Back pain, postural balance and quality of life in vertebral fragility fractures: a prospective cohort study

Dalila Scaturro[1], Sofia Tomasello[2], Giulia Letizia Mauro[1]

[1] Department of Oncology and Stomatological Surgical Disciplines, University of Palermo, Palermo, Italy; [2] University of Verona, Verona, Italy

ABSTRACT

Osteoporosis is characterized by poor bone quality, reduced bone mass and and increased risk of fragility fractures. Vertebral fragility fracture can result in chronic pain, postural and balance disorders and poor quality of life (QoL).

The purpose of this longitudinal cohort study was to assess the effectiveness of two months of rehabilitation in patients with at least two vertebral fragility fractures receiving vitamin D and denosumab. In 28 patients, we studied the following measures of outcome before (T0) and after (T1) an eight-week rehabilitation programme: pain (Numerical Rating Scale), QoL (36-Item Short Form Survey and Mini-Osteoporosis Quality of Life Questionnaire), vertigo (Dizziness Handicap Inventory, Italian version), mobility (Timed-Up and Go, TUG test) and instrumental posturographic assessment (posturography system). At the end of the treatment improvements in pain and QoL were recorded in all the patients. Pain reduction was recorded in patients with more than two vertebral fractures. In addition, functional improvement (TUG test) was found in those with two vertebral fractures. Our results suggest that combined intervention, including anti-osteoporosis drugs (denosumab, vitamin D) and postural rehabilitation, should be proposed to osteoporotic patients with multiple fragility vertebral fractures.

KEYWORDS

Osteoporosis, postural balance, pain, quality of life.

Background

Osteoporosis is characterized by poor bone quality, reduced bone mass and and increased risk of fragility fractures [1]. Worldwide, its prevalence is increasing with increasing age. According to the International Osteoporosis Foundation, osteoporosis causes more than 8.9 million fractures each year (1000 per hour). Vertebral fragility fractures are the most common [2]. Even though the main symptoms related to fractures are chronic pain, limited social participation and poor quality of life (QoL), less than a third of patients with vertebral fragility fractures seek medical attention [3]. Even though they are often asymptomatic, fractures may impair mobility and may also result in postural changes associated with impaired gait pattern and poor physical performance [4]. The reduction in the thickness of the vertebral body changes the biomechanical forces on the spine, thus affecting its structural stability [5]. Unless properly treated, vertebral fractures, in particular dorsal ones, may lead to a progressive increase in thoracic kyphosis and consequently a forward displacement of the centre of gravity, with a consequent increased risk of both new vertebral fractures and falls [5,6]. There is therefore a clear correlation between mobility, fragility fractures and falls [7,8]. However, the role of dizziness and vertigo in increasing the risk of falling is poorly considered, in spite of their 30% prevalence in the elderly [9]. Assessing and treating the vestibular and non-vestibular components of vertigo can reduce complications, such as falls [10], but data on the relationship between vertebral fragility fractures and postural control are not yet well defined [10]. Osteoporotic patients with fragility fractures need a multidisciplinary approach in which drug therapy is a key preventive intervention [11,12]. Anti-resorptive drugs and supplementation of calcium and vitamin D significantly reduce the risk of new fractures, thereby also reducing the risk of vertebral refractures and consequently of increased kyphosis and spinal misalignment [11,13,14]. Patients with fragility fractures treated with denosumab and vitamin D are an ideal cohort in which to analyze the effectiveness of pharmacological therapy combined with rehabilitation treatment on pain and functional alterations and their influence on perceived QoL in women with osteoporosis [13,14].

Article history
Received 19 Jan 2023 – Accepted 28 Apr 2023

Contact
Dalila Scaturro; dalila.scaturro@unipa.it
Department of Oncology and Stomatological Surgical Disciplines, University of Palermo, Palermo, Italy - Mobile phone number: +39 320 6945411

Purpose

The purpose of our study was to evaluate the effectiveness of rehabilitation on pain, postural balance and QoL in postmenopausal women with vertebral fragility fractures under therapy with denosumab for more than 12 months.

