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Results of a Home Exercise Program for Patients with Osteoporosis Resulting from Neurological Disorders

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ABSTRACT

There are no studies in the literature on the effect of exercise in reversing osteoporosis of the upper extremities for people with neurological disorders. The purpose of this study was to explore what conditions respond to a home exercise program for the upper extremities. Sixteen patients, divided randomly into experimental and control groups, were recruited for this trial for at least one year. Both upper extremities of the patients, affected and unaffected, were tested pre and post trial with the Hologic QDR for bone area, bone mineral content (BMC), bone mineral density (BMD), fat, muscle mass, muscle mass plus BMD, total weight, and relative fat content (percent). The home exercise program involved the subject squeezing a ball, one hand at a time, 20 times each, three times a day, at least three times a week, while sitting with the elbow flexed and the arm resting comfortably at the side of the trunk or on an armrest. A significant difference ($p < 0.02$) was found in bone area, BMC, BMD or relative fat content between the affected and sound sides both before and after the study, although all parameters were much different for each patient. We found a statistically significant difference in a change in the bone area for the affected upper extremities of the control group, but not of the experimental group. Subjective reactions of the subjects were positive. They stated that they felt they were improving and contributing to their recovery. Patients with Parkinson's disease, but not those with cerebral infarction, seemed to react to the exercise with an increase in bone mineral content, although the difference was not significant due to the scarce number of subjects. This is a preliminary pilot study to help develop further research on what condition is likely to respond to exercise for protection against osteoporosis.

Key words: *Exercise, Osteoporosis, Neurological disorders*

Osteoporosis is a disease of the skeletal system characterized by low bone mineral density and micro architectural deterioration of the bone tissue[28,32,42]. This condition leads to an increased fragility of the bone, which may very likely result in a fracture[3,21] associated with chronic disabling pain[28]. Osteoporosis influences various organs[28] and psychosocial conditions[4,9,12,25,29]. Although it was once considered a natural part of aging[24,27,33,35,40], many factors seem to contribute to the cause of this disease[5,28,29,38].

Regular physical activity and its effects on the health of bones have been the subject of many clinical and observational studies, especially for the elderly and post-menopausal women[2,12,16–18,20,22,26,30,32,44]. The effects of physical exercise for post-menopausal women might reshape both the geometry and structure of specific bone segments, such as the ultradistal radius[1,7]. Increased physical activity might also be helpful in increasing lumbar bone mineral density (BMD) in postmenopausal osteoporotic women[14,15]. Exercise programs for older individuals should be designed to maximize musculoskeletal benefits while minimizing dangers from intensive exercise[3]. Evans[8] stressed that resistance training of the elderly is important to improve bone density, muscle mass, strength, and balance and to decrease the risk for an osteoporotic bone fracture in postmenopausal women. There is, in fact, an awareness of the need for exercise to prevent osteoporosis, but many people complain of the lack of time, lack of self-discipline, health problems, lack of interest, or poor terrain[10]. On the other hand, following a supervised training period, an unsupervised aerobic and step program for premenopausal women helped maintain the significant BMD increases originally obtained during the supervised period of their study[11]. Walker et al[43] suggested that supervision was not an issue in their study, where their post-menopausal sub-

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jects with osteoporosis were able to maintain their height and the BMD of the lumbar area over a five-year period.

After a four-year trial, long-term regular aerobic physical activity in middle-aged men did not have any effect on the age-related loss of the femoral BMD[13]. Kerschan et al[19] suggested that an unvarying home-based exercise program might not be an effective method for improving the status of elderly women. Weight-bearing exercises such as walking and jogging can have a modest benefit in the prevention and treatment of osteoporosis, whereas site-specific resistive exercises appear to have a more consistent effect on bone mineralization and muscle strength[39].

