



Original Article

The weight-bearing exercise for better balance program improves strength and balance in osteopenia: a randomized controlled trial

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Abstract. [Purpose] This study investigated the effect of the Weight-bearing Exercise for Better Balance program on the strength of hip flexors, extensors, abductors, adductors, and knee flexors and extensors and balance in osteopenia. [Subjects and Methods] Twenty-four postmenopausal females with osteopenia volunteered to participate in this study and were randomly assigned into two equal groups of 12: the experimental and control groups. The Weight-bearing Exercise for Better Balance program was applied to the experimental group, while the control group did not receive any treatment. Isokinetic peak torque per body weight values of the hip flexors, extensors, abductors, adductors, and knee flexors and extensors were measured by Biodex System 3 isokinetic dynamometer for both groups before and after six weeks of the program. Balance was assessed in both groups using the Berg Balance Scale. [Results] There was a statistically significant increase in post-intervention mean values of all measured variables compared with pre-intervention values in the experimental group. Also, there was a statistically significant increase in post-intervention mean values of all measured variables except for those of the hip extensors in the experimental group compared with the control group. [Conclusion] The weight-bearing exercise for better balance program has significant effects on lower extremity muscle strength and body balance in postmenopausal females with osteopenia.

Key words: Weight-bearing, Strength, Osteopenia

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INTRODUCTION

Osteoporosis is considered a major public health problem¹⁾. It is a chronic progressive skeletal disease characterized by low bone mineral density (BMD) leading to bone fragility and increased susceptibility to fractures²⁾. Muscle mass, force, power, and BMD decrease with age³⁾. In osteoporosis, bone loss occurs without symptoms, so it has been described as a silent disease⁴⁾. Osteoporosis management guidelines recommend the use of dual energy x-ray absorptiometry (DEXA) scans for BMD screening⁵⁾. Central DEXA of the lumbar spine and proximal femur is the preferred method for BMD testing⁶⁾. The World Health Organization (WHO)⁷⁾ categorizes BMD as follows: normal BMD, T-score of -1 or higher; osteopenia, T-score between -1 and -2.5 ; and osteoporosis, T-score equal to -2.5 or less.

Osteopenia is a condition of decreased BMD and is analogous to prehypertension, so it is the precursor to osteoporosis⁸⁾. Management of osteopenia prevents fracture-related morbidity and mortality⁹⁾. Patients with osteoporosis have a higher risk of fracture when compared with those in the same age group due to increased risk of fall¹⁰⁾. The risk of fracture is 2.7 times higher for females with osteoporosis and 1.7 times higher for females with osteopenia than females with normal BMD¹¹⁾. Because osteopenia is so much more common than osteoporosis, the majority of fractures occur in the population of patients

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with osteopenia¹²). There is a positive effect of physical activity on bone strength and on preventing osteoporosis¹³). Strophe et al.¹⁴) showed that physical activity during growth increases bone mass and strength with persistent benefits¹⁵).

During physical activity, mechanical forces are exerted on bones by the effect of the ground reaction forces and the contractile activity of the muscles, resulting in maintenance or gain of bone mass^{16, 17}). It was illustrated that an exercise program that improves flexibility, body balance, muscle power of lower extremities, and walking ability reduces the incidence of falls in the elderly. The combination of strength and balance training plays a preventive role in bone fragility and prevents falls in elderly people¹⁸). Exercises challenging balance, which are part of the Weight-bearing Exercise for Better Balance (WEBB) program, are the key feature of successful exercise programs for the prevention of falls in older people. The WEBB program includes a warm-up exercise, coordination (balance) exercises, and strength/coordination exercises. Each exercise has several levels of difficulty¹⁹). The question this randomized controlled trial attempted to answer was does WEBB program improve lower extremity muscle strength and body balance in postmenopausal females with osteopenia?