Materials and methods

Study design

A prospective cohort study involving 52 women recruited from the rehabilitation department of the University Hospital in Palermo was conducted. The study received local ethics committee (Palermo Ethics Committee I) approval and was conducted in compliance with the principles of the Helsinki Declaration. Written informed consent was obtained from each participant.

Participants

Inclusion criteria: postmenopausal osteoporosis with at least two vertebral fragility fractures; pharmacological treatment with denosumab for at least 12 months plus cholecalciferol; 25(OH)D3 serum concentration ≥ 20 ng/ml. Patients with auricular diseases were excluded.

Intervention

The patients underwent an initial physical examination (T0) and a second one at the end of the 12-week treatment period (T1). All patients received a 45-minute session of rehabilitation treatment 3 times a week, for a total of 20 sessions. During these sessions they performed postural re-education integrated with balance reactions and visual stabilisation training, walking and endurance training, and subsequently it was recommended that they continue with spine stretching exercises.

Outcome measurement tools

Numerical rating scale (NRS)

Pain intensity was measured using an NRS, with the patient required to select an integer (0-10 integers) that best reflects their pain intensity: "0" represents "no pain" and "10" represents "the strongest pain" [15].

The 36-item Short Form Survey (SF-36)

The SF-36 consists of 36 items divided into the following eight health domains: general health, physical functioning, physical role, body pain, vitality, social functioning, emotional role, and mental health. For each domain the total score ranges from 0 to 100 points, with a higher score indicating a better QoL [16].

Mini-Osteoporosis Quality of Life Questionnaire (Mini-OQOL)

The Mini-OQOL evaluates QoL in patients with osteoporosis. It investigates five areas of health (symptoms, emotional state, physical function, daily activities and social activities) Each of its 10 questions is assigned a grade of between 1 and 7. The total score of the questionnaire therefore ranges from 10 to 70. For each item, a score of 1 corresponds to the worst possible functionality (extreme difficulty, permanent fear and extreme anxiety), while a score of 7 is associated with the best possible functionality (no difficulty, fear or anxiety) [17].

Timed Up and Go (TUG) test

Posture, balance and fall risk were assessed using the TUG test. Subjects performing the TUG test are asked to get up from a chair, approach a sign positioned at a distance of 3 m, turn around in a circle, return to the chair and sit on it. Performance time is measured in seconds and lower values indicate better balance control and a lower risk of falling [18].

Disability Handicap Inventory (DHI)

Vertigo was investigated using the Italian version of the DHI (DHI-I). It is a 25-item questionnaire that measures the impact of vertigo on functional domains (9 items), emotional domains (8 items) and physical domains (7 items) [19].

Assessment of balance and gait

Posture was recorded using the FreeMed posturography system, including the FreeMed baropodometric platform. Posturographic analysis was performed by means of a stabilizing platform; patients, barefoot, were asked to maintain the static position, keeping their arms by their sides, and their head and gaze in neutral position with eyes open for 5 seconds and then closed.

For the posturographic analysis, the following parameters were considered: total/ forefoot/ backfoot right and left foot support surface calculated in cm^2; total/ forefoot/ backfoot load (%); center of pressure during the oscillations on the x-axis (lateral oscillations) and on the ordinates (front-back oscillations) (CoP X and CoPY), finally the point of maximum right and left foot pressure (Right Pod degree).

The stabilometric analysis also evaluated the surface ellipse (cm), the bundle length of the oscillation, the maximum oscillation, the average velocity (mm/s), finally the standard deviation of the oscillation with eyes open and closed. For the Dynamic analysis, the length of the gait line during the walk (mm) were considered, also the total/forefoot/ backfoot load (%).