However, there are very few studies on patients with osteoporosis resulting from neurological disorders. A few studies have been conducted on subjects with a sustained spinal cord injury[6,23,31,34,37,41] and disuse osteoporosis due to bone metabolism disorders[41]. Some medications can also lead to osteoporosis, for example betadine used for hyperthyroidism[41]. Valayer-Chaleat et al[41] suggested that the combination of disuse osteoporosis and iatrogenic hyperthyroidism might induce a reduction of BMD for spinal cord injured patients. Patients with spinal cord injuries at or above C7 are extremely physically inactive, which may cause a decline of the growth hormone secretion, resulting in hyposomatomedinemia[37]. If the muscle mass could be increased, the effect on bone density may be favorable and may help protect against osteoporosis. Leeds et al[23] and Petrofsky and Phillips[34] used exercise with functional electrical stimulation to obtain an increase in BMD. Although an increase in BMD did not occur[23], their training resulted in a more rapid increase in muscular strength and endurance than the reversal of osteoporosis, which leads to a susceptibility for fractures[34]. They recommend "impact vibration" to produce an increase in BMD. A standing and ambulation device was used to reverse osteoporosis in patients with paraplegia, but there was no significant change in the BMD[31]. Cowell et al[6] suggested that it is important to prevent the paraplegic from functional degeneration, but caution and careful research is necessary to insure the safety of the patient and to prevent unnecessary injury.

No studies could be found on the effects of exercise in reversing disuse osteoporosis for people with long-standing neurological disorders except for the spinal cord injury subjects. There were also no reports on the effects of exercise for the upper extremity. Therefore, the authors decided to undertake a clinical study on the effects of exercise on the upper extremities of patients with osteoporosis due to neurological disorders. A home program was chosen to provide the patients with a continuous program to be done over a long period of time, i.e. at least one year. The program chosen needed to be simple and safe in order to obtain compliance.

MATERIALS AND METHODS

Sixteen patients who presented at the neurology department of the out-patient clinic of the Hiroshima Prefectural College of Health Sciences were recruited as participants of this controlled trial for at least one year. All the patients were Japanese and had neurological conditions that included an incomplete paralysis of one of their upper extremities (Table 1). Patients were randomly divided into exercise group and control group according to their entry sequence.

The characteristics of the subjects were quite varied, as each one was included into the program strictly on the basis of the order in which s/he was recommended and admitted to our clinic and diagnosed with osteoporosis. No matching was attempted, and the selection of groups was random. The nine experimental subjects trained on a daily basis, approximately three times a day. The seven control subjects continued as usual, with their standard physical therapy being the only form of exercise performed. No adverse effects were noted from this study or from the use of a home exercise program. We confirmed both from the patients and from their families that the exercise was performed completely as instructed. The subjects reported at the time of the first return visit and at the follow-up visits that compliance with the program was good. The subject's word was taken as the measure of compliance. Participation rate was 100% throughout the program. They all reported that it was easy to perform and that they had very little difficulty in remembering to do the exercises.

The diagnoses included Parkinson's disease (2 subjects in the exercise group; 1 subject in the control group), spondlyosis deformans (1 subject in the exercise group), cerebral infarction (4 subjects in the exercise group: 3 subjects in the control group), cerebellar ataxia; multiple system atrophy (1 subject in the exercise group), cerebral hemorrhage (1 subject in the exercise group; 2 subjects in the control group), and subarachnoid hemorrhage (1 subject in the control group). The age of patients in the exercise group was 64.2 ± 9.6 years old (mean ± SD) and in the control group was 57.6 ± 15.4. The duration of the illness was 3.8 ± 3.0 and 3.9 ± 4.2 years in the exercise group and control group, respectively. The onset of diseases was determined from the history of patients as the time when they first complained of disorders related to the disease. Nine of the patients, five males and four females, comprised the experimental exercise program, while seven patients, four males and three females, served as controls.

Osteoporosis was diagnosed according to the

Table 1. Demographics of the Subjects

Experimental Group

Subject	Sex	Age (1)	Diagnosis	Onset (2)	Region (3)	Treatment (4)
1	F	50	Parkinson's disease	3	Left arm	3
2	M	69	Spondylosis deformans	0.5	Left arm	1.5
3	M	67	Cerebral infarction	5	Left arm	1.5
4	F	73	Cerebellar ataxia	6	Left arm	2
5	M	62	Cerebral infarction	1	Left arm	3
6	M	49	Cerebral infarction	1	Left arm	1
7	M	61	Cerebral hemorrhage	6	Left arm	2.5
8	F	73	Parkinson's disease	2	Right arm	1
9	F	74	Cerebral infarction	10	Left arm	1

Control Group

Subject	Sex	Age (1)	Diagnosis	Onset (2)	Region (3)	Testing (5)
1	M	71	Cerebral infarction	14	Right arm	2.5
2	F	26	Subarachnoid hemorrhage	3	Right arm	1
3	F	65	Cerebral hemorrhage	3	Right arm	1
4	M	59	Cerebral hemorrhage	1	Left arm	1.5
5	M	69	Cerebral infarction	2	Right arm	1.5
6	F	62	Parkinson's disease	2	Left arm	1.5
7	M	51	Cerebral infarction	2	Right arm	1.5