SUBJECTS AND METHODS

Twenty-four postmenopausal females with osteopenia volunteered to participate in this study and were randomly assigned into two equal groups of 12. The WEBB program was applied to the experimental group, while the control group did not receive any treatment. Isokinetic peak torque per body weight (PT/BW) values of the hip flexors, extensors, abductors, adductors, and knee flexors and extensors, and Berg Balance Scale (BBS) balance scores were measured before and after six weeks of the WEBB program for all participants in both groups. All participants were recruited from a group of females admitted to El-Haram Hospital, Giza, Egypt, to assess their BMD through a DEXA scan. The aim and procedures of the study were explained to the recruited females. The Research Ethical Committee, Faculty of Physical Therapy, Cairo University, approved this study (P.T.REC/012/00731). All participants provided written informed consent before data collection. The study complied with the ethical standards of the Declaration of Helsinki.

The eligibility criteria were as follows: Postmenopausal females aging from 50 to 60 years of age. The mean \pm standard deviation (SD) values for age, body mass, and height of the experimental group were 59.08 (\pm 4.14) years, 92.50 (\pm 11.80) kg, and 160.42 (\pm 2.02) cm, respectively. Those of the control group were 58.58 (\pm 3.92) years, 86.58 (\pm 12.21) kg, and 159.33 (\pm 1.72) cm, respectively, as represented in Table 1. All participants were diagnosed with osteopenia, as indicated by a T-score value of between -1 and -2.5 SD of the normal mean value of young persons of the same gender. None of the participants participated in sports or athletic activities. Hip and knee muscle strength were at least grade four as assessed using manual muscle test. Personal data of the participants were collected. The data included name, age, address, weight, height, and phone number. The nature of the study, aims, equipment, and procedures were explained to the participants to familiarize them with the study before starting measurements.

A Biodex System 3 Isokinetic Dynamometer (Biodex Medical Systems, Shirley, NY, USA) was used to measure the isokinetic PT/BW values for the hip and knee muscles of the dominant lower extremity. All measured variables were evaluated in a concentric mode of muscle contraction²⁰) at an angular velocity of $60^\circ/\text{sec}$ ²⁰⁻²²) for five repetitions²³). The BBS was used to assess body balance in this study^{24, 25}). The BBS is designed to measure balance among older people with impairment in balance function by assessing the performance of functional tasks. It is a 5-point scale ranging from 0–4 and consisting of 14 items. The maximum total Score of the BBS is 56²⁶). All participants in both groups were assessed for both isokinetic strength and BBS balance scores twice before and after the intervention.

The WEBB program in the current study was performed five times per week for six weeks. Repetitions of each exercise of the WEBB program were increased gradually according to the patient's tolerance as recommended by Sherrington et al¹⁹). The program consists of a warm-up exercise, two coordination exercises and three types of coordination and strength exercises. The warm-up exercise performed at the beginning of the program was high stepping on a spot for 10 seconds five times for each limb, alternatively between limbs. This exercise also enhances coordination and endurance. After that, coordination and strength exercises were performed with different levels of difficulty. The two exercises that targeted coordination were standing with a decreased base and stepping in different directions.

The standing with a decreased base exercise was performed bilaterally with the following gradually increasing levels of difficulty: 1) feet together and level, 2) semi-tandem stance, 3) tandem stance, and 4) standing on one leg. The exercise was performed at each level of difficulty for one minute. The stepping in different directions exercise was performed bilaterally with the following gradually increasing levels of difficulty: 1) long step with a narrow base of support by asking the participant

Table 1. Descriptive statistics for the mean age, body mass, and height of the experimental and control groups

	Experimental group	Control group
Age (years)	59.1 \pm 4.1	58.6 \pm 3.9
Body mass (kg)	92.5 \pm 11.8	86.5 \pm 12.2
Height (cm)	160.4 \pm 2.0	159.3 \pm 1.7

to take the longest step possible with a narrow base of support (5 cm wide) and to maintain this position for one minute, 2) stepping forward over an object, and 3) stepping sideways over an object; for stepping forward and sideways over an object, the participant was asked to take a step forward or sideways, as appropriate, over an object that was gradually raised higher. The object height was 15 cm in the first two weeks of training, 20 cm in the second two weeks, and 25 cm in the third two weeks. The exercise was performed at each level of difficulty for one minute.