Statistical analysis

All data were presented as mean + standard deviation (SD) for continuous variables and as median for ordinal variables. A Student's t-test for continuous variables and Mood tests for ordinal variables were used to compare differences in demographic characteristics, stability, static and dynamic baropodometric parameters, and the questionnaires. P-values <0.05 were considered statistically significant.

Results

Of the 52 women initially recruited, five were excluded due to severe systemic disorders diagnosed during the study and 19 due to missing follow-up data (T1). The other 28 completed the rehabilitation protocol. They were then divided into Group 1 (six patients with two vertebral fractures) and Group 2 (22 patients with more than two vertebral fractures) (Figure 1). Table I shows the baseline characteristics of the study population. The average age was 66.5±5.3 years. At T1, statistically significant improvements in the NRS and SF-36 were reported in our cohort. Within-group analysis showed significant improvements in the NRS and TUG test, in group 2 and group 1 respectively (Table I). Tables II, III and IV show that there were no variations in static and dynamic posture.

Discussion

To our knowledge, this is the first study to evaluate the effectiveness, on pain, mobility, postural control and QoL, of a combined approach, involving the use of denosumab and vita-

Figure 1 Study population selection process.

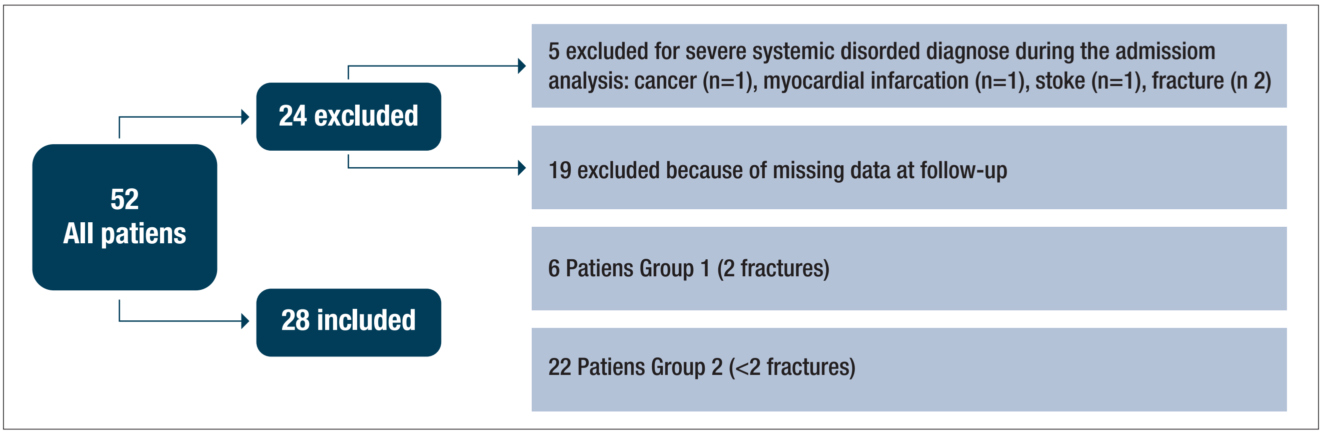

Table I Baseline characteristics and clinical outcome measurements before and after treatment.

