ID Design Press, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2019 Apr 15; 7(7):1160-1165.
https://doi.org/10.3889/oamjms.2019.271
eISSN: 1857-9655
Clinical Science

Effect of Exercises on Quality of Life in Patients with Postmenopausal Osteoporosis – Randomized Trial

Valentina Koevska*, Erieta Nikolikj-Dimitrova, Biljana Mitrevska, Cvetanka Gjeracaroska-Savevska, Marija Gocevska, Biljana Kalcovska

Institute of Physical Medicine and Rehabilitation, Faculty of Medicine, Ss. Cyril and Methodius University of Skopje, Skopje, Republic of Macedonia

Citation: Koevska V, Nikolikj-Dimitrova E, Mitrevska B, Gjeracaroska-Savevska C, Gocevska M, Kalcovska B. Effect of Exercises on Quality of Life in Patients with Postmenopausal Osteoporosis – Randomized Trial. Open Access Maced J Med Sci. 2019 Apr 15; 7(7):1160-1165. https://doi.org/10.3889/oamjms.2019.271

Keywords: Postmenopausal osteoporosis; Exercises; Quality of life

***Correspondence:** Valentina Koevska. Institute of Physical Medicine and Rehabilitation, Faculty of Medicine, Ss. Cyril and Methodius University, Skopje, Republic of Macedonia. E-mail: valeskoevska@yahoo.com

Received: 18-Feb-2019; **Revised:** 03-Apr-2019; **Accepted:** 04-Apr-2019; **Online first:** 14-Apr-2019

Funding: This research did not receive any financial support

Competing Interests: The authors have declared that no competing interests exist

Abstract

BACKGROUND: Osteoporosis is a systemic skeletal disease characterised by a low bone density and microarchitectural deterioration of bone tissue leading to decrease of its strength and increased risk of fracture. Drug therapy decreases the risk of fracture, thus influencing on the mechanism of bone remodelling. Non-pharmacological interventions include specific exercises for osteoporosis that improve muscle strength and balance, decrease pain and improve quality of life.

AIM: To compare the quality of life in patients with postmenopausal osteoporosis who practice exercises with those who do not practice on the beginning and after a year.

MATERIJAL AND METHODS: A randomised Single-blind randomised controlled prospective trial study, which included 92 women with postmenopausal osteoporosis diagnosed and treated at the Institute of Physical Medicine and Rehabilitation in Skopje, Republic of Macedonia. Patients were randomly assigned to three groups: the first group of patients with exercises and physical modalities (gr. I), the second group with exercises (gr. II), and the third control group of patients who did not practice exercises (gr. III). Exercises were practised 3 times a week; each exercise was repeated for 5-8 times. Patients regularly took bisphosphonates, calcium and vitamin D. The follow-up period lasted for one year. Quality of life was determined with a specific questionnaire Qualeffo-41.

RESULTS: The results showed, significant statistical difference in terms of pain, physical activity, social life, the perception of own health were shown between the groups ($p < 0.0001$), only in term of mental function were no significant ($p < 0.3$).

CONCLUSION: Patients who practice exercises for osteoporosis have a significantly better quality of life than patients who do not perform exercises.

Introduction

Osteoporosis is a systemic skeletal disease characterised by a low bone mineral density and microarchitectural deterioration of bone with a consequent decrease of its density and increased risk of fractures [1]. According to the data of the World Health Organization (WHO), osteoporosis is on the fourth place after cardiovascular diseases, cancer and stroke. Approximately 30% of all postmenopausal women in the United States of America and Europe have PO. Ageing of populations worldwide will be responsible for a major increase in the incidence of osteoporosis in postmenopausal women [2]. The first clinical manifestation very often is vertebral fractures, which can happen during normal activities such as stairs climbing, weight bearing etc. Age, deformity as kyphosis, disturbance of balance and non-specific back pain, increases the risk of a fall, for a new fracture, poor quality of life, disability and high mortality [3], [4].