The three types of exercises that targeted both coordination and strength were the sit-to-stand (squatting) exercise, heel raise exercises, and forward and lateral step-up exercises. 1) The sit-to-stand (squatting) exercise was performed with the following gradually increasing levels of difficulty: a) bilateral squatting on two limbs with hand assistance, b) bilateral squatting on two limbs without hand assistance by crossing the arms across the chest, and c) unilateral squatting on one limb while the other limb is elevated above the ground. 2) The heel raise exercise included bilateral and unilateral heel raise exercises. 3) The forward and lateral step-up exercises were performed with a height of 15 cm and 10 repetitions in the first two weeks, a height of 20 cm and 15 repetitions in the second two weeks, and a height of 25 cm and 20 repetitions in the third two weeks of training. Each level of difficulty for each exercise was performed 10 times in the first two weeks, 15 times in the second two weeks, and 20 times in the third two weeks of training.

Two-way mixed design multivariate analysis of variance (MANOVA) was conducted in the current study to test the effect of the WEBB program on seven dependent variables: isokinetic PT/BW values of the hip flexors, extensors, abductors, adductors, and knee flexors and extensors and BBS balance scores. Measurements were recorded from all participants in both groups before and after six weeks of the WEBB program in the experimental group. Levene's test of equality of error variance was insignificant for all measured variables, indicating homogeneity between groups. Also, Mauchly's sphericity test was insignificant, indicating homogeneity of the within factor (time of testing). Descriptive statistics illustrated the mean values of all measured variables before and after the intervention in both groups, as presented in Table 2.

RESULTS

Before starting the study procedures, a pilot study was conducted with six participants to determine the appropriate sample size. Power analysis was conducted at a significance level of 5% and a test power of 80%. It revealed that a minimum of nine participants were required for each group (i.e., 18 for both groups). A total of 78 participants were assessed, and 54 who did not meet the inclusion criteria were excluded. Only 24 participants met the inclusion criteria and were included in the study. They were subdivided into two equal groups of 12. There was no loss of participants to follow-up for any reason. After completing the study, statistical analysis revealed a high power of significance (98%) for the study.

Multiple pairwise comparisons revealed a significant increase in the post-intervention mean values of PT/BW of the hip flexors, extensors, abductors, adductors, and knee flexors and extensors and BBS balance scores in the experimental group compared with the pre-intervention values ($p < 0.05$). In the control group, multiple pairwise comparisons revealed no significant difference in the post-intervention mean values of all measured variables compared to the pre testing values ($p > 0.05$). Moreover, there was a significant increase in the post-intervention mean values of all measured variables except the PT/BW of the hip extensors in the experimental group compared with the control group ($p < 0.05$). In addition, a significant interaction was found for tested group and time factors in all measured variables ($p < 0.05$). This means that the effect of the WEBB program on measured variables depends on the testing time, and this effect was not the same at the two times of testing.

DISCUSSION

The current study was conducted to investigate the effect of the WEBB program on isokinetic hip and knee muscles strength and body balance in postmenopausal females with osteopenia. The significant improvements in the measured variables illustrated the effective role of the WEBB program in cases of osteopenia. The WEBB program was developed to

Table 2. Mean isokinetic PT/BW values and BBS scores

Measured variables	Mean \pm SD (Nm/kg for PT/BW and degrees for BBS balance scores)			
	Experimental group		Control group	
	Pre	Post	Pre	Post
Hip flexor PT/BW	46.4 \pm 17.9	89.03 \pm 28.1*	38.1 \pm 12.8	42.3 \pm 19.6
Hip extensor PT/BW	28.8 \pm 17.9	55.56 \pm 25.5*	41.9 \pm 21.5	46.3 \pm 26.5
Hip abductor PT/BW	30.4 \pm 15.4	67.80 \pm 12.6*	37.7 \pm 19.5	32.7 \pm 14.4
Hip adductor PT/BW	23.4 \pm 11.2	47.98 \pm 21.1*	25.3 \pm 13.4	20.2 \pm 8.0
Knee flexor PT/BW	18.3 \pm 6.1	38.39 \pm 7.2*	20.0 \pm 5.7	23.5 \pm 5.3
Knee extensor PT/BW	56.6 \pm 16.3	121.7 \pm 40.7*	52.4 \pm 24.4	50.7 \pm 25.5
Balance score (BBS)	34.3 \pm 9.0	47.92 \pm 2.8*	34.4 \pm 8.6	32.9 \pm 8.7

*Significant at alpha level < 0.05

specifically target poor balance and lower limb muscle weakness for people at risk of falls²⁷). In addition, weight-bearing exercises provide an effective way to stress important sites of bones improving muscular strength and body balance, which reduces the risk for falls²⁸).