	ALL PATIENTS (N=28)			GROUP 1: 2 FRACTURES (N=6)			GROUP 2: >2 FRACTURES (N=22)			*P*-VALUE BETWEEN-GROUP IN T0
	T0	T1	*p*-value	T0	T1	*p*-value	T0	T1	*p*-value	
Age (years)	66.5±5.3			65.5±7.6			66.8±4.6			0.71
BMI (kg/m²)	26.5±4.0			24.0±4.6			27.2±3.6			0.16
NRS	6.5 (1.0)	5.0 (2.0)	<0.05	5.0 (2.7)	3.0 (0.7)	0.54	7.0 (1.7)	6.0 (1.7)	<0.05	0.65
SF-36	42.2±15.8	50.4±13.2	<0.05	45.0±18.5	58.0±10.4	0.17	41.5±15.4	48.3±1.2	0.12	0.48
Mini-OQOL	47.0±10.0	51.9±9.4	0.06	52.7±8.3	55.5±9.5	0.59	45.5±10.0	51.0±9.3	0.07	0.11
DHI-I	38.3±25.5	32.7±22.1	0.38	31.5±25.5	29.2±25.2	0.88	40.2±25.8	33.7±21.8	0.37	0.68
TUG	13.0 (2.0)	11.5 (2.5)	0.78	12.0 (0.0)	10.5 (1.0)	<0.05	14.0 (1.7)	12.7 (2.5)	0.76	0.02

BMI=body mass index, **NRS**=numerical rating scale; **Mini-OQOL**= Mini-Osteoporosis Quality of Life Questionnaire, **DHI-I**= Dizziness Handicap Inventory, Italian version, **TUG**=Timed Up and Go test

Table II Posturographic analysis.

	ALL PATIENTS (N=28)			GROUP 1: 2 FRACTURES (N=6)			GROUP 2: >2 FRACTURES (N=22)		
	T0	T1	*p*-value	T0	T1	*p*-value	T0	T1	*p*-value
Left surface cm²	104.6 ± 21.5	101.0 ± 25.2	0.57	97.7 ± 21.0	102.8 ± 16.0	0.64	106.5 ± 21.7	100.5 ± 27.5	0.43
Right surface cm²	104.6 ± 20.1	102.6 ± 19.5	0.71	103.8 ± 22.1	101.7 ± 11.5	0.84	104.8 ± 20.1	102.9 ± 21.4	0.76
Left forefoot surf. cm²	56.8±13.6	54.4±17.1	0.56	54.5±11.9	58.7±11.9	0.56	57.4±14.3	53.2±18.3	0.40
Right forefoot surf. cm²	56.9±12.8	55.1±13.4	0.61	58.7±13.3	57.7±10.4	0.89	56.5±12.9	54.5±14.2	0.63
Left backfoot surf. cm²	47.7±9.3	46.6±9.5	0.66	43.0±9.2	44.0±7.0	0.84	49.0±9.1	47.3±10.1	0.56
Right backfoot surf. cm²	47.8±9.7	47.4±8.1	0.87	45.5±9.8	44.0±3.2	0.73	48.5±9.9	48.4±8.8	0.97
Left load %	49.9±5.7	48.5±6.0	0.39	47.8±7.2	50.5±8.7	0.58	50.4±5.3	48.0±5.1	0.13
Right load %	50.1±5.7	51.1±6.0	0.39	52.2±7.2	49.5±8.7	0.58	49.6±5.3	52.0±5.1	0.13
Left forefoot load %	42.6 ± 8.0	42.3 ± 11.9	0.92	45.5 ± 3.2	51.0 ± 12.8	0.35	41.8 ± 8.8	39.9 ± 10.8	0.53
Right forefoot load %	44.9 ± 10.4	44.9 ± 10.7	0.99	45.7 ± 5.0	49.5 ± 10.1	0.43	44.7 ± 11.6	43.6 ± 10.8	0.75
Left backfoot load %	57.4 ± 8.0	57.7 ± 11.9	0.92	54.5 ± 3.2	49.0 ± 12.8	0.35	58.2 ± 8.8	60.1 ± 10.8	0.53
Right backfoot load %	55.1 ± 10.4	55.1 ± 10.7	0.99	54.3 ± 5.0	50.5 ± 10.1	0.43	55.3 ± 11.6	56.4 ± 10.8	0.75
CoP X Coord	13.9 ± 2.4	14.2 ± 2.2	0.67	12.6 ± 1.8	13.0 ± 2.7	0.78	14.3 ± 2.4	14.5 ± 1.9	0.74
CoP Y Coord	15.9 ± 2.2	16.2 ± 2.2	0.59	14.3 ± 0.7	14.7 ± 2.5	0.74	16.3 ± 2.3	16.6 ± 1.9	0.64
Left Pod Degree	6.3 ± 4.0	7.5 ± 3.7	0.28	4.8 ± 3.2	6.8 ± 2.6	0.26	6.7 ± 4.2	7.6 ± 4.0	0.47
Right Pod Degree	7.6 ± 4.8	9.4 ± 5.5	0.19	4.8 ± 4.1	10.0 ± 3.7	0.04	8.4 ± 4.8	9.3 ± 5.9	0.58