Treatment of these patients has to be comprehensive and include both, pharmacological and non-pharmacological interventions. Drug therapy reduces the risk of fracture by influencing the mechanism of bone remodelling. These drugs decrease the risk of vertebral fracture by 30-70%, hip fractures by 20-40% and non-vertebral fractures by 15-20% [5], [6]. Non-pharmacological interventions

include specific physical exercises for osteoporosis to improve muscle strength and balance, decrease pain, and improve quality of life [7]. In general, exercises are simple, do not require large financial costs and specific expensive equipment, and can be done at home. Exercises for osteoporosis are designed so that they enable better spinal stability and posture [8], [9], [10]. In the literature, only a few previous randomised studies have been published about the effect of exercises and physical activity on quality of life in osteoporotic patients. These studies have applied diverse methodologies and have presented controversial results [11], [12]. In our country, no such study has been conducted so far. Also, the questionnaire about the quality of life in postmenopausal osteoporotic patients has been applied for the first time in our country.

Our study aimed to evaluate the effectiveness of exercises for osteoporosis on quality of life in patients with postmenopausal (PO).

Material and Method

This was a randomised blind, one-sided trial, which included 92 patients with postmenopausal osteoporosis (PO) diagnosed and treated at the Institute of Physical Medicine and Rehabilitation in Skopje, R. Macedonia. The inclusion criterion was diagnosed osteoporosis. Diagnostic criterion was taken from total t score -1.5 SD to -2.5 SD, determined with x-ray DXA densitometry. The survey was approved by the Ethics Committee for people research at the Faculty of Medicine, Ss. Cyril and Methodius University, the Republic of Macedonia (Num.03-124/2, approved 22.03.2015year), and each of the patients was previously informed about the research from the researcher and signed informed consent to participate in it. Exclusion criteria were: secondary osteoporosis, fever, lumbar sciatica, pacemaker, cardiorespiratory instability, arrhythmia, malignant disease, neurological diseases.

Patients were randomly assigned to three groups: the first group of patients with exercises and physical modalities (gr. I), the second group with exercises (gr. II), and the third control group of patients who did not practice exercises (gr. III). At the beginning of the study, the first group (gr. I) received physical modalities (interferent currents and magnetic therapy) for 3 weeks, each day with a weekend break. Physical modalities were given for the treatment of pain. Exercise program consisted of: respiratory exercises, active exercises and exercises for strengthening the paravertebral muscles, active exercise for maintaining the range of motion of the joints of upper and lower extremities and spine, exercises for strengthening the muscles of the upper and lower extremities, isometric exercises for strengthening the abdominal muscles and exercises for balance. For weight-bearing exercises, the weight was determined by the functional abilities of the patients, 1 (one) kilogram at the most. Exercises were performed 3 times per week; each exercise was repeated for 5 to 8 times. Patients regularly took bisphosphonates, calcium and vitamin D. The follow-up period lasted for one year. Quality of life was evaluated with the specifically designed questionnaire for quality of life-Qualeffo-41 at the beginning and the end of the investigation.

Qualeffo-41 is a specially designed questionnaire approved by the International Association for Osteoporosis for measuring the quality of life in patients with postmenopausal osteoporosis [13]. The questionnaire consists of 41 items and includes 5 domains: pain, physical function, social activities, general health perception and mental function. Total score (TS) and domain scores (DS) are calculated by the following formulas:

$$TS = \frac{\text{(actual score –lowerest possible score) x 100}}{\text{score range}}$$

$$DS = \frac{\text{(average score- lp score*)x100}}{\text{score range}}$$

* lowest possible score

Total score along with domain scores was standardised to a 100-point scale; score 0 shows that the patient has no problems, that is, the quality of life is excellent, whereas score 100 shows maximum problems, that is, poor quality of life. All patients independently filled in the questionnaire at the beginning and the end of the investigation.

The statistical analysis of the obtained data was made in the statistical program SPSS for Windows 17.0. Qualitative data were presented with absolute and relative numbers; the quantitative data were shown by the measures of descriptive statistics (mean ± SD, median with IQR). Cronbach's alpha was used to determine the degree of internal consistency of the questions in the five areas of the Quality of Life Questionnaire in postmenopausal women (QUALEFFO-41). For comparing the three analysed groups of patients, nonparametric and parametric methods for independent samples were used (Chi-square test, and Kruskal-Wallis test. The values of $p < 0.05$ were statistically significant.