The insignificant difference in hip extensor strength between groups may be attributed to inability of participants to perform deep squatting in the sit-to-stand exercise, which targets hip extensor strength as tolerance was limited with increasing age. Activation of the gluteus maximus is greatly influenced by increasing the squat depth to 90° of hip flexion, as reported by Caterisano et al.²⁹). In addition, isokinetic testing of hip extensor strength was performed in the range of 45° hip flexion to 0° hip extension, and this may not be the accurate range for maximal activation of hip extensors, as reported by Worrell et al.³⁰), who found that full hip extension elicited the greatest amount of gluteus maximus myoelectric activity. A study by Burke et al.³¹) supported the results of the current study and concluded that balance and strengthening exercises are important in improving postural control and lower limb muscle strength in elderly females with osteoporosis. They assessed the efficacy of an eight-week program of balance and strengthening exercises on postural control and isokinetic strength of knee flexors, extensors, and ankle dorsiflexors of females with osteoporosis. Their results revealed significant improvement of all balance and strength measures.

Also, Carter et al.³²) indicated no significant changes in isokinetic knee extension strength after 10 weeks of posture and coordination training. They illustrated that the participants in the exercise group showed an increase in isokinetic knee extension strength, although not statistically significant, compared with their control group (4.9% and 12.8%, respectively). However, in another study, Carter et al.³³) increased the training period to 20 weeks for the intervention group and noticed a significant effect, and they indeed found significant increases in dynamic isokinetic knee extension strength. This illustrates that ensuring a sufficient period for a treatment program has a marked effect on the results.

The same results were obtained by Sherrington et al.³⁴), who studied the effect of two weeks weight-bearing versus non-weight-bearing exercises on strength, balance, gait, and functional performance among older inpatients following hip fracture. Although there were significant improvements in the outcome measures after testing, there were no significant differences between groups. It was concluded that two weeks of training was not enough to produce statistically significant differences between groups.

Concerning balance, the results of the current study are in agreement with those of Teixeira et al.²⁵) who evaluated the effect of a progressive muscular strength and functional training program including proprioception and balance training on the BBS balance score and prevention of falls in postmenopausal females with osteoporosis. It was concluded that progressive muscular strength and proprioception training were effective in improving muscular strength, balance, and reducing the number of falls in their experimental group compared to their control group.

The results of the current study are also supported by the results of a study done by Gunendi et al.³⁵), who evaluated the effect of a 4-week submaximal aerobic exercise program on postural balance in postmenopausal females with osteoporosis. Balance ability of all subjects was measured by the Timed Up and Go test (TUG), Four Square Step test (FSS), and BBS. All balance scores of the intervention group were significantly increased compared to the control group.

Although the present study was a randomized trial with random allocation of participants for controlling the confounding factors, some methodological limitations were still present. They include the inability to assess each participant for both isokinetic and balance measures in the same day due to some laboratory difficulties. The learning effect gained after the pre-intervention test of measured outcomes was another limitation that could affect the post-intervention test results, but it may be overcome to some extent by comparing the results with the control group. Another limitation was the inability to confirm that all participants gave their best efforts during testing. The investigators tried to overcome this limitation by instructing all participants to do their best during testing.

In conclusion, the WEBB program has significant effects on lower extremity muscles strength and body balance. It can be included in intervention programs that aim to improve lower extremity muscle strength and body balance in osteopenia.