CoP=centre of pressure;

Table III Stability analysis.

OPEN EYES									
	ALL PATIENTS (N=28)			GROUP 1: 2 FRACTURES (N=6)			GROUP 2: >2 FRACTURES (N=22)		
	T0	T1	*p*-value	T0	T1	*p*-value	T0	T1	*p*-value
Surface ellipse cm	129.9 ± 101.1	152.9 ± 205.8	0.60	87.8 ± 61.9	89.8 ± 56.3	0.95	141.4 ± 107.6	170.1 ± 228.6	0.60
Bundle length mm	493.3 ± 154.3	529.0 ± 170.4	0.42	475.5 ± 175.9	582.2 ± 143.6	0.28	498.2 ± 152.1	514.5 ± 177.2	0.75
Oscillation maximum	2.0 ± 1.3	2.0 ± 0.6	0.79	1.6 ± 0.3	1.9 ± 0.4	0.19	2.2 ± 1.5	2.0 ± 0.7	0.61
Velocity average mm/s	10.1 ± 3.1	10.7 ± 3.4	0.48	9.7 ± 3.6	11.8 ± 2.8	0.30	10.2 ± 3.1	10.4 ± 3.5	0.82
X, average	0.1 ± 7.4	–1.5 ± 9.6	0.50	–1.8 ± 7.9	3.0 ± 11.0	0.6	0.41 ± 7.4	–2.7 ± 9.0	0.19
Y, average	–17.3 ± 12.9	–17.0 ± 11.7	0.93	–164 ± 11.3	–11.9 ± 13.9	0.55	–17.6 ± 13.6	–18.4 ± 11.0	0.82
X, standard deviation	2.2 ± 1.0	2.5 ± 1.3	0.30	1.6 ± 0.8	2.1 ± 0.5	0.21	2.4 ± 1.0	2.7 ± 1.4	0.47
Y, standard deviation	2.8 ± 1.2	2.7 ± 1.5	0.95	2.6 ± 0.9	2.2 ± 1.2	0.54	2.8 ± 1.3	2.9 ± 1.6	0.86
CLOSED EYES									
	ALL PATIENTS (N=28)			GROUP 1: 2 FRACTURES (N=6)			GROUP 2: >2 FRACTURES (N=22)		
	T0	T1	*p*-value	T0	T1	*p*-value	T0	T1	*p*-value
Surface ellipse cm	248.4 ± 370.9	192.3 ± 205.1	0.49	148.3 ± 134.3	102.4 ± 101.4	0.52	275.8 ± 411.0	216.9 ± 220.7	0.56
Beam length mm	536.5 ± 142.6	560.8 ± 209.9	0.61	559.0 ± 172.0	516.9 ± 82.3	0.61	530.4 ± 137.6	572.8 ± 233.1	0.47
Oscillation, maximum	5.6 ± 4.3	6.3 ± 5.1	0.53	5.0 ± 2.9	8.2 ± 8.4	0.41	5.7 ± 4.6	5.9 ± 3.9	0.91
Velocity, average mm/s	10.8 ± 2.9	11.3 ± 4.1	0.61	11.3 ± 3.5	10.4 ± 1.5	0.60	10.6 ± 2.8	11.5 ± 4.6	0.45
X, average	0.3 ± 8.4	–1.5 ± 8.7	0.42	–3.5 ± 12.1	2.2 ± 8.0	0.36	1.4 ± 7.1	–2.6 ± 8.8	0.11
Y, average	–17.2 ± 12.7	–16.5 ± 10.3	0.83	–13.5 ± 9.0	–13.3 ± 10.9	0.97	–18.2 ± 13.5	–17.4 ± 10.2	0.83
X, standard deviation	3.0 ± 2.8	2.5 ± 1.6	0.37	2.1 ± 1.1	1.9 ± 1.3	0.79	3.2 ± 3.0	2.6 ± 1.6	0.39
Y, standard deviation	3.0 ± 2.0	3.2 ± 2.2	0.74	3.0 ± 1.9	2.3 ± 1.8	0.51	3.1 ± 2.0	3.5 ± 2.3	0.51