Results

Patients were with a mean age of 60.64±6.7 years; the youngest patient was 43 years old, and the oldest 73 years. The largest number/percentage of examined patients was at the age of 60 to 69 years-53 (57.61%). According to the level of education, patients with completed high school predominated (48.91%)

(Table 1).

Table 1: Distribution of patients according to age and level of education

Characteristics of patients	N (%)
Age groups, n (%)	
40 – 49	4 (4.35)
50 – 59	28 (30.43)
60 – 69	53 (57.61)
70 – 75	7 (7.61)
Mean ± SD	(60.64 ± 6.7) min – max (43 – 73)
Education, n (%)	
Primary	22 (23.91)
High	45 (48.91)
University	25 (27.17)

Patients of the three groups did not differ significantly in terms of menopausal status (p = 0.3). Patients without physical agents and exercises (gr.I), insignificantly rarely from patients in the other two groups provided anamnestic data for early menopause (36.67%, 46.88%, 56.67% respectively). The presence of risk factors for osteoporosis was 65.63% of patients treated with physical agents and exercises (gr.I), 80% of patients treated with exercise (gr.II), and 73.33% of patients without physical therapy and exercises (gr.III),. Statistical analysis was non-significant, between the three groups, for the frequency of risk factors for PO (p = 0.44). The difference was also non-significant in terms of the number of risk factors present (p = 0.7). The analysis of the three groups compared to the present comorbidity showed that 71.88% of patients treated with physical agents and exercises (gr.I), 56.67% of patients treated with exercise (gr.II), and 76.67% of patients without physical therapy and exercises (gr.III), had accompanying chronic conditions. The tested difference between subjects with and without co-morbidity, and depending on how the disease was treated, was statistically non-significant (p = 0.22) (Table 2).

Table 2: Statistical difference between groups for early menopause, risk factors, number of risk factors, and comorbidity

Variable	I groups	II groups	III groups	P value
Early menopause n (%)				
No	17 (53.13)	13 (43.33)	19 (63.33)	χ =2.41
Yes	15 (46.88)	17 (56.67)	11 (36.67)	P = 0.299
Risk factors n (%)				
No	11 (34.38)	6 (20)	8 (26.67)	χ = 1.62
Yes	21 (65.63)	24 (80)	22 (73.33)	P = 0.444
Number of risk factors n (%)				
0	11 (34.38)	6 (20)	8 (26.67)	χ = 0.67
1	7 (21.88)	11 (36.67)	10 (33.33)	P = 0.7
2	12 (37.5)	9 (30)	10 (33.33)	
3	2 (6.25)	4 (13.33)	2 (6.67)	
Comorbidity n (%)				
No	9 (28.13)	13 (43.33)	7 (23.33)	χ = 3.04
Yes	23 (71.88)	17 (56.67)	23 (76.67)	P = 0.22

X (Chi-square test); H(Kruskal-Wallis).

When comparing the results of QUALEFFO-41 obtained at the beginning and at the end of our study for each group longitudinally, we noticed a significant improvement in all domains in the first and in the second group of patients, whereas in the third group, who did not practice exercises, there were no significant changes in the domains, except in the social life that showed a substantial impairment.