REFERENCES

- 1) Kannus P, Niemi S, Parkkari J, et al.: Nationwide decline in incidence of hip fracture. *J Bone Miner Res*, 2006, 21: 1836–1838. [[Medline](#)] [[CrossRef](#)]
- 2) Mauck KF, Clarke BL: Diagnosis, screening, prevention, and treatment of osteoporosis. *Mayo Clin Proc*, 2006, 81: 662–672. [[Medline](#)] [[CrossRef](#)]
- 3) Walsh MC, Hunter GR, Livingstone MB: Sarcopenia in premenopausal and postmenopausal women with osteopenia, osteoporosis and normal bone mineral density. *Osteoporos Int*, 2006, 17: 61–67. [[Medline](#)] [[CrossRef](#)]
- 4) Zhu K, Prince RL: Lifestyle and osteoporosis. *Curr Osteoporos Rep*, 2015, 13: 52–59. [[Medline](#)] [[CrossRef](#)]
- 5) Nordin C: Screening for osteoporosis: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med*, 2011, 155: 276, author reply 276–277. [[Medline](#)] [[CrossRef](#)]
- 6) Lewiecki EM, Gordon CM, Baim S, et al.: International Society for Clinical Densitometry 2007 adult and pediatric official positions. *Bone*, 2008, 43: 1115–1121. [[Medline](#)] [[CrossRef](#)]
- 7) World Health Organization (WHO): Prevention and management of osteoporosis. *World Health Organ Tech Rep Ser*, 2003, 921: 1–164. [[Medline](#)]
- 8) Chobanian AV, Bakris GL, Black HR, et al. National Heart, Lung, and Blood Institute Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure National High Blood Pressure Education Program Coordinating Committee: The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA*, 2003, 289: 2560–2572. [[Medline](#)] [[CrossRef](#)]