(1) Age at beginning of experiment
(2) Approximate years from onset till program began
(3) Region = area of weakness/paralysis
(4) Treatment = length of time in approximate year (s)
(5) Testing = length of time between Hologic tests in approximate year (s)

diagnostic criteria for osteoporosis in Japan (1996), these criteria being widely used in Japan[14,15]. The left upper extremity was the involved side for 8 subjects in the exercise group and 2 subjects in the control group. The right upper extremity was the involved side for 1 subject in the exercise group and 5 subjects in the control group.

All subjects were tested for upper extremity bone area, BMC, BMD, and muscle mass, both before the beginning of the program and at the end. The upper extremities were chosen as the object of this study because weight-bearing is not involved and no unintentional stimulation was likely to occur.

The participants were examined by a neurologist and diagnosed with a neurological disorder (Table 1) and osteoporosis resulting from the paralysis caused by the neurological disorder. They were determined fit to participate in both the experiment and the physical therapy program. All patients received their standard physical therapy programs during the entire study. They were informed about the general purpose of the experiment; all were fully able to understand the instructions given and consented to participate. Prior to the beginning of the experiment, both upper extremities of the patients were tested with the Hologic QDR 4500A (Waltham, MA, U.S.A.) for: bone area (cm^2), bone mineral content (BMC) (g), bone mineral density (BMD) (g/cm^2), fat (g), lean (muscle mass) (g), lean plus BMD (g), total grams, and relative fat content. The subjects were retested after the program had been followed for at least a year (Table 1). The program was begun soon after the first Hologic examination was completed. Therefore, the start and end of the experiment was at different times for each subject. The average length of the home program was 1.83 years (ranging from 1 to 3 years). The average length of time between the Hologic tests was 1.5 years (ranging from 1 to 2.5 years) for the control group.

Treatment and Assessment

After an examination by a neurologist and a bone density test (Hologic), the subjects of the exercise group were interviewed individually and told the specific purpose of the therapy program. The subjects were informed that an exercise program would help improve muscle strength and bone density through the contraction of the muscles. Each subject, sitting in his/her wheelchair or on a standard chair, in a comfortable position, was then presented with three toy balls that were of different hardnesses: soft, regular and hard. A ball was chosen as part of the exercise program to provide an isotonic resistance to the finger flexors, since it is believed that resistance at specific sites tend to provide a more effective osteogenic stimulus than a generally distributed loading at a low intensity[39]. S/he was asked to squeeze each ball a few times to determine which hardness was suitable for his/her program. However, each person was allowed to change the ball while the program was in progress, if so desired.

After choosing a ball, the subject was instructed to slowly squeeze the ball as hard as possible 10 times with the uninvolved hand and then 10 times with the involved hand. The exercise was performed with the patient sitting in a wheelchair or chair, with the elbow flexed and the arm resting comfortably at the side of the trunk or on an armrest. This round was repeated once again. The subjects were told to perform this regimen at home three times a day and at least three times a week or more. Each subject returned in one week and then several times during the length of the program to review the program and discuss any problems encountered. Most of the subjects reported no difficulty with the program, and most actually stated that it was easy to comply. Although occasional follow-ups were done during the course of the program, the exercise program remained unvaried for the length of the study. The physical therapists in charge of the standard therapy program also occasionally asked the subjects about compliance with the home program and reported the comments to the first author. A post-bone density test (Hologic) was performed when the physician in charge determined there was a need for such a test.

The subjects of the control group also were examined by a neurologist, received a pre-bone density test (Hologic), standard physical therapy treatment, and a post-bone density test (Hologic). They did not perform the ball home exercise program, nor did they receive any instructions about the benefits of such a program.

A subjective reaction survey was planned beforehand and presented to the patients at the beginning of the study. Patients were asked to relate their impressions of the effect of the exercise program at the end of the study as compared with their state at the beginning of the program.

A paired t-test was performed on all the results to compare the effects of the home exercise program, and the level of confidence was set at the 95 percentile.

