbar spine and femoral neck in group-I (Weight-bearing exercises program) than group-II (Non-weight-bearing exercises program); after 6 months of training. This revealed that weight-bearing has more influence on bone density especially on weight -bearing bones. This came in agreement with many previous works[19,21,28,41]. Verschueren 2004[41] found that whole body vibration training significantly increased bone mineral density of the proximal hip in postmenopausal women. This may be explained by that the muscular forces are highest during weight-bearing mode of exercises[38,19]. It may have more osteogenic effect on bone than non-weight-bearing[18]. Weight-bearing exercises e.g. running, jumping also may be useful to increase bone strength, mass, and morphometry in middle aged ostoepenia[21] especially at weight-bearing sites[23].

In contrast to the current study Huang et al 2003[22] found that both weight-bearing exercises (running) and non-weight-bearing exercises (swimming) benefits the intrinsic and extrinsic bone mechanical properties. Huang et al 2003[22] studied the growing bone of rats (animals) not osteoprotic bone and investigated the bone mechanical properties while this study conducted on osteoprotic bone of elderly humans and recorded "T-score" as a predictor of bone density in osteoprosis. In addition bone mechanical properties were not investigated.

The exercise program in this study was designed to be suited to elderly subjects based on previous researches[2,13,,25,35]. The subjects trained two times per week for 30- 45 minutes in the session[25]. The program proceeded with warming up period of walking and gentle stretching[2,13]. The total time of program was 6 months to be enough to improve bone density[2,41]. The weight-bearing exercises were performed with ninety degree of knee flexion to avoid high compression force inside the knee and pain. The exercises in non-weight-bearing program were with resistance 25 % of 1 repetition maximum (1RM) for three sets, eight repetitions[13,35].

The quality of life was one of the measured variables in the current study because the assessment of quality of life is needed to properly quantify the disease burden[1]. Health-related quality of life assessment has become an integral part in assessment and follow-up of osteoporotic subjects[33]. The "ECOS 16 questionnaire" was used in the current study to predict quality of life in elderly with osteoporosis. The "ECOS 16 questionnaire" is reported to be a valid and reliable tool for the evaluation of health-related quality of life in postmenopausal women with osteoporosis[4].

The results of the current study proved that the quality of life measured by "ECOS 16 questionnaire" significantly increased after both weight-bearing and non-weight-bearing exercise programs without any significant differences between both treatment groups. This was supported by many previous studies[13,35]. It seems that the programs focusing on strengthening exercises could help in prevention of physical dependence and thereby improves the quality of life in elderly[35]. Many authors found that the well-designed supervised exercise program may have psychosocial advantages such as alleviation of feelings of depression, loneliness, and isolation and improvements in cognitive function[13]. These are the main parts of "ECOS 16 questionnaire" which was improved in both groups after both exercises programs.

Conclusion

It was concluded from this study that weight -bearing exercises could increase bone mineral density greater than the non-weight-bearing exercises in elderly subjects with osteoporosis. At the same time both weight-bearing and non-weight-bearing exercises are effective in improving the quality of life of those patients.

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الملخص العربي

تمرينات تحميل الوزن مقابل تمرينات عدم تحميل الوزن في علاج هشاشة العظام لدي المسنين

تهدف هذه الدراسة إلى مقارنة تأثير تمرينات تحميل الوزن وعدم تحميل الوزن علي مرضي هشاشة العظام من المسنين. تشمل هذه الدراسة أربعين مريضاً من المسنين (13من الذكور و27 من الإناث) تتراوح أعمارهم ما بين ستين وسبعين عاما. بعد أن تم تشخيصهم انهم يعانون من هشاشة العظام طبقا لمقياس كثافة العظام "مقياس تى اقل من -2.5 " تم تقسيم المرضي عشوائيا إلى مجموعتين متساويتين في العدد: المجموعة الأولى تشمل عشرون مريضاً (6 من الذكور و 14 من الإناث) متوسط أعمارهم (2.9 ± 65.7) تم تدريبهم ببرنامج تمرينات تحميل الوزن.المجموعة الثانية تشمل عشرون مريضاً(7 من الذكور و 13 من الإناث) متوسط أعمارهم (3.2±65.8) تم تدريبهم ببرنامج تمرينات عدم تحميل الوزن. كانت مدة تدريب جميع المرضى تتراوح بين ثلاثون - وخمسة وأربعون دقيقة في الجلسة الواحدة بمعدل مرتان أسبوعيا لمدة ستة أشهر. تم قياس كثافة العظام "مقياس تى" للفقرات القطنية، والرقبة الفخذية اليمني، عن طريق جهاز "ديكسا" قبل وبعد برنامج العلاج بالإضافة إلى قياس جودة الحياة بمقياس (إكوس16) .أثبتت النتائج الإحصائية وجود تحسن ملحوظ في قياس كثافة العظام "مقياس تى" للفقرات القطنية، الرقبة الفخذية اليمني، في المجموعتين مع زيادة تحسن كثافة العظام في المجموعة الأولى بعد تمرينات تحميل الوزن عن المجموعة الثانية. و تحسن جودة الحياة لدي المجموعتين مع عدم وجود فارق معنوي بين المجموعتين. يستخلص من نتائج هذا البحث أن برنامج تمرينات تحميل الوزن له تأثير أعلي في زيادة كثافة العظام وعلاج هشاشة العظام عند المسنين وان كلا من تمرينات تحميل وعدم تحميل الوزن لها تأثير فعال في تحسن جودة الحياة لمرضي هشاشة العظام من المسنين.