Table 3. Results from the questionnaire on quality of life Qualeffo-41

Domain	Reception / control	Group	All groups		P value	
			Mean ±SD	Min - Max		
Domain 1 /pain/	Reception	I	59.09 ± 17.2	25 – 90	F=5.3, p = 0.006** 1 vs 2, p = 0.023* 2 vs 3 p = 0.011*	Post-hoc
		II	44.4 ± 25.7	0 - 85		
		III	60.77 ± 20.7	0 - 100		
	Control	I	40.87 ± 20.6	0 - 100	F=13.2, p = 0.000** 1 vs 3, p = 0.004** 2 vs 3, p < 0.001*	Bonfe-rroni
		II	31.0 ± 23.2	0 – 90		
		III	59.3 ± 21.3	0 – 80		
Domain 2 / Physical function	Reception	I	36.59 ± 17.9	0 – 80	F=2.84, p = 0.06	Post-hoc
		II	28.47 ± 19.8	0.2 – 63		
		III	39.42 ± 17.8	10 – 86		
	Control	I	19.95 ± 13.3	5 – 100	F=18.55, p < 0.001** 1 vs 3, p < 0.001** 2 vs 3, p < 0.001**	Dunnett T3
		II	19.99 ± 15.4	0 – 93		
		III	41.8 ± 19.3	13 – 100		
Domain 3 /social function/	Reception	I	48.66 ± 24.5	5 – 100	F=1.2, p = 0.32	Post-hoc
		II	43.29 ± 28.8	0 – 93		
		III	53.48 ± 24.0	13 – 100		
	Control	I	34.58 ± 19.9	5 – 91	F=24.5, p < 0.001** 1 vs 3, p < 0.001** 2 vs 3, p < 0.001**	Bonfe-rroni
		II	27.65 ± 21.64	0 – 90		
		III	67.06 ± 27.9	0.8 – 100		
Domain 4 /health perception	Reception	I	62.76 ± 23.1	1 – 92	F=2.87, p < 0.06	Post-hoc
		II	54.8 ± 26.9	16 – 100		
		III	69.9 ± 23.1	25 – 100		
	Control	I	45.88 ± 22.1	8 – 92	F=25.71, p< 0.000** 1 vs 3, p < 0.000** 2 vs 3, p < 0.000**	Bonfe-rroni
		II	41.5 ± 21.9	16 – 100		
		III	78.2 ± 21.2	33 – 100		
Domain 5 /mental function	Reception	I	44.42 ± 11.7	25 – 78	F=1.21, p = 0.3	Post-hoc
		II	41.17 ± 11.1	22 – 66		
		III	40.13 ± 11.3	16 – 64		
	Control	I	41.16 ± 11.5	25 – 70	F=0.36, p = 0.3	Bonfe-rroni
		II	39.37 ± 7.8	25 – 61		
		III	39.3 ± 9.5	22 – 55		

We found a statistically significant difference among the three groups of patients in the average score for the domain pain at the end of the investigation (p < 0.000). However, this significant difference was due to the significantly higher average score in the control group compared to the group treated with physical agents and exercises (59.3 ± 21.3 *vs* 40.87 ± 20.6 p=0.004), and the group treated with exercises alone (59.3 ± 21.3 *vs* 31.0 ± 23.2 p < 0.0001). This was mainly a result of the regular practising of exercises by patients in the first and the second group. We can conclude that at the end of the follow-up period, patients who did not perform exercises had substantially diminished the quality of life regarding presence and severity of pain in comparison with the other two groups of patients (Table 3).

On the final check-up, a significantly different average score for the domain physical activities among the three groups was observed (p < 0.0001). Post hoc analysis confirmed a significant difference between the control and the first group (41.8 ± 19.3 *vs* 19.95 ± 13.3; p < 0.0001), and between the control and the second group (41.8 ± 19.3 *vs* 19.99 ± 15.4; p < 0.0001). After one-year follow-up, patients from the control group, who did not practice exercises for osteoporosis, showed substantially diminished the quality of life regarding physical activities when compared to the other two groups of patients (Table 3). On the final check-up, the difference was statistically significant (p < 0.0001) for the domain social life, which was due to the significantly higher average score for this domain between the control and the first group (67.06 ± 27.9 *vs* 34.58 ± 19.9, p < 0.0001), and between the control and the second

group (67.06 ± 27.9 *vs* 27.65 ± 21.64, p < 0.0001). The comparison of the quality of life among the three groups from the aspect of social functioning at the end of the investigation, showed that patients from the control group, who did not practice exercises, had a significantly larger number of problems in performing social activities when compared to the other two groups, (Table 3). Significant differences were observed (p < 0.000) in the domain of perception of their general health at the end of the investigation. On the last check-up, the average score for the general health perception in the group treated with interferential currents, magnet and exercises was 45.88 ± 22.1, in the group performing exercises 41.5 ± 21.9, and in the control group, who did not practice exercises, the score was significantly higher (78.2 ± 21.2). At the end of the follow-up period, patients who did not practice exercises rated their general health condition as significantly poorer compared to the patients from the other two groups (Table 3).