RESULTS

The results of the paired t-test are shown in Table 2. A change in the bone area (cm^2) for the affected upper extremities of the control group showed a significant increase ($p = 0.02$), while the BMD did not change and fat content seemed to increase. These results suggest a fatty change of the bone and/or muscle, leading to an increased bone fragility. There exists a significant difference ($p < 0.02$) in bone area, BMC, and BMD, between the affected and sound sides both before and after the study, even though all the parameters were much different for all patients (Table 3). All the remaining results, as a whole, did not show any statistically significant difference. In other words, the home exercise program produced no remarkable change in the bone area, BMC, BMD, or muscle mass in any of the subjects.

However, subjective reactions of the subjects were positive in that they reported feeling improvement in their muscular strength and state of well-being. Many patients also stated that doing the exercises at home made them feel as if they were positively contributing to their own recovery process.

Parameters of bone metabolism were compared for each patient for all the before and after examination results (Table 3). Patients with Parkinson's disease seem to show an increase in BMC and BMD from the exercise of the affected arm, as compared with either the sound arm or with the control group, the latter of which seem to show a decrease in BMC and BMD after a similar duration. In contrast, patients with cerebral infarction did not seem to exhibit an increase in BMC and BMD from exercise of their affected arm, when

Table 2. Results of the paired t-tests for the pre-investigation and post-investigation of the exercise program (95% level of confidence)

Subject/Results	Exp.Gp: Affected (1)	Exp. Gp: Sound (2)	Exp. Gp: Affected (3)	Control: Sound (4)
Area: cm^2	0.66	0.61	0.02	0.34
Bone mineral content: g	0.93	0.41	0.24	0.51
Bone mineral density: g/cm^2	0.36	0.84	0.94	0.69
Fat: g	0.20	0.17	0.21	0.29
Lean (muscle) g	0.36	0.83	0.86	0.20
Lean + Bone mineral content: g	0.35	0.73	0.83	0.25
Total: g	0.86	0.24	0.30	0.16
% Fat	0.06	0.15	0.15	0.27

(1) Results of affected upper extremities of experimental group
(2) Results of sound upper extremities of experimental group
(3) Results of affected upper extremities of control group
(4) Results of sound upper extremities of control group

Table 3. Parameters of bone metabolism for each subject

Experimental Group: Before Affected Arm

Subject	Sex	Age	Region	Area: cm²	BMC: gm	BMD: gm/ cm²	Fat: gm	Lean	Lean+BMC: gm	Total: gm	% Fat
1	F	50	Left	209	141	0.677	1199	1938	2080	3279	36.6
2	M	69	Left	126	82	0.65	57	1536	1618	1674	3.4
3	M	67	Left	199	115	0.578	1071	1982	2097	3168	33.8
4	F	73	Left	140	76	0.543	1054	1355	1431	2485	42.4
5	M	62	Left	184	109	0.591	765	2331	2440	325	23.9
6	M	49	Left	197	146	0.742	636	2135	2281	2917	21.8
7	M	61	Left	162	116	0.713	1386	1897	2012	3398	40.8
8	F	73	Right	39	14	0.349	643	1395	1408	2051	31.3
9	F	74	Left	88	42	0.478	704	1327	1369	2073	33.9

Experimental Group: Before Sound Arm

Subject	Sex	Age	Region	Area: cm²	BMC: gm	BMD: gm/ cm²	Fat: gm	Lean	Lean+BMC: gm	Total: gm	% Fat
1	F	50	Right	208	144	0.688	1013	1991	2135	3148	32.2
2	M	69	Right	144	100	0.698	156	1853	1953	2110	7.4
3	M	67	Right	251	201	0.802	867	2538	2740	3607	24
4	F	73	Right	138	74	0.536	1031	1565	1639	2671	38.6
5	M	62	Right	224	169	0.755	855	2803	2972	3827	22.3
6	M	49	Right	201	162	0.803	570	2684	2845	3415	16.7
7	M	61	Right	226	158	0.696	1143	2441	2599	3742	30.6
8	F	73	Left	114	51	0.449	756	1081	1432	2189	34.6
9	F	74	Right	152	94	0.618	696	1454	1548	2244	31