Table IV Dynamic analysis.

	ALL PATIENTS (N=28)			GROUP 1: 2 FRACTURES (N=6)			GROUP 2: >2 FRACTURES (N=22)		
	T0	T1	*p*-value	T0	T1	*p*-value	T0	T1	*p*-value
Left gait line, length, mm	187.6 ± 36.5	186.9 ± 23.9	0.93	162.7 ± 63.5	175.7 ± 26.6	0.66	194.5 ± 23.0	190.0 ± 22.8	0.52
Right gait line, length, mm	184.3 ± 44.8	186.5 ± 18.1	0.80	177.5 ± 40.7	184.7 ± 9.9	0.69	186.1 ± 46.6	187.0 ± 19.9	0.93
Left forefoot load, %	60.4 ± 6.2	62.9 ± 5.4	0.11	60.0 ± 6.7	65.2 ± 5.1	0.17	60.5 ± 6.2	62.3 ± 5.5	0.31
Right forefoot load, %	61.7 ± 5.8	61.0 ± 5.8	0.63	65.0 ± 5.7	60.3 ± 5.6	0.19	60.8 ± 5.6	61.1 ± 6.0	0.86
Left backfoot load, %	39.6 ± 6.2	37.1 ± 5.4	0.11	40.0 ± 6.7	34.8 ± 5.1	0.17	39.5 ± 6.2	37.7 ± 5.5	0.31
Right backfoot load, %	38.3 ± 5.8	39.0 ± 5.8	0.63	35.0 ± 5.7	39.7 ± 5.6	0.19	39.2 ± 5.6	38.9 ± 6.0	0.86
Left side load, %	50.7 ± 6.6	50.4 ± 6.3	0.85	53.5 ± 7.7	53.3 ± 7.8	0.97	49.9 ± 6.2	49.5 ± 5.7	0.84
Right side load, %	48.7 ± 5.6	50.0 ± 5.5	0.39	47.7 ± 5.8	53.8 ± 5.5	0.09	49.0 ± 5.7	48.9 ± 5.1	0.98

min D plus rehabilitation treatment, in patients with multiple vertebral fractures [13,14]. Our findings suggest that this treatment strategy could be effective on pain, particularly in osteoporotic women with more than two vertebral fractures. In addition, the same therapy could improve balance in women with two vertebral fragility fractures. It should be noted that, in agreement with other studies [20], the rehabilitation treatment was well tolerated, despite the severity of bone fragility in our population.

Stanghelle et al. claimed that low QoL was significantly associated with both impaired physical functioning and increased pain intensity in women with vertebral fragility fractures; their findings supported the role of therapeutic exercise in pain management [21]. In a prospective real practice study, which included osteoporotic women with vertebral fractures (50% of the participants had at least three fractures) and chronic back pain, administration of denosumab for 1 year was effective in reducing back-related disability and QoL. The analgesic effects of this drug are related to the negative modulation of nuclear factor-ϰB, by inhibition of the RANK/RANKL pathway, resulting in inhibition of osteoclast activity with reduction of local acidification and of bone pain [13,14,22].