The three groups of patients had non-significantly different quality of life regarding their mental functioning, both on admission (p = 0.3) and at the end of the follow-up (p = 0.3), indicating that the method of treatment of primary osteoporosis had no significant impact on their mental functions (Table 3).

Table: 4 Results from the statistically significant difference in total Qualeffo-41 score among groups

Total Qualiffo-41	(mean ± SD)	All groups min - max	p value
On admission			
Group 1	41.32 ± 12.2	20 – 67	F = 2.36, p = 0.1
Group 2	36.57 ± 15.2	12 – 71	
Group 3	43.92 ± 12.3	16 – 75	
Control			
Group 1	28.86 ± 8.4	15 – 50	F = 33.5, p < 0.0001
Group 2	26.98 ± 11.8	12 – 65	1 vs 3, p = 0.00011
Group 3	47.43 ± 11.75	20 – 65	2 vs 3, p = 0.00011

The comparative analysis of total average scores showed that, on admission, there were no significant differences in quality of life among the three groups of patients (p = 0.1), whereas, at the end of the follow-up, significant differences were registered (p < 0.0001). Post hoc analysis showed a significant difference in total average score between the control and the first group and between the control and the second group (p = 0.00011). The average total score on the last check-up was 28.86 ± 8.4 for the first group, 26.98 ± 11.8 for the second group, and significantly higher for the third group (47.43 ± 11.75) (Figure 1) (Table 4).

Discussion

There are many general questionnaires for measuring the quality of life to evaluate the general health condition; however, none of them is as specific for PO as is the Qualeffo-4. Over the last decade, its application in assessing the quality of life in patients with OP has been emphasised due to its specificity, coherence and extensiveness. Osteoporosis (OP) can negatively influence the quality of life, thus limiting and restricting the performance of everyday activities. Chronic pain as a result of PO might lead to depression, anxiety, frustration and social isolation. Practising exercises have become an important intervention in increasing the self-confidence in women in performing their activities and tasks. Regular practising of exercises in women with PO has a positive effect on the general health condition, social inclusion, self-respect, better mood and conscience for better body shape and has decreased depression, anxiety and fear from falls.

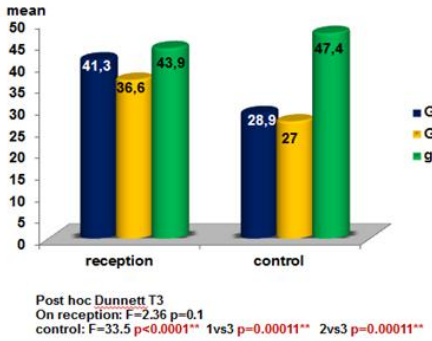

Figure 1: Results from the statistically significant difference in total Qualeffo-41 score among Groups

Our study has shown that all patients with PO demonstrated a significant improvement in the quality of life in all domains of the questionnaire for one year. This was supported by the results obtained for the average scores in all domains when we compared them at the beginning and the end of the study. It means that patients with back pain have a poor quality of life. Also, the other domains such as physical functioning, social life, general health perception and mental function showed a substantial improvement at the end of the study. This is also supported by the result in the total Qualeffo-41 score, which at the end of the study was significantly increased. In the last 10 years, a small number of studies has been conducted that examined the influence of exercises on quality of life in patients with OP for one year by applying the Qualeffo-41 questionnaire.

Similar to our study is the investigation of Evstigneeva *et al*., which demonstrated that after 12 months of performing exercises for PO the questionnaire about the quality of life showed a significant improvement in the quality of life in patients. Total Qualeffo-41 score after 12 months was significantly better in the group of patients who practised exercises (44.2 ± 7.5) compared to the control group (56.6 ± 9.4), p < 0.0001.