Experimental Group: After Affected Arm

Subject	Sex	Age	Region	Area: cm²	BMC: gm	BMD: gm/ cm²	Fat: gm	Lean	Lean+BMC: gm	Total: gm	% Fat
1	F	54	Left	215	146	0.68	1554	1705	1851	3405	45.6
2	M	70	Left	143	95	0.664	107	1575	1670	1777	6
3	M	69	Left	197	118	0.599	1026	1848	1967	2993	34.3
4	F	75	Left	124	69	0.555	885	1362	1431	2316	38.2
5	M	65	Left	160	83	0.52	641	2074	2157	2797	22.9
6	M	49	Left	203	147	0.725	782	2177	2324	3106	25.2
7	M	63	Left	166	114	0.686	2315	2106	2220	4535	51.1
8	F	74	Right	62	22	0.352	827	1415	1437	2264	36.5
9	F	75	Left	94	43	0.457	771	1171	1215	1985	38.8

Experimental Group: After Sound Arm

Subject	Sex	Age	Region	Area: cm²	BMC: gm	BMD: gm/ cm²	Fat: gm	Lean	Lean+BMC: gm	Total: gm	% Fat
1	F	54	Right	222	147	0.661	1360	1650	1797	3157	43.1
2	M	70	Right	144	111	0.765	139	2129	2240	2379	5.8
3	M	69	Right	240	185	0.771	1004	2640	2825	3829	26.2
4	F	75	Right	130	69	0.529	954	1536	1605	2559	37.3
5	M	65	Right	212	163	0.768	720	2811	2974	3694	19.5
6	M	49	Right	200	163	0.812	651	2617	2780	3430	19
7	M	63	Right	230	150	0.652	1792	2392	2542	4334	41.3
8	F	74	Left	116	52	0.447	863	1437	1489	2352	36.7
9	F	75	Right	152	94	0.62	691	1341	1435	2126	32.5

Control Group: Before Affected Arm

Subject	Sex	Age	Region	Area: cm²	BMC: gm	BMD: gm/ cm²	Fat: gm	Lean	Lean+BMC: gm	Total: gm	% Fat
1	M	71	Right	177	105	0.594	2082	2553	2658	4740	43.9
2	F	26	Right	139	78	0.563	2443	993	1072	3515	69.5
3	F	65	Right	131	81	0.621	1026	1403	1485	2511	40.9
4	M	59	Left	201	155	0.772	634	1881	2037	2671	23.7
5	M	69	Right	181	162	0.897	299	2026	2188	2487	12
6	F	62	Left	177	105	0.592	1070	1651	1756	2826	37.9
7	M	51	Right	180	120	0.665	798	1943	2063	2861	27.9

Control Group: Before Sound Arm

Subject	Sex	Age	Region	Area: cm²	BMC: gm	BMD: gm/ cm²	Fat: gm	Lean	Lean+BMC: gm	Total: gm	% Fat
1	M	71	Left	245	183	0.594	1003	2624	2807	3810	26.3
2	F	26	Left	163	98	0.604	1876	1451	1549	3425	54.8
3	F	65	Left	145	95	0.659	613	1527	1623	2235	27.4
4	M	59	Right	196	163	0.831	680	2074	2237	2917	23.3
5	M	69	Left	205	227	1.107	329	2115	2342	2672	12.3
6	F	62	Right	176	111	0.62	1287	1810	1921	3208	40.1
7	M	51	Left	214	159	0.746	541	2205	2365	2906	18.6

Control Group: After Affected Arm

Subject	Sex	Age	Region	Area: cm²	BMC: gm	BMD: gm/ cm²	Fat: gm	Lean	Lean+BMC: gm	Total: gm	% Fat
1	M	74	Right	191	112	0.585	1505	2207	2319	3824	39.4
2	F	27	Right	147	81	0.555	2878	1114	1196	4074	70.6
3	F	66	Right	134	85	0.635	1248	1478	1563	2812	44.4
4	M	60	Left	206	165	0.904	889	2215	2381	3271	27.2
5	M	71	Right	189	152	0.805	814	1891	2044	2859	28.5
6	F	64	Left	177	106	0.6	1064	1669	1775	2839	37.5
7	M	53	Right	204	123	0.606	1507	1978	2101	3609	41.8

Control Group: After Sound Arm

Subject	Sex	Age	Region	Area: cm²	BMC: gm	BMD: gm/ cm²	Fat: gm	Lean	Lean+BMC: gm	Total: gm	% Fat
1	M	74	Left	236	180	0.764	698	2848	3029	3727	18.7
2	F	27	Left	159	93	0.589	1854	1323	1416	3271	56.7
3	F	66	Left	148	95	0.645	884	1556	1652	2536	34.9
4	M	60	Right	208	177	0.851	819	2316	2494	3313	24.7
5	M	71	Left	209	169	0.807	372	2212	2381	2753	13.5
6	F	64	Right	177	106	0.596	1450	1695	1801	3252	44.6
7	M	53	Left	224	169	0.755	964	2527	2696	3661	26.3

compared to either the sound arm or the control group. The number of patients is so limited that no significant difference was detected.