A possible role for the OPG/RANK/RANKL pathway in the pathogenesis of skeletal muscle wasting has also been suggested. It has been experimentally proven that systemic injection of OPG (osteoprotegerin) restores muscle strength and improves muscle quality in mouse models of muscular dystrophy. In addition, muscle RANK regulates the accumulation of calcium ions and the activity Ca2+ATPases of the sarco/endoplasmic reticulum (SERCA) of fast-twitch muscle fibres, which are involved in fall prevention. The administration of Denosumab determines a significant lower incidence of falls compared with placebo (21%) as has been reported in randomized controlled trials that evaluated the effectiveness of denosumab in fragility fracture prevention [13,14]. With regard to the impairment mobility, our results agree with those reported by a recent Cochrane systematic review, which found moderate quality tests, in particular the TUG test, to support the effectiveness of exercise in improving physical performance in patients with vertebral fractures [23,24]. In addition, a further study suggests that thoracic hyperkyphosis is associated with increased TUG test time in older women with vertebral fractures. In our study, postural parameters did not appear to be affected by rehabilitation, and this is probably due to the short treatment period. However, they consolidate findings reported in other articles where no correlations were found between the instrumental parameters of postural balance and vertebral fractures in osteoporotic patients [24]. On the other hand, progressive high-intensity resistance exercises have been found to improve thoracic kyphosis without increasing the risk of new vertebral fractures or worsening existing vertebral deformities [25]. Our data support the safety of therapeutic exercise even in a population with severe bone fragility, suggesting that concerns are not justified.

However, the study has some limitations: the small sample size, lack of muscle strength evaluation, and lack of a control group.

Conclusions

A combined approach, including anti-resorptive drugs and rehabilitation intervention, reduces pain and improves balance and quality of life. Our results also suggest that this surgery is useful and should also be proposed to patients with multiple vertebral fragility fractures.