- 9) Cummings SR, Melton LJ: Epidemiology and outcomes of osteoporotic fractures. *Lancet*, 2002, 359: 1761–1767. [[Medline](#)] [[CrossRef](#)]
- 10) Liu-Ambrose T, Eng JJ, Khan KM, et al.: Older women with osteoporosis have increased postural sway and weaker quadriceps strength than counterparts with normal bone mass: overlooked determinants of fracture risk? *J Gerontol A Biol Sci Med Sci*, 2003, 58: M862–M866. [[Medline](#)] [[CrossRef](#)]
- 11) Jordan KM, Cooper C: Epidemiology of osteoporosis. *Best Pract Res Clin Rheumatol*, 2002, 16: 795–806. [[Medline](#)] [[CrossRef](#)]
- 12) Pasco JA, Seeman E, Henry MJ, et al.: The population burden of fractures originates in women with osteopenia, not osteoporosis. *Osteoporos Int*, 2006, 17: 1404–1409. [[Medline](#)] [[CrossRef](#)]
- 13) Janz KF, Thomas DQ, Ford MA, et al.: Top 10 research questions related to physical activity and bone health in children and adolescents. *Res Q Exerc Sport*, 2015, 86: 5–12. [[Medline](#)] [[CrossRef](#)]
- 14) Stroppe MA, Nigh P, Carter MI, et al.: Physical activity-associated bone loading during adolescence and young adulthood is positively associated with adult bone mineral density in men. *Am J Men Health*, 2015, 9: 442–450. [[Medline](#)] [[CrossRef](#)]
- 15) Kohrt WM, Bloomfield SA, Little KD, et al. American College of Sports Medicine: American College of Sports Medicine Position Stand: physical activity and bone health. *Med Sci Sports Exerc*, 2004, 36: 1985–1996. [[Medline](#)] [[CrossRef](#)]
- 16) Moreira LD, Oliveira ML, Lirani-Galvão AP, et al.: Physical exercise and osteoporosis: effects of different types of exercises on bone and physical function of postmenopausal women. *Arq Bras Endocrinol Metabol*, 2014, 58: 514–522. [[Medline](#)] [[CrossRef](#)]
- 17) Vieira S: Different land-based exercise training programs to improve bone health in postmenopausal women. *Med Sci Tech*, 2013, 54: 158–163. [[CrossRef](#)]
- 18) Halvarsson A, Franzén E, Ståhle A: Balance training with multi-task exercises improves fall-related self-efficacy, gait, balance performance and physical function in older adults with osteoporosis: a randomized controlled trial. *Clin Rehabil*, 2015, 29: 365–375. [[Medline](#)] [[CrossRef](#)]
- 19) Sherrington C, Whitney JC, Lord SR, et al.: Effective exercise for the prevention of falls: a systematic review and meta-analysis. *J Am Geriatr Soc*, 2008, 56: 2234–2243. [[Medline](#)] [[CrossRef](#)]
- 20) Yahia D, Jribi A, Ghroubia D, et al.: A study of isokinetic trunk and knee muscle strength in patients with chronic sciatica. *Ann Phys Rehabil Med*, 2010, 53: 239–249. [[CrossRef](#)]
- 21) Teng W, Keong C, Ghosh A, et al.: Effects of a resistance training program on isokinetic peak torque and anaerobic power of 13–16 years old taekwondo athletes. *JSHS*, 2008, 2: 111–121.
- 22) Thorp LE, Wimmer MA, Foucher KC, et al.: The biomechanical effects of focused muscle training on medial knee loads in OA of the knee: a pilot, proof of concept study. *J Musculoskelet Neuronal Interact*, 2010, 10: 166–173. [[Medline](#)]
- 23) Baldon RM, Nakagawa TH, Muniz TB, et al.: Eccentric hip muscle function in females with and without patellofemoral pain syndrome. *J Athl Train*, 2009, 44: 490–496. [[Medline](#)] [[CrossRef](#)]
- 24) Muir SW, Berg K, Chesworth B, et al.: Use of the Berg Balance Scale for predicting multiple falls in community-dwelling elderly people: a prospective study. *Phys Ther*, 2008, 88: 449–459. [[Medline](#)] [[CrossRef](#)]
- 25) Teixeira LE, Silva KN, Imoto AM, et al.: Progressive load training for the quadriceps muscle associated with proprioception exercises for the prevention of falls in postmenopausal women with osteoporosis: a randomized controlled trial. *Osteoporos Int*, 2010, 21: 589–596. [[Medline](#)] [[CrossRef](#)]
- 26) Berg KO, Maki BE, Williams JI, et al.: Clinical and laboratory measures of postural balance in an elderly population. *Arch Phys Med Rehabil*, 1992, 73: 1073–1080. [[Medline](#)]
- 27) Canning CG, Sherrington C, Lord SR et al: Exercise therapy for prevention of falls in people with Parkinson's disease: a protocol for a randomised controlled trial and economic evaluation. *BMC Neurol*, 2009, 22: 9-4.
- 28) Pruitt LA, Jackson RD, Bartels RL, et al.: Weight training effects on bone mineral density in early post menopausal women. *J Bone Miner Res*, 1992, 7: 197–185.
- 29) Caterisano A, Moss RF, Pellingier TK, et al.: The effect of back squat depth on the EMG activity of 4 superficial hip and thigh muscles. *J Strength Cond Res*, 2002, 16: 428–432. [[Medline](#)]
- 30) Worrell TW, Karst G, Adamczyk D, et al.: Influence of joint position on electromyographic and torque generation during maximal voluntary isometric contractions of the hamstrings and gluteus maximus muscles. *J Orthop Sports Phys Ther*, 2001, 31: 730–740. [[Medline](#)] [[CrossRef](#)]
- 31) Burke TN, França FJ, Ferreira de Meneses SR, et al.: Postural control in elderly persons with osteoporosis: efficacy of an intervention program to improve balance and muscle strength: a randomized controlled trial. *Am J Phys Med Rehabil*, 2010, 89: 549–556. [[Medline](#)] [[CrossRef](#)]
- 32) Carter ND, Khan KM, Petit MA, et al.: Results of a 10 week community based strength and balance training programme to reduce fall risk factors: a randomised controlled trial in 65–75 year old women with osteoporosis. *Br J Sports Med*, 2001, 35: 348–351. [[Medline](#)] [[CrossRef](#)]
- 33) Carter ND, Khan KM, McKay HA, et al.: Community-based exercise program reduces risk factors for falls in 65- to 75-year-old women with osteoporosis: randomized controlled trial. *CMAJ*, 2002, 167: 997–1004. [[Medline](#)]
- 34) Sherrington C, Lord SR, Herbert RD: A randomised trial of weight-bearing versus non-weight-bearing exercise for improving physical ability in inpatients after hip fracture. *Aust J Physiother*, 2003, 49: 15–22. [[Medline](#)] [[CrossRef](#)]
- 35) Gunendi Z, Ozyemisci-Taskiran O, Demirsoy N: The effect of 4-week aerobic exercise program on postural balance in postmenopausal women with osteoporosis. *Rheumatol Int*, 2008, 28: 1217–1222. [[Medline](#)] [[CrossRef](#)]