Neither duration of the disease from the onset nor dominant/non-dominant side seemed to influence the effect of exercise on the bone metabolism. In addition, age or male/female sex did not show any significant difference in the effect of exercise.

DISCUSSION

In most of the literature, exercise is considered a major treatment modality in the prevention and reversal of osteoporosis[4,21,22,36]. Compared with drug therapy, an adapted individual training program has several advantages: no adverse side effects, less costly, which is especially important in view of exploding health care costs, and more enjoyable[19]. Unfortunately, the effect of regular exercise and which type of exercise is effective in the osteoporotic process is not easily established[3,39,43]. Exercise supposedly influences bone metabolism by increasing muscle mass, which in turn causes an increase of the blood flow in the bone marrow. Thus, the turnover of bone is enhanced, osteoblasts are activated, osteogenesis occurs, and bone mass increases[17]. Experiments, mainly on postmenopausal women and the elderly, did not reveal any influence from exercise on bone mass[13,19], although Adami et al[1] noted that a change in the geometry and shape of the bones tested occurred. Other authors found it possible to prevent BMD loss in premenopausal, perimenopausal, and postmenopausal women through exercise, supervised and/or unsupervised [7,11,14,15,17,18,40,44]. Regular weight-bearing exercises have influenced BMD in the greater trochanter of both men and women[20]. However, for healthy, functionally largely nondisabled postmenopausal women at high risk of osteoporosis, an unvarying training program does not have enough impact to affect pain, disability, body sway, muscle strength, and, consequently, bone loss[20]. All the programs in the studies reviewed were long-term, for six months or longer. In addition, exercise may aid in the development of new bone formation in paraplegic patients[6], and impact vibration may increase the BMD in spinal cord injured subjects[34]. On the contrary, functional electrical stimulation cycle ergometry did not affect the BMD of quadriplegic men[23], and functional neuromuscular stimulation ambulation training sessions produced no significant changes in BMD for 16 paraplegic patients[31].

Although exercise is considered such an important part in the prevention and treatment of osteoporosis, it has been noted that many people actually do not perform adequate amounts and types of exercise[10,26]. Behavior modification is necessary but difficult to achieve[38], particularly for people with physical disabilities. Consequently, this study was conducted on subjects with osteoporosis resulting from neurological disorders.

The training program must be easy to learn, easy to do, and easy to review at regular intervals[19,26]. For a successful exercise program, it must be adhered to by the patient. If the cost is prohibitive or if the exercises produce pain or fatigue, the patient will unlikely continue[39]. The time necessary to do the exercise or the inconvenience of having to go to a facility to perform the program will also affect the continuation of a commitment to any program[39]. A home exercise program can be as effective as a supervised hospital program for women diagnosed with osteoporosis[43].

With all these factors in mind, the authors decided on a simple, easy to perform, home exercise program. Especially since the patients were already diagnosed with a neurological condition resulting in osteoporosis and also since the exercises were to be performed unsupervised, at home, the exercises had to be safe, as well. No adverse effects were noted during the study, and all the experiment subjects stated that the program was easy to adhere to. Unfortunately, our preliminary pilot study on total subjects showed no statistically significant changes in BMD or muscle mass as a result of our home exercise program. It may be that the specificity, intensity, and/or duration of the exercise were not optimal for the prevention or reversal of osteoporosis in our subjects[43]. However, we observed a tendency of a more favorable effect for patients with Parkinson's disease, probably due to an association between Parkinson's disease and estrogen.

Perhaps the effect of this program was noted more in the context of a change in the "quality of life" than in any actual physical condition. Walker et al[43] also noted that even when there are no significant improvements in bone mass, regular exercise might have a beneficial effect on psychological factors and a general sense of well-being. Further studies should be conducted to determine if an exercise program could be of benefit for patients with paralysis from neurological disorders. The type, amount, and timing of the exercise needed to produce a reversal, or even maintenance, in disuse osteoporosis should be investigated. Whether the exercises need to be supervised or not should also be the topic for a further study. The authors also recommend a more controlled, matched grouping and a longer period in further investigations, especially focusing on patients with Parkinson's disease.

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