References

1. Tarantino U, Iolascon G, Cianferotti L, et al. Clinical guidelines for the prevention and treatment of osteoporosis: summary statements and recommendations from the Italian Society for Orthopaedics and Traumatology. J Orthop Traumatol. 2017;18(Suppl 1):3-36.
2. Hernlund E, Svedbom A, Ivergård M, et al. Osteoporosis in the European Union: medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). Arch Osteoporos. 2013;8(1):136.
3. Clark EM, Gooberman-Hill R, Peters TJ. Using self-reports of pain and other variables to distinguish between older women with back pain due to vertebral fractures and those with back pain due to degenerative changes. Osteoporos Int. 2016;27(4): 459-67 [published correction appears in Osteoporos Int. 2018;29(6):1475].
4. Imai T, Tanaka S, Kawakami K, Miyazaki T, Hagino H, Shiraki M; A-TOP (Adequate Treatment of Osteoporosis) Research Group.. Health state utility values and patient-reported outcomes before and after vertebral and non-vertebral fractures in an osteoporosis clinical trial. Osteoporos. Int. 2017;28(6):1893-901.
5. Lorbergs AL, Murabito JM, Jarraya M, et al. Thoracic kyphosis and physical function: the Framingham Study. J Am Geriatr Soc. 2017;65(10):2257-64.
6. Izzo R, Guarnieri G, Guglielmi G, Muto M. Biomechanics of the spine. Part I: spinal stability. Eur J Radiol. 2013;82(1):118-26.
7. Iolascon G, Moretti A, Giamattei MT, Migliaccio S, Gimigliano F. Prevalent fragility fractures as risk factor for skeletal muscle function deficit and dysmobility syndrome in post-menopausal women. Aging Clin Exp Res. 2015;27 Suppl 1:S11-6.
8. Iolascon G, de Sire A, Calafiore D, et al. Multifactorial assessment of risk of falling in 753 post-menopausal women: a multicenter cross-sectional study by the Italian Group for the Study of Metabolic Bone Diseases. Clin Interv Aging. 2020;15:1077-84.
9. Fernández L, Breinbauer HA, Delano PH. Vertigo and dizziness in the elderly. Front Neurol. 2015;6:144.
10. Falossi F, Notarstefano C, Miccoli M, Pelagatti A, Raffaetà G. Balance impairment and fragility vertebral fractures. Clin Ter. 2020;171(3):e240-e244.
11. Iolascon G, Moretti A, Toro G, Gimigliano F, Liguori S, Paoletta M. Pharmacological therapy of osteoporosis: what's new? Clin Interv Aging. 2020;15:485-91.
12. Jin YZ, Lee JH, Xu B, Cho M. Effect of medications on prevention of secondary osteoporotic vertebral compression fracture, non-vertebral fracture, and discontinuation due to adverse events: ameta-analysis of randomized controlled trials. BMC Musculoskelet Disord. 2019;20(1):399.
13. Moretti A, de Sire A, Curci C, Toro G, Gimigliano F, Iolascon G. Effectiveness of denosumab on back pain-related disability and quality-of-life in patients with vertebral fragility fractures. Curr Med Res Opin. 2019;35(1):151-5.
14. Migliaccio S, Francomano D, Romagnoli E, et al. Persistence with denosumab therapy in women affected by osteoporosis with fragility fractures: a multicenter observational real practice study in Italy. J Endocrinol Invest. 2017;40(12):1321-26.
15. Giangregorio LM, Papaioannou A, Macintyre NJ, et al. Too Fit To Fracture: exercise recommendations for individuals with osteoporosis or osteoporotic vertebral fracture. Osteoporos Int. 2014;25(3):821-35.
16. Williamson A, Hoggart B. Pain: a review of three commonly used pain rating scales. J Clin Nurs. 2005;14(7):798-804.
17. Ware JE Jr. SF-36 health survey update. Spine (Phila Pa 1976). 2000;25(24):3130-9.
18. Cook DJ, Guyatt GH, Adachi JD, et al. Development and validation of the mini-osteoporosis quality of life questionnaire (OQLQ) in osteoporotic women with back pain due to vertebral fractures. Osteoporosis Quality of Life Study Group. Osteoporos Int. 1999;10(3):207-13.
19. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. Phys Ther. 2000;80(9):896-903.
20. Nola G, Mostardini C, Salvi C, Ercolani AP, Ralli G. Validity of Ital-

ian adaptation of the Dizziness Handicap Inventory (DHI) and evaluation of the quality of life in patients with acute dizziness. Acta Otorhinolaryngol Ital. 2010;30(4):190.

21. Stanghelle B, Bentzen H, Giangregorio L, Pripp AH, Bergland A. Associations between health-related quality of life, physical function and pain in older women with osteoporosis and vertebral fracture. BMC Geriatr. 2019;19(1):298.
22. Makarova EV, Marchenkova LA, Eryomushkin MA, Styazkina EM, Chesnikova EI. Balance and muscle strength tests in patients with osteoporotic vertebral fractures to develop tailored rehabilitation programs. Eur J Transl Myol. 2020;30(3):9236.
23. Tetsunaga T, Tetsunaga T, Nishida K, et al. Denosumab and alendronate treatment in patients with back pain due to fresh osteoporotic vertebral fractures. J Orthop Sci. 2017;22(2):230-6.
24. Gibbs JC, MacIntyre NJ, Ponzano M, et al. Exercise for improving outcomes after osteoporotic vertebral fracture. Cochrane Database Syst Rev. 2019;7(7):CD008618.
25. Watson SL, Weeks BK, Weis LJ, Harding AT, Horan SA, Beck BR. High-intensity exercise did not cause vertebral fractures and improves thoracic kyphosis in postmenopausal women with low to very low bone mass: the LIFTMOR trial. Osteoporos Int. 2019;30(5):957-64.