In another study, a general questionnaire about the quality of life in patients with PO was applied. Patients were followed for 13 months and were divided into three groups: the first group

practised exercises 3 times per week, the second 2 times per week and the third, control group, did not perform exercises. Their results were similar to our results. The total score about the quality of life in both groups who practiced exercises showed a significant improvement ($p < 0.0001$); gr. 1 (at the beginning 330.2 ± 22.02 and at the end 369.05 ± 1.5) and gr. 2 (at the beginning 313.3 ± 22.01 and at the end 348.8 ± 22.6), but not in the control group (at the beginning 312.3 ± 35.09 and at the end 311.4 ± 35.7) [14].

The largest number of investigations is with a shorter follow-up period, and usually, the type of the exercises and their influence on the quality of life in patients with PO has been compared. For example, one study compared the effect of the three different types of exercises on the back pain and quality of life in an adult population with low bone density. A total of 98 women participated in the study, divided into three groups. The investigation lasted for 6 months. The results showed no significant difference among the groups in the total score of Qualeffo-41 questionnaire [15].

The study conducted by Schröder et al. comprised 45 patients with PO who were assigned to two groups: the first group had the usual exercise program for PO, and the second group had exercises similar to our program. The total score for the quality of life in both groups showed improvement; in the first group (at the beginning 26.0 ± 11.2 and the end 23.9 ± 10.0; $p = 0.766$) and in the second group (at the beginning 29.7 ± 9.8 and the end 21.8 ± 8.1; $p < 0.001$), but the changes in the second group were statistically significant. In three months, there was an improvement in all domains on the Qualeffo-41 questionnaire in both groups, with higher significance in the second group [16].

The study of Schröder *et al*. covering three months and the study of Liu-Ambrose TY *et al.,* covering six months have shown that even for a shorter period the exercises for PO improved the quality of life in patients with osteoporosis.

Similar results have been demonstrated in the study of Bennell *et al*., presenting a significant pain decrease and a significant improvement in the domain of physical functioning even though patients practised the exercises only for three months [17], which was not the case in our study.

One of the advantages of exercises is that they do not represent a burden to the home budget and they can be performed at home. They can yield good results as it was presented in the investigation of Papaioannou A *et al*., where the questionnaire about the quality of life showed a significant improvement after a 12-month follow-up period [18]. It has to be emphasised that practising exercises should be a continuous process in which patients are actively involved.

Exercises should be practised regularly because with advancing age the muscle tissue is decreased as well as the strength of the muscles and physical abilities. Therefore, exercises maintain physical condition, mobility and social life and hence contribute to a better quality of life.

In conclusion, the exercise program for osteoporosis has significantly improved the quality of life in patients after one year of practising in all four domains: pain, physical activities and mobility, social activities and perception about general health condition ($p < 0.0001$). The role of exercises in the treatment of patients with postmenopausal osteoporosis is undisputable.

References

1. Black DM, Rosen CJ,Clinical Practice. Postmenopausal Osteoporosis. N Engl J Med. 2016; 374:254-62. https://doi.org/10.1056/NEJMcp1513724 PMid:26789873

2. Reginster JY. Burlet N. Osteoporosis: A still increasing prevalence. Bone. 2006; 38 (2 suppl.1):4-9. https://doi.org/10.1016/j.bone.2005.11.024 PMid:16455317

3. Kanis JA, Johansson H, Odén A, Johnell O, De LAet C, Eisman JA, et al. A familiy history of fracture and fracture risk: a meta-analysis. Bone. 2004; 35:1029-37. https://doi.org/10.1016/j.bone.2004.06.017 PMid:15542027

4. Johnell O, Kanis JA. An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. Osteoporos Int 2006; 17(12):1726-33. https://doi.org/10.1007/s00198-006-0172-4 PMid:16983459

5. Body JJ, Bergmann P, Boonen S, Boutsen Y. Devogelaer JP, Goemaere S et al. Evidence-based guidelines for the pharmacological treatment of postmenopausal osteoporosis: a consensus document by the Belgian Bone Club. Osteoporos Int. 2010; 21:1657-80. https://doi.org/10.1007/s00198-010-1223-4 PMid:20480148 PMCid:PMC2931762

6. MacLean C, Newberry S, Maglione M, McMahon M, Ranganath V, Suttorp M et al. Systematic review: comparative effectiveness of treatments to prevent fractures in men and women with low bone density or osteoporosis. Ann Intern Med. 2008; 148:197-213. https://doi.org/10.7326/0003-4819-148-3-200802050-00198 PMid:18087050

7. Pfeifer M, Sinaki M, Geusens P, Boonen S, Preisinger E, Minne HW; ASBMR Working Group on Musculoskeletal Rehabilitation. Musculoskeletal rehabilitation in osteoporosis: a review. J Bone Miner Res. 2004; 19(8):1208-14. https://doi.org/10.1359/JBMR.040507 PMid:15231006

8. Burr J, Shephard R, Cornish S, Vatanparast H, Chilibeck P. Arthritis, osteoporosis, and low back pain: evidence-based clinical risk assessment for physical activity and exercise clearance. Can Fam Physician. 2012; 58(1):59-62. PMid:22267624 PMCid:PMC3264014

9. Sinaki M. Exercise for patients with osteoporosis: management of vertebral compression fractures and trunk strengthening for fall prevention. PMR. 2012; 4(11):882-8. https://doi.org/10.1016/j.pmrj.2012.10.008 PMid:23174554

10. Caputo EL, Costa MZ, Influence of physical activity on quality of life in postmenopausal women with osteoporosis, (Rev). Bras reumatol. 2014; 54(6):467-73.

11. Korpelainen R, Keinänen-Kiukaanniemi S, Nieminen P, Heikkinen J, Väänänen K, Korpelainen J. Long-term outcomes of exercise: follow-up of a randomized trial in older women with

osteopenia. Arch Intern Med. 2010; 170(17):1548-56. https://doi.org/10.1001/archinternmed.2010.311 PMid:20876406

12. Evstigneeva L, Lesnyak O, Bultink IE, Lems WF, Kozhemyakina E, Negodaeva E et al. Effect of twelve-month physical exercise program on patients with osteoporotic vertebral fractures: a randomized, controlled trial, Osteoporos Int. 2016; 27:8: 2515-24. https://doi.org/10.1007/s00198-016-3560-4 PMid:26984569

13. Van Schoor NM, Knol DL, Glas CA, Ostelo RW, Leplège A, Cooper Cet al. Development of the Qualeffo-31, an osteoporosis-specific quality-of-life questionnaire. Osteoporos Int. 2006; 17:543-51. https://doi.org/10.1007/s00198-005-0024-7 PMid:16362146

14. Borba-Pinheiroa CJ. Resistance training programs on bone related variables and functional independence of postmenopausal women in pharmacological treatment: A randomized controlled trial. Archives of Gerontology and Geriatrics. 2016; 65:36-44. https://doi.org/10.1016/j.archger.2016.02.010 PMid:26956618

15. Liu-Ambrose TY, Khan KM, Eng JJ, Lord SR, Lentle B, McKay HA. Both resistance and agility training reduce back pain and improve helth-related quality of life in older women with low bone mass, (Original article). Osteoporosis Int. 2005; 16(11):1321-29. https://doi.org/10.1007/s00198-005-1842-3 PMid:15702262

16. Schröder G, Knauerhase A, Kund G, Schober HC et al. Effects of physical therapy on quality of life in osteoporosis patients - a randomized clinical trial. Health and Quality of Life Outcomes. 2012; 10:101. https://doi.org/10.1186/1477-7525-10-101 PMid:22920839 PMCid:PMC3511275

17. Bennell LK, Matthews B, Greig A, Briggs A, Kelly A, Sherburn M, et al. Effects of an exercise and manual therapy program on physical impairments, function and quality-of-life in people with osteoporotic vertebral fracture: a randomised, single-blind controlled (pilot trial). BMC Musculoskeletal Disorders. 2010; 11:36. https://doi.org/10.1186/1471-2474-11-36 PMid:20163739 PMCid:PMC2830179

18. Papaioannou A, Adachi JD, Winegard K, Ferko N, Parkinson W, Cook RJ et al: Efficacy of home-based exercise for improving quality of life among elderly women with symptomatic osteoporosis related vertebral fractures. Osteoporos Int. 2003; 14(8):677-82. https://doi.org/10.1007/s00198-003-1423-2 PMid:12879220